Ambient concentrations of selected organochlorines in soils

Organochlorines Programme
Ministry for the Environment

December 1998

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Organochlorines in New Zealand:
Ambient concentrations of selected organochlorines in soils

Published by
Ministry for the Environment
PO Box 10-362
Wellington

ISBN 0 478 09034 X

December 1998

Printed on elemental chlorine free 50% recycled paper

Foreword

People around the world are concerned about organochlorine contaminants in the environment. Research has established that even the most remote regions of the world are affected by these persistent chemicals.

Organochlorines, as gases or attached to dust, are transported vast distances by air and ocean currents – they have been found even in polar regions. Organochlorines are stored in body fat and accumulate through the food chain. Even a low concentration of emission to the environment can contribute in the long term to significant risks to the health of animals, including birds, marine mammals and humans.

The contaminants of concern include dioxins (by-products of combustion and of some industrial processes), PCBs, and a number of chlorinated pesticides (for example, DDT and dieldrin). These chemicals have not been used in New Zealand for many years. But a number of industrial sites are contaminated, and dioxins continue to be released in small but significant quantities.

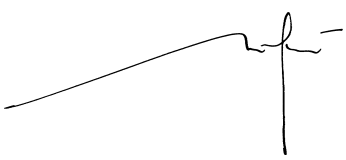
In view of the international concern, the Government decided that we needed better information on the New Zealand situation. The Ministry for the Environment was asked to establish an Organochlorines Programme to carry out research, assess the data, and to consider management issues such as clean up targets and emission control standards. As the contaminants are of high public concern, the Programme established networks for consultation and is keeping the public informed.

The fundamental research carried out under this programme has established for the first time the actual concentrations of these contaminants in the New Zealand environment – country-wide – in air, soil, rivers and estuaries. In addition, the dietary intakes of New Zealanders has been estimated through a study of organochlorine concentrations in food. The existing "body burdens" of the New Zealand population – the concentrations of organochlorines stored in fatty tissue – are also being assessed.

The publication of these New Zealand research reports marks an important contribution to international knowledge about these toxic chemicals. The comprehensive data contained in these reports is made all the more significant because of the scarcity of other data from the southern hemisphere.

The work has been peer reviewed internationally by experts and we are assured it is of the highest quality. We acknowledge the important contribution made by all those involved in the project within government and the private sector, from within New Zealand and abroad.

Finally, these reports lay a solid foundation in science for the development of policy. What message can we take from these results about the state our environment? Internationally, it appears that New Zealand could be categorised as being "moderately clean". While providing some comfort, this leaves no room for complacency. This research will assist the Government in preparing national environmental standards and guidelines for these contaminants to safeguard the health of New Zealanders and the quality of our environment.



Simon Upton
MINISTER FOR THE ENVIRONMENT

Executive summary

This report presents the findings of one component of the Organochlorines Programme of the Ministry for the Environment. A nation-wide environmental survey has been carried out to determine the background levels of organochlorine substances in terrestrial and aquatic media, and in ambient air. Here data are reported on the concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), organochlorine pesticides and chlorophenols quantified in New Zealand soils.

A total of 51 composite soil samples were collected from reference sites, and agricultural and urban areas. Soils from reference sites were collected from National Parks and Department of Conservation estate land in remote areas, comprising indigenous forest and grassland. Soils from agricultural environs were sampled from hill country farms and flat land pastoral lands throughout the country. Urban soils were collected from parks and reserves in the provincial centres of Whangarei, Hamilton, Napier, New Plymouth, Masterton, Timaru, Greymouth and Invercargill. Samples were also collected from residential and commercial/light industrial areas in the metropolitan centres of Auckland and Christchurch.

The results from this environmental survey show that, with few exceptions, environmental loadings of PCDDs, PCDFs, PCBs and chlorophenols in New Zealand soils are markedly lower than concentrations reported for soils in other developed countries. Organochlorine pesticide concentrations in forest and grassland soils, and in urban centres, were also lower than for comparable environments reported overseas. However, as hill country and flat land soils were not analysed for pesticide residues, no conclusions can be made on the extent of pesticide contamination of agricultural lands in general in New Zealand, nor on how New Zealand's agricultural environment compares with agricultural environments overseas.

Concentrations of PCDDs and PCDFs (including half LOD values for non-detectable congeners) were typically in the range 0.17 - 1.99 ng I-TEQ kg^{-1} dry weight in forest and grassland soils, 0.17 - 0.90 ng I-TEQ kg^{-1} in agricultural soils and 0.26 - 6.67 ng I-TEQ kg^{-1} in urban soils (Table ES1).

Table ES1 PCDD and PCDF I-TEQ concentrations in New Zealand soils (ng kg^{-1} DW)[1]

Land type	Min.	Max.	Median	Mean
Indigenous forest	0.17	1.99	1.26	1.06
Indigenous grassland	0.35	0.85	0.72	0.64
Hill country pasture	0.37	0.90 (9.14)[2]	0.58	0.56[3]
Flat land pasture	0.17	0.74	0.54	0.52
Provincial centre	0.72	3.73 (33.0)[2]	1.05	1.50[3]
Metropolitan centre	0.26	6.67	1.72	1.83

1 Includes half LOD values for non-detected congeners.
2 Single outlier in parenthesis.
3 Mean concentration excludes the single outlier.

For forest, grassland and agricultural soils, I-TEQ levels were typically at least one tenth lower if LOD values were excluded from the TEQ calculation. Exclusion of half LOD values also resulted in a notably lower I-TEQ result for provincial centre and metropolitan centre soils. Two samples had elevated concentrations of 2,3,7,8-TCDD, which could be associated with the manufacture and use of the herbicide 2,4,5-T.

For all land types, the more highly chlorinated PCDDs were the most abundant and frequently detected congeners. On average, 1,2,3,4,6,7,8-HpCDD and OCDD contributed 75% or more of the total I-TEQ level determined when half LOD values were excluded from the TEQ calculation.

The concentrations of PCDDs and PCDFs quantified in New Zealand soils are consistently lower than concentrations reported in soils collected from Europe and North America. For all samples the soil I-TEQ concentrations are generally well below the New Zealand and overseas guidelines for agricultural, residential and industrial land use.

Twenty five PCB congeners, including the toxicologically significant non *ortho*- and mono *ortho*-PCB congeners were analysed in all samples. No PCB congeners were quantified in most of the forest, grassland or agricultural soils. A limited number of congeners were found in urban soils, giving PCB concentrations (including half LOD values) for provincial centres in the range 0.30 - 3.38 μg kg^{-1} dry weight and for metropolitan centres in the range 0.23 - 9.74 μg kg^{-1} (Table ES2). The most frequently detected and abundant PCB congeners found in provincial and metropolitan centre soils were PCB #153 and #138. These two congeners accounted for approximately 45% of the sum of PCB congeners measured, and together with congeners #101, #118, #187, #180 and #170, accounted for approximately 85% of the sum of PCB congeners measured.

Table ES2 Sum of PCB congener concentrations in New Zealand soils (μg kg^{-1} DW)[1]

Land type	Min.	Max.	Median	Mean
Indigenous forest	0.14	1.20	0.24	0.42
Indigenous grassland	0.13	0.25	0.16	0.18
Hill country pasture	0.12	0.18	0.15	0.15
Flat land pasture	0.12	0.37	0.20	0.22
Provincial centre	0.30	3.38	1.94	1.90
Metropolitan centre	0.23	9.74	1.61	2.65

[1] Includes half LOD values for non-detected congeners.

For all soils, PCB TEQ levels were determined in the range 0.065 - 1.33 ng TEQ kg^{-1} dry weight. These levels were typically an order of magnitude lower than the corresponding PCDD and PCDF I-TEQ levels for the same land type.

The concentrations of PCBs found in New Zealand soils are consistently lower than the levels that have been reported from overseas studies. Concentrations found in urban soils in New Zealand compare favourably with results reported for pristine and agricultural environments in Europe and Asia.

Organochlorine pesticides were analysed in forest and grassland soils, and in urban soils collected from provincial and metropolitan centres. The most frequently detected pesticides were HCB and dieldrin, along with DDT residues including DDT degradation products. In forest and grassland soils, HCB and dieldrin were consistently detected, but never exceeded 1.0 μg kg^{-1} dry weight. DDT and DDE were found at all forest and grassland sites, but no residues exceeded a concentration of 3 μg kg^{-1} dry weight. Aldrin, heptachlor and HCH isomers were never found in forest and grassland soils, and were rarely quantified in soils collected from provincial and metropolitan centres.

HCB, dieldrin and chlordane were more frequently detected in urban New Zealand soils. These pesticides were measured to a maximum concentration of 1.22 μg kg^{-1} (HCB), 42.1 μg kg^{-1} (dieldrin) and 1.72 μg kg^{-1} dry weight (γ-chlordane). Concentrations were generally similar, regardless of whether the soil was from a provincial or a metropolitan centre. In contrast, DDT residues were measured at provincial and metropolitan centres over a broad range of concentrations. For most provincial sites, concentrations of pp'-DDT and DDT degradation products were typically at or below 15 μg kg^{-1}, although a concentration of 121 μg kg^{-1} dry weight was measured in Invercargill. The two metropolitan centres studied were markedly different with respect to DDT residue concentrations. Auckland had generally comparable concentrations to provincial centre soils, whilst Christchurch concentrations were consistently higher, in the range 78.8 - 340 μg kg^{-1} dry weight. These results indicate that for provincial centres and Auckland, with some exceptions, DDT usage was historically low. Christchurch soil concentrations, on the other hand, suggest multiple applications of DDT have historically occurred in this centre.

Chlorophenol contamination was found in only six of the 51 soils analysed. Three forest soils contained 2,4,6-trichlorophenol to a maximum concentration of 8.2 μg kg^{-1} dry weight and the Northland hill country pasture sample contained 2,4,5-trichlorophenol at a concentration of 10.1 μg kg^{-1}. Pentachlorophenol was measured in the Greymouth provincial centre soil (2.1 μg kg^{-1}) and in one sample from Christchurch (0.95 μg kg^{-1}). No indigenous grassland or flat land pastoral soils, or any other hill country or urban soils contained any detectable chlorophenol residues.

The contaminant concentration data sets for PCDDs, PCDFs, PCBs, organochlorine pesticides and chlorophenols in all soil samples analysed are detailed in full in Appendices D to G and in the Organochlorines Programme Environmental Survey database available from the Ministry's website (http://www.mfe.govt.nz/issues/waste/organo.htm). A summary of comparative international data is provided in Appendices H to J. Appendices B and C contain detailed information on the soil sampling and analytical programmes, including the results from the analysis of field and laboratory quality control samples. Appendix A summarises the historical use of organochlorines in New Zealand, and details their current regulatory status.

Acknowledgements

The success of this study has been dependent upon the involvement of many people who have contributed in various ways and at various stages of the project, from the initial study design, through the sample collection and analysis phase, to the final report writing and peer review.

The authors would like to acknowledge the contributions made by the following:
Greg Arnold, Chandra Bandaranayake, Alistair Bingham, Lawrence Boul, Kat Brand, Cheryl Calvert, Peter Day, Brian Duffy, Beth Dye, Helen Fossil, Cherry Gibb, Keitha Giddens, Norman Hawcroft, Allan Hewitt, Matthias Hierteis, Karen Hofmann, Pat Holland, Paul Jones, Vin Khurana, Scott Leathem, Beatrice Lee, Andrea Lister, Peter McIntosh, Geoff Mills, Tracy Morrison, Mario Offergeld, Lawrence Porter, Eric Reiner, Gareth Salt, Blair Smith, Gavin Stevenson, Bob Symons, Barry Straight, Karin Taylor, Matthew Taylor, Tania Trower, Tania van Maanen, J Veitch, Dave Waddell, Heather Wallace, Andrew Wards and Bob Wilcock.

The authors are grateful for the cooperation of the New Zealand Department of Conservation, City and District Councils, and individual farm owners who allowed samples to be taken from their property.

Special thanks are expressed to Hugh Wilde for coordinating the field sampling programme, and for his enthusiasm towards this project.

The authors would also like to acknowledge the participation of the international experts who contributed information and advice, and who undertook peer review of the initial study design or this publication: Ray Clement, Heidi Fiedler, Peter Fürst, Kevin Jones, Michael McLachlan and Chris Rappe.

Finally, the authors thank all current and former members of the Organochlorines Programme Consultative Group for their involvement in this study: Jim Barnett, Michael Bates, Bill Birch, Mark de Bazin, Ian Cairns, Paul Dell, Simon Hales, Donald Hannah, John Hohapata, Bill Jolly, Jocelyn Keith, Bob Moffat, Tony Petley, Peter Sligh, Michael Szabo, Norm Thom, Simon Towle and Jim Waters.

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1 Introduction

In 1995, the Ministry for the Environment commenced a national Organochlorines Programme to characterise the extent of contamination of the New Zealand environment by selected organochlorine contaminants, and establish risk-based environmental acceptance criteria for these substances. The organochlorines that are the focus of this programme are:

- The polychlorinated dibenzo-p-dioxins (PCDDs) and the polychlorinated dibenzofurans (PCDFs). These are often referred to generically as 'dioxins', but throughout this report, the PCDD and PCDF nomenclature is used;
- Polychlorinated biphenyls (PCBs);
- Organochlorine pesticides including DDT, aldrin, dieldrin and chlordane;
- Chlorophenols, in particular pentachlorophenol (PCP).

The development of risk-based acceptance criteria for organochlorines requires information on the background concentrations of these contaminants in the environment, in humans, and on exposure pathways. To support this process, the Organochlorines Programme has undertaken a series of detailed scientific investigations, including a major survey to determine the concentrations of PCDDs, PCDFs, PCBs, organochlorine pesticides and chlorophenols in environmental media. This environmental survey has involved the collection and analysis of approximately 250 samples of air, soil, river water, river biota and estuarine sediment and shellfish.

This report presents the findings of the environmental survey to determine the background concentrations of PCDDs, PCDFs, PCBs, organochlorine pesticides and chlorophenols in New Zealand soils. Separate reports have been published on organochlorine concentrations in New Zealand rivers (Buckland *et al*., 1998a), estuaries (Scobie *et al*., 1998) and in ambient air (Buckland *et al*., 1999). These data will be used in an environment risk assessment, which will be published as a separate report.

The objectives of the soil study described in this report were:

1) to obtain information on the background concentrations of organochlorine contaminants in New Zealand soils;
2) to enable the level of contamination of the New Zealand terrestrial environment to be seen in an international context;
3) to provide scientific data for use in a risk-based approach to support the development and application of national environmental standards and guidelines for organochlorine contaminants.

The environmental survey was undertaken to determine the background concentrations of the target organochlorine substances in the New Zealand environment. This study was not intended to identify or characterise known environmental hot spots (such as contaminated sites), or to directly assess emissions from known point sources. The sampling strategy for this survey was therefore designed to avoid areas of known contamination considered not to be representative of overall terrestrial environment.

The Organochlorines Programme

The Organochlorines Programme was initiated in response to a recognition of the need to minimise industrial emissions of PCDDs and PCDFs to air and water, clean-up sites contaminated with organochlorine residues and manage the safe disposal of waste stocks of organochlorine chemicals such as the PCBs and persistent pesticides. The Organochlorines Programme is consistent with current international concerns on persistent organic pollutants (UNEP, 1997).

The Organochlorines Programme as a whole comprises the study of environmental and human levels of organochlorine substances; the development of an inventory of ongoing PCDD and PCDF emissions; and the estimation of the risk posed by these substances. The integration of these and other components of the Organochlorines Programme is shown in Figure 1.1. The outcomes from the overall programme will be:

- National environmental standards for PCDDs and PCDFs and where necessary environmental guidelines or standards for PCBs, organochlorine pesticides and chlorophenols;
- Identified clean-up technologies that can safely and effectively destroy organochlorine wastes;
- An integrated management strategy for PCDDs, PCDFs and other organochlorine contaminants and wastes in New Zealand;
- Identification of issues for the phase-out of organochlorines;
- Informed public input to Government decisions on the management of organochlorines in the New Zealand environment.

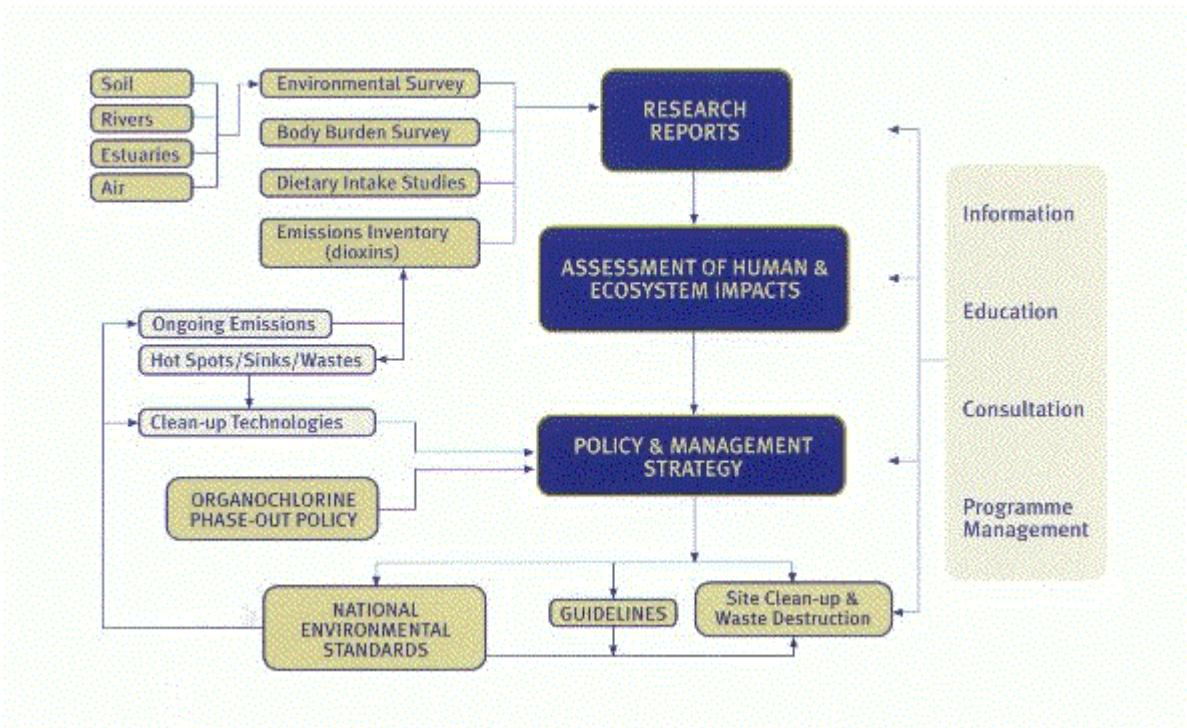
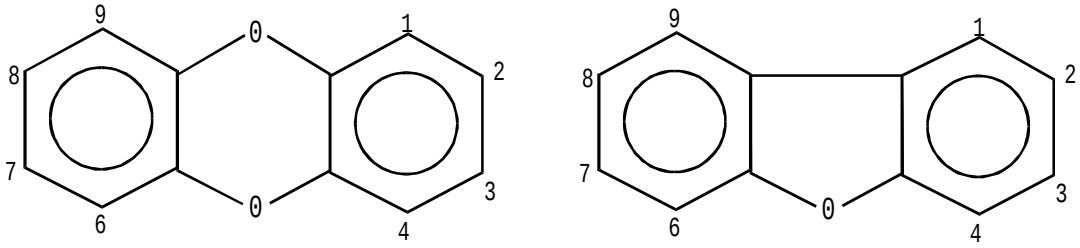


Figure 1.1 Overview of the New Zealand Organochlorines Programme

2 Background information on PCDDs, PCDFs and PCBs

2.1 PCDDs and PCDFs

The PCDDs and PCDFs are two groups of aromatic compounds having the basic structures shown in Figure 2.1.



Dibenzo-p-dioxin Dibenzofuran

Figure 2.1 Structures of dibenzo-p-dioxin and dibenzofuran

Both groups of chemicals may have up to eight chlorine atoms attached at carbon atoms 1 to 4 and 6 to 9. Each individual compound resulting from this is referred to as a congener. Each specific congener is distinguished by the number and position of chlorine atoms around the aromatic nucleus. In total, there are 75 possible PCDD congeners and 135 possible PCDF congeners. Groups of congeners with the same number of chlorine atoms are known as homologues. The number of congeners in each homologue group is shown in Table 2.1.

Toxicity

Congeners containing 1, 2 or 3 chlorine atoms are thought to be of no toxicological significance. However, the 17 congeners with chlorine atoms substituted in the 2,3,7,8-positions are thought to pose a risk to human and environmental health. Toxic responses include dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development and endocrine functions. Of the 17 congeners, the most toxic, and widely studied, congener is 2,3,7,8-TCDD. Increasing substitution from 4 to 8 chlorine atoms generally results in a marked decrease in potency.

Toxic equivalents

In environmental media, the PCDDs and PCDFs occur as complex mixtures of congeners. To enable a complex, multivariate dataset to be reduced to a single number, a system of toxic equivalents (TEQs) has been developed. The toxic equivalents method is based on the available toxicological and *in vitro* biological data, and knowledge of structural similarities among the PCDDs and PCDFs, to generate a set of weighting factors, each of which expresses the toxicity of a particular PCDD or PCDF congener in terms of an equivalent amount of 2,3,7,8-TCDD. Multiplication of the concentration of a PCDD or PCDF congener by this toxic equivalents factor (TEF) gives a corresponding 2,3,7,8-TCDD TEQ concentration. The toxicity of any mixture of PCDDs and PCDFs, expressed as 2,3,7,8-TCDD, is derived by summation of the individual TEQ concentrations. This is reported as the 'Total TEQ' for a mixture.

Table 2.1 Homologues and congeners of PCDDs and PCDFs

Abbreviation	Homologue name	No. of possible congeners	No. of possible 2,3,7,8-chlorinated congeners
MCDD	Monochlorodibenzo-p-dioxin	2	0
DiCDD	Dichlorodibenzo-p-dioxin	10	0
TrCDD	Trichlorodibenzo-p-dioxin	14	0
TCDD	Tetrachlorodibenzo-p-dioxin	22	1
PeCDD	Pentachlorodibenzo-p-dioxin	14	1
HxCDD	Hexachlorodibenzo-p-dioxin	10	3
HpCDD	Heptachlorodibenzo-p-dioxin	2	1
OCDD	Octachlorodibenzo-p-dioxin	1	1
MCDF	Monochlorodibenzofuran	4	0
DiCDF	Dichlorodibenzofuran	16	0
TrCDF	Trichlorodibenzofuran	28	0
TCDF	Tetrachlorodibenzofuran	38	1
PeCDF	Pentachlorodibenzofuran	28	2
HxCDF	Hexachlorodibenzofuran	16	4
HpCDF	Heptachlorodibenzofuran	4	2
OCDF	Octachlorodibenzofuran	1	1

Although a number of toxic equivalents schemes have been developed, the most widely adopted system to date is that proposed by the North Atlantic Treaty Organisation, Committee on Challenges to Modern Society (NATO/CCMS), known as the International Toxic Equivalents Factor (I-TEF) scheme (Kutz *et al*., 1990). This approach assigns a TEF to each of the 17 toxic 2,3,7,8-chlorinated PCDDs and PCDFs (Table 2.2). The remaining non 2,3,7,8-chlorinated congeners are considered biologically inactive and are assigned a TEF of zero.

The I-TEF scheme has recently been revised and expanded through the auspices of the World Health Organisation (WHO) to provide TEF values for humans and wildlife (Van den Berg *et al*., 1998). Thus WHO-TEFs are now available for humans/mammals (Table 2.2), fish and birds[1].

Sources

PCDDs and PCDFs are not produced intentionally, but are released to the environment from a variety of industrial discharges, combustion processes and as a result of their occurrence as unwanted by-products in various chlorinated chemical formulations.

Historically the manufacture and use of chlorinated aromatic chemicals have been major sources of PCDDs and PCDFs in the environment. Most notable examples include the wood preservative and biocide PCP, 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) and the PCBs.

Other processes, such as the manufacture of chlorine-bleached pulp, have led to environmental contamination by PCDDs and PCDFs, as well as the trace contamination of pulp and paper products.

[1] The PCDD and PCDF TEQ data given in this report have been calculated using the I-TEFs, since most comparative literature data also use this scheme to report TEQ results. However, all PCDD and PCDF concentrations are tabulated, allowing the reader to recalculate the total TEQ concentration for any sample using the new WHO-TEF values (Van den Berg *et al*., 1998).

Table 2.2 Toxic equivalents factors for PCDDs and PCDFs

PCDD and PCDF congener	I-TEF (Kutz *et al*., 1990)	WHO-TEF (humans/mammals) (Van den Berg *et al*., 1998)
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	0.5	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.001	0.0001
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PeCDF	0.05	0.05
2,3,4,7,8-PeCDF	0.5	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.001	0.0001

Combustion processes are recognised as being another important source of PCDDs and PCDFs. Most thermal reactions which involve the burning of chlorinated organic or inorganic compounds appear to result in the formation of these substances. PCDDs and PCDFs have been detected in emissions from the incineration of various types of wastes, particularly municipal, medical and hazardous wastes, from the production of iron and steel and other metals, including scrap metal reclamation, from fossil fuel plants, domestic coal and wood fires, and automobile engines (especially when using leaded fuels) as well as accidental fires. An extensive review of PCDD and PCDF sources has been published by Fiedler *et al*., (1990), and more recently by the United States Environmental Protection Agency (US EPA, 1998).

Although natural, non-anthropogenic, combustion sources (like forest fires) have probably always been a source of PCDDs and PCDFs, the background levels associated with the pre-industrial processes (before the 1930s/1940s) are found to be negligible when compared to those resulting from more recent industrial activities (Kjeller *et al*., 1991; Beurskens *et al*., 1993; Jones and Alcock, 1996).

Tighter Government regulations, improved industrial processes and the use of modern pollution control equipment have resulted in a lowering of PCDD and PCDF emissions from known industrial sources in many countries. However, it is unlikely that a complete elimination of these contaminants will be possible due to uncontrolled releases, such as forest fires and other accidental fires.

2.2 Polychlorinated biphenyls

The PCBs were commercial products prepared industrially by the chlorination of biphenyl. The commercial preparations were graded and marketed according to their chlorine content, for example Aroclor 1232 contains 32% by weight of chlorine and Aroclor 1260 contains 60% by weight of chlorine.

PCBs comprise 209 congeners. The basic aromatic biphenyl nucleus is shown in Figure 2.2, and the distribution of PCB congeners arising from the attachment of chlorine atoms to this nucleus is given in Table 2.3.

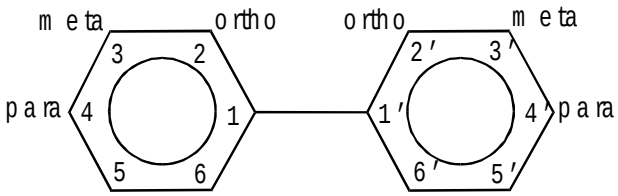


Figure 2.2 Structure of biphenyl

Table 2.3 Distribution of PCB congeners

No. of Cl substituents	Cl_1	Cl_2	Cl_3	Cl_4	Cl_5	Cl_6	Cl_7	Cl_8	Cl_9	Cl_{10}
No. of congeners	3	12	24	42	46	42	24	12	3	1

Toxicity and toxic equivalents

As with the PCDDs and PCDFs, the biologic and toxic effects of PCBs are highly dependent both on the degree of chlorination and on the position of the chlorine atoms (i.e. whether they are *ortho*, *meta* or *para* to the phenyl-phenyl bridge at carbon-1). To account for the varying toxicity of the PCB congeners, the WHO-European Centre for Environmental Health (WHO-ECEH) and the International Programme on Chemical Safety (IPCS) have developed a suite of TEFs for 'dioxin-like' PCBs (Table 2.4) (Ahlborg *et al*., 1994). These TEFs, which are applied in a manner identical to the I-TEFs developed for the PCDDs and PCDFs, embrace those PCBs that bind to the Ah-receptor and elicit dioxin-specific biochemical and toxic responses. The WHO has recently revised and expanded these TEFs (Van den Berg *et al*., 1998) to include TEFs for humans/mammals (Table 2.4) as well as fish and birds[2].

PCBs also exhibit 'non-dioxin-like' toxicity in which the toxic effects are not mediated through the Ah-receptor (Safe and Hutzinger, 1987; Safe, 1994). These effects include cancer promotion, endocrine disruption and neuro-behavioural toxicity. Importantly, the TEF concept developed for the PCDDs and PCDFs and the 'dioxin-like' PCBs cannot be applied to 'non-dioxin-like' effects that are not Ah-receptor mediated.

[2] The PCB TEQ data given in this report have been calculated using the 1994 WHO-TEFs. However, all PCB concentrations are tabulated, allowing the reader to recalculate the total TEQ concentration for any sample using the revised WHO-TEF values (Van den Berg *et al*., 1998).

Table 2.4 Toxic equivalents factors for PCBs

Type	Congener		WHO/IPCS TEF (Ahlborg *et al.*, 1994)	WHO-TEF (humans/mammals) (Van den Berg *et al.*, 1998)
	IUPAC No.	Structure		
Non-*ortho*	PCB #81	3,4,4',5-TCB		0.0001
	PCB #77	3,3',4,4'-TCB	0.0005	0.0001
	PCB #126	3,3',4,4',5-PeCB	0.1	0.1
	PCB #169	3,3',4,4',5,5'-HxCB	0.01	0.01
Mono-*ortho*	PCB #105	2,3,3',4,4'-PeCB	0.0001	0.0001
	PCB #114	2,3,4,4',5-PeCB	0.0005	0.0005
	PCB #118	2,3',4,4',5-PeCB	0.0001	0.0001
	PCB #123	2',3,4,4',5-PeCB	0.0001	0.0001
	PCB #156	2,3,3',4,4',5-HxCB	0.0005	0.0005
	PCB #157	2,3,3',4,4',5'-HxCB	0.0005	0.0005
	PCB #167	2,3',4,4',5,5'-HxCB	0.00001	0.00001
	PCB #189	2,3,3',4,4',5,5',-HpCB	0.0001	0.0001
Di-*ortho*	PCB #170	2,2',3,3',4,4',5-HpCB	0.0001	
	PCB #180	2,2',3,4,4',5,5'-HpCB	0.00001	

Historical uses of PCBs

PCBs have been widely used in industry as heat transfer fluids, hydraulic fluids, solvent extenders, flame retardants and dielectric fluids (Waid, 1986). The unusual industrial versatility of PCBs is directly related to their chemical and physical properties which include resistance to acids and bases, compatibility with organic materials, resistance to oxidation and reduction, excellent electrical insulating properties, thermal stability and nonflammability.

The widespread use of PCBs, coupled with industrial accidents and improper disposal practices, has resulted in significant environmental contamination by these substances in many northern hemisphere countries.

3 Organochlorines in New Zealand

3.1 PCDDs and PCDFs

No rigorous estimate has ever been made of the total emissions of PCDDs and PCDFs to the New Zealand environment. However, an inventory of emissions to air, land and water is currently being undertaken as a component of the Organochlorines Programme.

Historic releases of PCDDs and PCDFs to the environment are thought to have resulted from the manufacture and use of the herbicide 2,4,5-T, the use of PCP in the timber industry and from spillages and other accidental releases of PCBs. 2,4,5-T was used in New Zealand for the control of gorse, blackberry and other woody weeds. In the 1980s there were a number of investigations into the effects of the manufacture and use of 2,4,5-T in this country, in part due to concerns relating to the presence of 2,3,7,8-TCDD as a microcontaminant of this herbicide (Coster *et al*., 1986; Brinkman *et al*., 1986; Ministry for the Environment, 1989). The manufacture of 2,4,5-T in New Zealand ceased in 1987, although some stocks remained which were likely to have been used after this date.

PCP was used in New Zealand primarily in the timber industry, but also to a relatively minor extent by the pulp and paper industry and the tanning industry, in mushroom culture and in home gardens. Its use (as sodium pentachlorophenate) in the timber industry was for the control of sapstain fungi in freshly cut timber. PCP in oil was also used in lesser amounts as a timber preservative. These historical activities, involving the use in the order of 5,000 tonnes of PCP, have resulted in the contamination of a number of sites throughout the country (Ellis, 1997, and references therein).

Two large bleach kraft pulp mills operate in the central North Island. These mills have historically used elemental chlorine in the bleach plant, although the concentrations of PCDDs and PCDFs in effluent discharges to receiving waters, and in pulp sludges, were low compared to contamination concentrations that have been reported in North America (NCASI, 1990). The use of elemental chlorine at both these mills has now been superseded by bleaching sequences based on chlorine dioxide following oxygen delignification.

There are no municipal waste incinerators in New Zealand. In the last decade, a number of smaller hospital waste incinerators have closed. However, there are still currently operating approximately 30 incinerators around the country that burn a variety of medical, pathological, quarantine and animal wastes. With the exception of a limited number of these plants that burn in excess of 500 kg of waste per hour, these are primarily small units with an average throughput of approximately 100 - 200 kg per hour.

Other incineration facilities include a small sewage sludge incinerator, wood and coal boilers, and units burning wood processing and wood manufacturing wastes. The domestic burning of wood and coal is also expected to emit PCDDs and PCDFs to the environment, along with uncontrolled and accidental fires.

PCDD and PCDF emissions will arise from a number of metallurgical plants, from cement kilns (predominantly from two major plants, including one kiln that burns waste oil as an auxiliary fuel) and from a single (small) hazardous waste incinerator that operates in New Zealand.

Leaded petrol, which has been associated with PCDD and PCDF emissions due to the use of ethylene dichloride and ethylene dibromide as scavengers for the lead in exhaust, has largely been phased out in New Zealand. Unleaded (91 octane) regular petrol was introduced in 1986, and in early 1996, premium (96 octane) petrol was changed to an unleaded formulation. A small amount of leaded fuel is still used for piston-engined aeroplanes and for specialist motor racing.

The major historical and current inputs of PCDDs and PCDFs to the New Zealand environment is given in Table 3.1.

Table 3.1 New Zealand sources of PCDDs and PCDFs

Historical inputs

Source	*PCDD/PCDF contaminant*
Agrichemicals from the use of 2,4,5-T	2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)
Timber treatment from the use of PCP	Primarily the more highly chlorinated PCDDs and PCDFs
Electricity industry from the use of PCBs	Primarily PCDFs, but also PCDDs if chlorobenzenes present
Pulp and paper (chlorine bleach process)	Primarily TCDFs
Combustion of fuels and incineration of wastes	Broad range of PCDDs and PCDFs
Motor vehicles (particularly from leaded fuels)	Broad range of PCDDs and PCDFs

Current inputs include

- Waste incineration, including medical and hazardous waste;
- Metallurgical industries, including metal smelting, refining and recycling;
- Industrial and domestic coal and wood combustion;
- Exhaust emissions from vehicles running on diesel and unleaded petrol;
- Controlled burn-offs;
- Uncontrolled and accidental fires;
- Sewage wastes;
- Ongoing releases from reservoirs, including sludge ponds and contaminated sites.

3.2 Polychlorinated biphenyls

Internationally, large-scale production of PCBs commenced in the 1930s for use in a variety of industrial applications. PCBs were never manufactured in New Zealand, but have been imported and used extensively in the electricity industry as insulating fluids or resins in transformers and capacitors. PCBs were also used in smaller quantities as heat transfer fluids, plasticisers, printing inks, flame retardants, paint additives, sealing liquids and immersion oils.

In March 1986, the New Zealand Customs Department placed a prohibition on importing PCBs, and later that year regulations to control the importation of PCBs were promulgated as an amendment to the Toxic Substances Regulations 1983. In 1988, a further amendment to the Toxic Substances Regulations 1983 prohibited the use and storage of PCBs with effect from 1 January 1994. Following two extensions, this regulation came into effect on 1 August 1995. A summary of the legislative status of PCBs in New Zealand is given in Table A1 (Appendix A).

Information relating to the quantity of PCBs imported into New Zealand is extremely limited, although some estimates have been made (OECD, 1987; Ministry for the Environment, 1988). Whilst the current holdings of PCBs are uncertain, more accurate assessments have been made of the quantity of PCBs that has been shipped overseas for destruction. These estimates put the

quantity of PCBs (including PCB contaminated material) exported from New Zealand since 1987 at approximately 1300 - 1600 tonnes (Ministry of Health, 1998).

3.3 Organochlorine pesticides

From the mid 1940s until the 1970s persistent organochlorine pesticides, including DDT, dieldrin and lindane, were used heavily in New Zealand. Although few records were kept of the volumes imported into the country, the most substantial quantities are likely to have been imported during the 1950s and 1960s. The main areas of use were agriculture, horticulture, timber treatment and public health (Table 3.2). Smaller amounts were also used for amenity purposes and in households.

Table 3.2 Summary of the historic usage of persistent organochlorine pesticides in New Zealand

Pesticide	Application
DDT	Used as a pasture insecticide to control grass grub (*Costelytra zealandia*) and porina (*Wiseana* sp.) caterpillars. Frequently mixed with fertiliser or lime and applied particularly to agriculture pastures, as well as lawns, market gardens and parks.
Lindane (γ-HCH)	Used as an insecticide in agriculture for the control of lice on cattle, ectoparasites (lice, keds and blowflies) in sheep and grass grub in pasture. Also used for insect control on vegetables and in orchards. Household use: flyspray, flea control, and carpet moth. Commercial hexachlorocyclohexane (HCH) was not officially used in New Zealand, although many dip sites show evidence of the use of crude HCH.
Aldrin and Dieldrin	Introduced in 1954 for use as stock remedies in sheep sprays or dips for controlling sheep ectoparasites. Aldrin was used to control horticultural pests such as wireworm, soldier fly and blackvine weevil, and in limited quantities to control household spiders. Dieldrin was used for controlling carrot rust fly, crickets and armyworm and was also used for timber preservation (mostly in plywood glues) and to mothproof carpets.
Chlordane	Broad spectrum agricultural insecticide, also used in the timber industry as a treatment against termites and borer, and as an insecticide in glues used for the manufacture of plywood, finger jointed and laminated timber.
Hexachlorobenzene (HCB)	Used experimentally between 1970 and 1972 as a seed dressing fungicide for cereal grain.
Heptachlor, Endrin and Toxaphene	Only small amounts of these pesticides were ever used in New Zealand. [Endrin and toxaphene were not included in the New Zealand survey].
PCP	In the order of 5,000 tonnes of PCP is estimated to have been used in the New Zealand timber industry over a 35 to 40 year period as an antisapstain (fungicidal) treatment for freshly cut timber (mainly *Pinus radiata*). Its use in the timber industry ceased in 1988. PCP was also used to a relatively minor extent by the pulp and paper industry and the tanning industry, in mushroom culture in home gardens and on roofs to control moss and algae.

The use of pesticides in New Zealand was not subject to compulsory regulatory control until the Agricultural Chemicals Act 1959 established the Agricultural Chemicals Board. The use of persistent organochlorine pesticides was then progressively restricted by a succession of legislation, so that, by the mid 1970s their use had effectively ceased in agriculture and horticulture. All persistent organochlorine pesticides except PCP were formally deregistered[3] by the Pesticides Board in 1989, and PCP was deregistered in 1991.

[3] Importation, manufacture or sale prohibited, though existing stocks can be used.

A chronology of persistent organochlorine pesticides in New Zealand and a summary of relevant legislation are given in Table A2 (Appendix A).

3.4 Global transportation of organochlorines

Organochlorine emissions or use in other countries, and their global transportation, represent an additional and ongoing source of these contaminants to the New Zealand environment. Considerable research has taken place in the northern hemisphere on the transboundary transport and global redistribution of contaminants. Studies have also investigated the transport in air and water of contaminants from the northern to the southern hemisphere. These phenomena are particularly relevant to the transportation of organochlorines and their deposition in New Zealand. However, the significance of these inputs relative to 'local' sources of organochlorines is difficult to assess and quantify.

4 Project design

This study was designed to determine the level of selected organochlorine contaminants in the New Zealand terrestrial environment. To ensure wide geographical coverage, the country was divided into eight strata on the broad basis of climate and geology, whilst working generally within current geographical (Regional Council) boundaries. These strata are described in Table B1 (Appendix B).

Soil samples were collected from each of these strata on the basis of six land types, as shown in Table 4.1.

Table 4.1 Land types and sample numbers

Land type	Number of samples collected
Indigenous forest	7
Indigenous grassland	5
Pasture on hill country land	8
Pasture on flat land	8
Urban residential land in provincial centres	8
Urban residential/industrial land in metropolitan centres	15

A total of 51 primary soil samples were collected, along with 14 quality control samples. A summary of the sampling locations for each of the land types is outlined below. Further details on the project design and sample collection programme are provided in Appendix B.

4.1 Forest and grassland soils

Indigenous forest and indigenous grassland soils were taken from National Parks and Department of Conservation estate land in remote areas. For the purpose of this study, they were defined as 'reference sites'. Four forested and three grassland sites were sampled in the North Island, and three forested and two grassland sites were sampled in the South Island (Figure 4.1 and Table 4.2).

Table 4.2 Indigenous forest and indigenous grassland sampling locations

Island	Indigenous forest	Indigenous grassland
North Island	Waipoua Forest Pirongia Forest Park Whirinaki Forest Park Rimutaka Forest Park	Ruahine Forest Park Mount Egmont National Park Tararua Forest Park
South Island	Arthurs Pass National Park Paparoa National Park Catlins Forest Park	Nelson Lakes National Park Blue Mountains

Typically, for each sample, soil cores were taken at 150 m equidistant points along the sides of an equilateral triangle, with sides measuring 1.5 km in length (i.e. a total of 27 soil cores per sample).

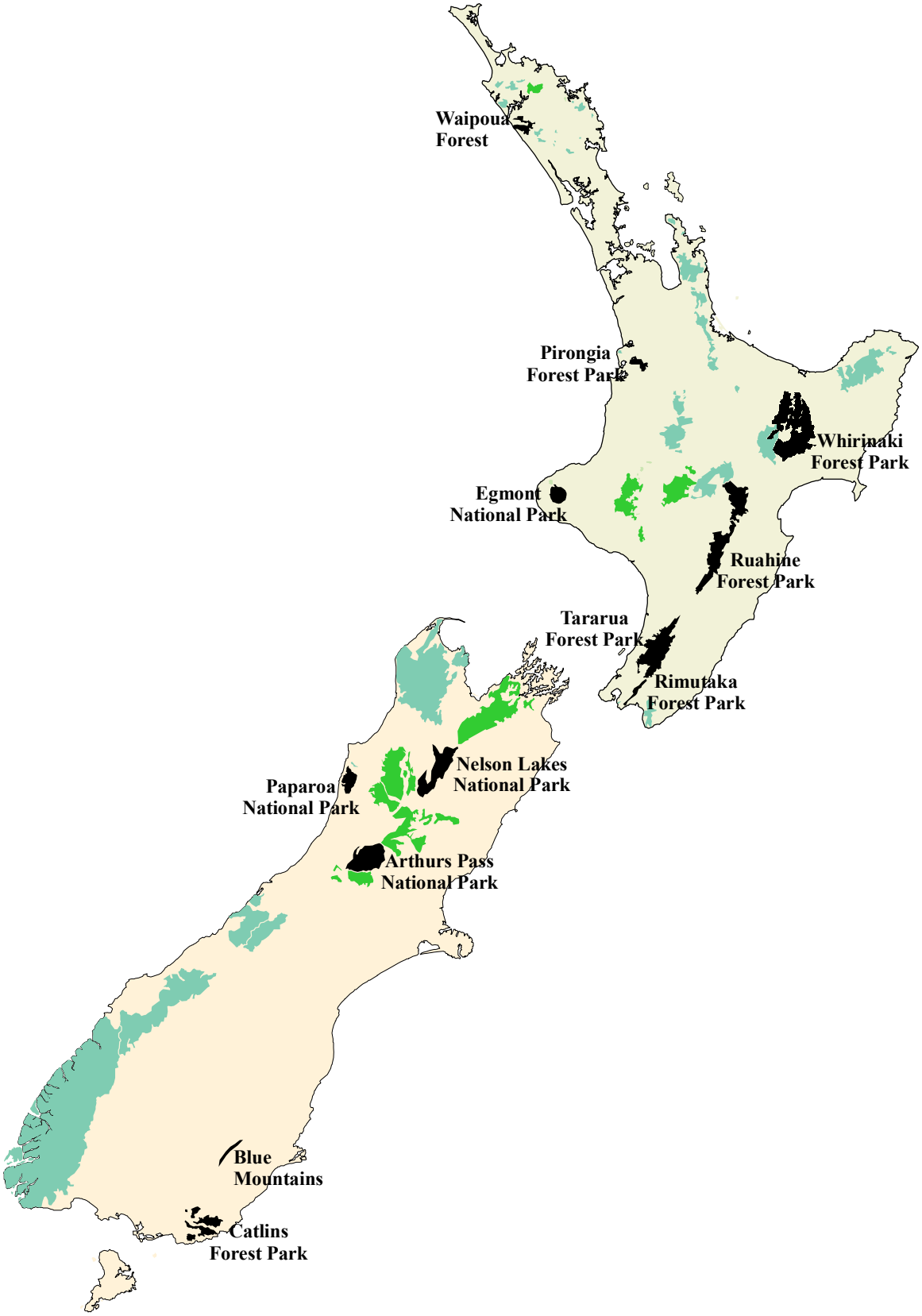


Figure 4.1 **Indigenous forest and indigenous grassland sampling locations**

Particular care was taken to ensure that samples were not collected from areas impacted by human activity. Sampling criteria included:

- no sample must be collected within 1 km of any road or track carrying motor vehicles, or within 1 km of any recreational area;
- any sampling point accessed from a walking track must be no closer than 40 m from the track.

4.2 Agricultural soils

Soils from agricultural environs were collected from both hill country and flat land pastoral land. Typically, these were dairy, beef or sheep farms. One sample of each land type was collected from each of the eight strata (a total of 16 samples). Within each stratum, each sample consisted of 54 soil cores collected from two randomly selected 'sampling stations' (27 cores per sampling station). Sampling stations were based on an equilateral triangle with sides measuring 1.5 km in length. Sampling criteria applied were:

- each sampling station was restricted to a single farm property;
- no samples to be collected within 1 km of a major state highway, 500 m of a secondary sealed road or 200 m of an unsealed road;
- no soil cores to be collected within 5 m of any wooden building or structure (such as fences or telegraph poles) to avoid any possible contamination from treated timbers.

4.3 Provincial and metropolitan centre soils

Eight soil samples were collected from eight provincial centres (one sample per stratum), and 15 soils were collected from two major metropolitan centres, Auckland (9 soils) and Christchurch (6 soils) (Figure 4.2). For each provincial centre, the sample was a composite of soil cores collected from four parks and reserves (Table 4.3). Nine cores were collected from each park or reserve using a 3 by 3 grid, with the spacing between the individual cores dependent upon the size of the park. Ideally a 50 m spacing was set between each core, but for smaller parks and reserves where this was not possible, no cores were closer than 25 m to each other. No cores were taken closer than 10 m from any park boundary, fence line or building.

Table 4.3 Provincial centre sampling locations

Provincial centre	Parks and reserves
Whangarei	Tarewa Park; Onerahi Domain; Beazley Park; Barge Park
Hamilton	Fairfield Park; Hayes Paddock; Lake Domain; Minogue Park
Napier	Botanical Gardens; Clive Square Memorial Park; Marine Parade Gardens; Kennedy Park Rose Garden
New Plymouth	Mt Moturoa Domain; Churchill Heights, Western Park; Marsland Hill; Brooklands Park
Masterton	Cameron and Soldiers Memorial Park; South Park; Douglas Park; Oxford Street Reserve
Timaru	Maori Park; Gleniti Park; West End Park; Alexandra Square
Greymouth	Karoro Domain; McLean Domain; Dixon Park; Greymouth Recreation Ground
Invercargill	Queens Park; Otakaro Park; Elizabeth Park; Russell Square

Figure 4.2 Provincial centre and metropolitan centre sampling locations

Samples from Auckland and Christchurch were collected from throughout the metropolitan centre. To ensure that the sampling programme covered a variety of urban locations and land uses within both centres, samples were collected from areas that could be described as either predominantly residential or commercial/light industrial.[4]

Each sample was again a composite of cores collected from typically four parks or reserves (Table 4.4). Twelve cores were collected using a 4 by 3 grid with ideally a 50 m spacing between each core, but no less than 25 m. Again, no cores were taken closer than 10 m from any park boundary, fence line or building.

Table 4.4 Metropolitan centre sampling locations

Metropolitan centre	Parks and reserves
Auckland	
North Shore City[1]	Mt Victoria; Stancich Reserve; Kauri Point Domain; Wainoni Park
North Shore City[1]	Eskdale Reserve; Normanton Reserve; Manuka Reserve; Centennial Park
Western[1]	Western Park; Point Erin Park; Blockhouse Bay Road Recreation Reserve; Craigavon Park
Mt Eden/Mt Roskill[1]	Manukau Domain; Potters Park; Melville Park
Tamaki/Maungakiekie[1]	Jellicoe Park; Hamlin Park; Mt Wellington War Memorial Park
Western and Tamaki/Maungakiekie[2]	Western Springs; One Tree Hill Domain; Murphy Park; Meloa Park
Hobson/Eastern Bays[1]	Point England Reserve; Glover Park; Waiatarua Reserve; M.J. Savage Memorial Park
Hobson/Eastern Bays[2]	Merton Park; Dove Myer Robinson Park; Auckland Domain
Manukau City[1]	Vine Street Reserve; Old School Site, Kirkbride Road; Mangere Domain; Waterlea Park
Christchurch City	
Merivale/Shirley[1]	Elmwood Park; Malvern Park; MacFarlane Park; Richmond Park; St James Park
City/Woolston[2]	Latimer Square; Edmonds Park; Palinurus Road
Spreydon/Halswell[1]	Simeon and Addington School; Barrington Park; Hoon Hay Park; Halswell Domain
Hornby/Birmingham Drive[2]	Goulding Ave; Leslie St; Hornby High School; Marylands Place
Avonhead/Burnside[1]	Crosbie Park; Burnside Park; Grant Armstrong Park; Nunweek Hockey Field
Port Hills[3]	Victoria; Bowenvale; Mt Vernon; Mt Pleasant

[1] Residential.
[2] Commercial/light industrial.
[3] Rural area on outskirts of Christchurch.

4.4 Collection of soil samples

Each soil sample collected was made up as a composite of a large number of individual surface soil cores. Each soil core was 25 mm in diameter and taken to a depth of 100 mm using a stainless steel soil corer. Grass over the sampling area was trimmed to ground level, and stones and all

[4] There are no areas of heavy industry in Auckland or Christchurch that are on a scale frequently found in major European or North American cities.

overlaying fresh or weakly decomposed organic matter (leaves and twigs etc.) were removed prior to sampling. Well decomposed litter, often mixed with mineral matter, was collected together with the underlying mineral A horizon.

All samples were collected in accordance with the study quality assurance project plan. Particular care was taken to avoid any possible contamination of the sample. Procedures included:

- no contact of the sample with plastic material;
- minimising any direct contact of the sample during the sampling processes with any item other than the soil corer;
- avoiding any exposure of the samples once collected with any materials other than the sampling containers;
- rigorous cleaning procedure of the soil corer and other sampling items between the collection of soil cores from different sampling locations or parks and reserves.

Quality control samples consisting of blind duplicates (6 samples), field blanks (6 samples) and equipment field rinsate blanks (2 samples) were collected. Relevant sampling information was recorded on a field log.

Details of the sampling programme and field log information are given in Appendix B.

4.5 Chemical analysis

All indigenous forest, indigenous grassland, provincial centre and metropolitan centre samples were analysed for the following organochlorine contaminants:

PCDDs and PCDFs. All 2,3,7,8-chlorinated congeners were determined congener-specifically. Total concentrations for non 2,3,7,8-PCDDs and PCDFs for each homologue group were also determined. Total TEQs were calculated, both excluding limit of detection (LOD) values and including half LOD values, using the I-TEFs (Table 2.2).

PCBs. 25 PCB congeners[5] were determined, (PCB #77, #126, #169, #28 + #31, #52, #101, #99, #123, #118, #114, #105, #153, #138, #167, #156, #157, #187, #183, #180, #170, #189, #202, #194, #206). PCB TEQs were calculated, both excluding LOD values and including half LOD values, using the 1994 WHO-TEFs (Table 2.4).

Pesticides. Hexachlorocyclohexanes (α-, β- and γ-HCH), hexachlorobenzene (HCB), aldrin, dieldrin, heptachlor, chlordanes (α- and γ-isomers), op'-DDT and pp'-DDT were determined, along with the pesticide degradation products, heptachlor epoxide, pp'-DDE and pp'-TDE (also known as pp'-DDD).

Chlorophenols. 2,4,6-trichlorophenol (TCP), 2,3,5-TCP, 2,4,5-TCP, 2,3,6-TCP, 2,3,4-TCP, 2,3,5,6-tetrachlorophenol (TeCP), 2,3,4,6-TeCP, 2,3,4,5-TeCP and PCP were determined.

Soils from hill country and flat land pastoral sites were analysed for PCDDs, PCDFs, PCBs and chlorophenols. These samples were not analysed for organochlorine pesticides as it was considered that the sampling programme was not sufficiently robust (i.e. had insufficient sampling points) to provide accurate and representative contaminant data for agricultural soils where an organochlorine (e.g. DDT) might have been intentionally applied to the land.

[5] PCB numbering by Ballschmiter and Zell (1980)

A fully homogeneous composite sample was prepared from the individual soil cores by cone and quartering. Samples were sieved to 2 mm size, and the • 2 mm portion was analysed. Percentage extraneous matter (material > 2 mm size) was determined gravimetrically.

The analysis was undertaken on field moist material. Quantification for PCDDs PCDFs, PCBs and organochlorine pesticides was by ^{13}C isotope dilution using capillary gas chromatography-high resolution mass spectrometry (GCMS). All data reported are corrected for recovery of ^{13}C surrogate standards. Chlorophenols were quantified using capillary gas chromatography with electron capture detection.

Full details of the sample preparation and analytical procedures are given in Appendix C.

4.6 Statistical analysis

Because environmental residue data of the type collected in this study are typically non-Gaussian, all statistical analyses were conducted using non-parametric methods. All statistical and graphical procedures were performed using the SYSTAT package (Wilkinson, 1996).

5 Organochlorine concentrations in New Zealand soils

A summary of organochlorine concentrations, including data for PCDDs, PCDFs and PCBs, and organochlorine pesticides (or their degradation products) determined in forest, grassland, agricultural, provincial and metropolitan soils is given in Table 5.1. Median and mean[6] results are reported for:

- sum of PCDDs and PCDFs, and I-TEQ;
- sum of PCBs and PCB TEQ;
- organochlorine pesticides, including γ-HCH, HCB, dieldrin, α-and γ-chlordane, and DDT residues;
- PCP.

Throughout this report, all concentration data is reported on a weight per dry soil weight basis unless otherwise specified.

Concentrations of PCDDs and PCDFs (including half LOD values for non-detectable congeners) were typically in the range 0.17 - 1.99 ng I-TEQ kg^{-1} (forest and grassland soils), 0.17 - 0.90 ng I-TEQ kg^{-1} (agricultural soils) and 0.52 - 6.67 ng I-TEQ kg^{-1} (urban soils in provincial and metropolitan centres). Exclusion of LOD values for non-detectable congeners resulted in noticeably lower TEQ levels, typically 0 - 0.50 ng I-TEQ kg^{-1} (forest and grassland soils), 0 - 0.18 ng I-TEQ kg^{-1} (agricultural soils) and 0.081 - 5.04 ng I-TEQ kg^{-1} (urban soils in provincial and metropolitan centres). Two samples (the hill country pastoral soil from Northland and one park – Mt Moturoa Domain – from New Plymouth) were found to have elevated concentrations of 2,3,7,8-TCDD, which could be associated with the manufacture and use of the herbicide 2,4,5-T.

The sum of PCDD and PCDF concentrations were in the range 17.1 - 306 ng kg^{-1} (forest and grassland soils), 13.1 - 372 ng kg^{-1} (agricultural soils) and 50.6 - 2850 ng kg^{-1} (urban soils in provincial and metropolitan centres). For all land types, the more highly chlorinated PCDD congeners were the most abundant and most frequently detected of the PCDDs and PCDFs. On average, 1,2,3,4,6,7,8-HpCDD and OCDD contributed 75% or more of the total I-TEQ level determined when half LOD values were excluded from the TEQ calculation.

No PCB congeners were measured in most grassland or agricultural soils. A limited number of congeners were found in urban soils, giving PCB concentrations (including half LOD values) of 0.067 - 0.23 ng TEQ kg^{-1} dry weight (provincial centre soils) and 0.087 - 1.33 ng TEQ kg^{-1} (metropolitan centre soils). The most frequently detected and abundant PCB congeners found in provincial and metropolitan centre soils were PCB #153 and #138.

[6] A mean concentration for each land type has been calculated only if the organochlorine contaminant was determined in more than two thirds of the samples analysed (i.e. on 66% or more of occasions). The rationale for this was that, if the contaminant was not frequently quantified in the samples, the mean value determined might not be truly representative of the entire data set, yet it could be misinterpreted as representing a 'national average' for New Zealand.

Table 5.1 Summary of PCDD, PCDF, PCB, organochlorine pesticide and PCP concentrations in New Zealand soils[1,2]

Organochlorine	Indigenous forest (n=7)		Indigenous grassland (n=5)		Hill country pasture (n=8)[3]		Flat land pasture (n=8)		Provincial centre (n=8)[3]		Metropolitan centre Auckland (n=9)		Metropolitan centre Christchurch (n=6)	
	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean
PCDDs and PCDFs														
Sum of PCDD/Fs[4]	111	152	67.0	69.9	43.0	44.2	62.3	95.3	239	435	430	781	195	274
Sum of PCDD/Fs[5]	105	143	63.5	54.4	16.1	27.4	56.9	87.9	235	431	411	774	192	271
Total I-TEQ[4]	1.26	1.06	0.72	0.64	0.58	0.56	0.54	0.52	1.05	1.50	1.76	2.46	0.79	0.90
Total I-TEQ[5]	0.095	0.21	0.078	0.058	0	0.032	0.021	0.037	0.36	0.93	0.65	1.23	0.30	0.41
PCBs														
Sum of PCBs[4]	0.24	0.42	0.16	0.18	0.15	0.15	0.20	0.22	1.94	1.90	1.83	2.72	1.49	2.54
Sum of PCBs[5]	0	0.25	0	0	0	0	0	0.045	1.82	1.79	1.72	2.61	1.37	2.43
Total PCB TEQ[4]	0.10	0.11	0.066	0.11	0.068	0.078	0.075	0.089	0.16	0.16	0.26	0.37	0.17	0.26
Total PCB TEQ[5]	0	0.0074	0	0	0	0	0	0.00043	0.046	0.042	0.046	0.19	0.022	0.058
Pesticides														
α-HCH	< 0.02	nc	< 0.01	nc	na	na	na	na	< 0.01	nc	< 0.01	nc	< 0.01	nc
β-HCH	< 0.01	nc	< 0.01	nc	na	na	na	na	< 0.01	nc	< 0.01	nc	< 0.03	nc
γ-HCH	< 0.02	nc	< 0.02	nc	na	na	na	na	< 0.02	nc	< 0.04	nc	< 0.04	nc
HCB	0.15	0.16	0.074	0.11	na	na	na	na	< 0.04	nc	0.10	0.21	0.084	0.085
Aldrin	< 0.01	nc	< 0.01	nc	na	na	na	na	< 0.02	nc	< 0.02	nc	< 0.02	nc
Dieldrin	0.24	nc	0.23	0.27	na	na	na	na	0.41	0.61	0.69	5.57	1.44	1.31
Heptachlor	< 0.03	nc	< 0.01	nc	na	na	na	na	< 0.01	nc	< 0.02	nc	< 0.01	nc
Heptachlor epoxide	< 0.01	nc	< 0.02	nc	na	na	na	na	< 0.01	nc	< 0.03	nc	< 0.01	nc
α-Chlordane	< 0.03	nc	< 0.04	nc	na	na	na	na	< 0.03	nc	0.080	nc	< 0.04	nc
γ-Chlordane	< 0.02	nc	< 0.03	nc	na	na	na	na	< 0.03	nc	0.050	nc	< 0.03	nc
pp'-DDE	1.20	1.14	0.67	0.77	na	na	na	na	9.32	22.9	4.09	12.5	190	230
pp'-TDE	0.087	nc	0.13	0.15	na	na	na	na	1.52	4.71	0.48	0.95	4.38	5.30
op'-DDT	0.11	0.14	0.10	0.10	na	na	na	na	0.76	1.77	0.95	1.02	20.6	23.5
pp'-DDT	0.83	1.18	0.76	0.93	na	na	na	na	12.0	23.6	8.54	10.9	131	172
Chlorophenols														
PCP	< 1	nc	< 2	nc	< 0.7	nc	< 0.7	nc	< 1	nc	< 0.7	nc	< 0.6	nc

1. For the sum of PCDD/Fs, I-TEQ and PCB TEQ, units are ng kg^{-1}, dry weight basis.
2. For the sum of PCBs and all pesticide and PCP concentrations, units are μg kg^{-1}, dry weight basis.
3. For sum of PCDD/Fs and Total I-TEQ, mean result excludes outlier for hill country pasture (Northland) and provincial centre (Mt Moturoa Domain, New Plymouth) soils.
4. Includes half LOD values for non-detected congeners.
5. Excludes half LOD values for non-detected congeners.

na = Not analysed (see Section 4.5)
nc = Not calculated (detected on fewer than 66% of occasions).

Contaminant concentration data

Comprehensive contaminant concentration data for PCDDs, PCDFs, PCBs, organochlorine pesticides and chlorophenols in indigenous forest and indigenous grassland soils, agricultural soils and provincial and metropolitan urban soils are reported in:

Appendix D	PCDDs and PCDFs
Appendix E	PCBs
Appendix F	Organochlorine pesticides
Appendix G	Chlorophenols

Supporting quality assurance (QA) data from the analysis of blind duplicate samples, field blanks, equipment rinsate blanks and split quality control (QC) samples are also provided in the relevant appendices.

A Microsoft Access database holding all analytical results and relevant associated sampling information on this environmental survey and a users manual (Microsoft Word) detailing the structure and operational (data search and processing) aspects of this database are available from the Ministry for the Environment's website (http://www.mfe.govt.nz/issues/waste/organo.htm).

The Organochlorines Programme Environmental Survey database contains the following information:

- concentration data for PCDDs, PCDFs, PCBs, organochlorine pesticides and chlorophenols in all composite soil samples analysed;
- concentration data for PCDDs, PCDFs, PCBs, organochlorine pesticides and chlorophenols in split QC soil samples analysed by a second independent cross-check laboratory;
- results of all laboratory quality control samples, including replicate analyses of a control soil, matrix spikes and laboratory blanks;
- surrogate standard recoveries for all soils and laboratory quality control samples analysed;
- results of analyses for percentage extraneous matter, total organic carbon and soil moisture content;
- field sampling parameters, including sampling dates, grid references and soil type.

Organochlorine pesticides were analysed only in forest and grassland soils, and in soils from provincial and metropolitan centres. The most frequently detected pesticides were HCB and dieldrin, along with DDT residues, including degradation products of DDT. Aldrin, heptachlor and HCH isomers were never found in forest and grassland soils, and were rarely quantified in soils collected from provincial and metropolitan centres.

HCB, dieldrin and chlordane were more frequently detected in urban New Zealand soils. These pesticides were measured in the range < 0.04 - 1.22 $\mu g\ kg^{-1}$ (HCB), 0.15 - 42.1 $\mu g\ kg^{-1}$ (dieldrin) and < 0.01 - 1.72 $\mu g\ kg^{-1}$ (γ-chlordane). DDT residues were measured in urban soils over a broad range of concentrations, For provincial centres, concentrations of pp'-DDT were typically at or below 15 $\mu g\ kg^{-1}$, with a maximum concentration of 121 $\mu g\ kg^{-1}$. Auckland soil DDT concentrations were generally comparable to provincial centre soils, whilst Christchurch soil DDT concentrations were consistently higher, in the range 78.8 - 340 $\mu g\ kg^{-1}$.

Hill country and flat land pastoral soils were not analysed for organochlorine pesticide residues, as it was considered that the sampling programme was not sufficiently robust (i.e. had insufficient sampling points) to provide accurate and representative contaminant data for agricultural soils where an organochlorine (e.g. DDT) might have been intentionally applied to the land.

Chlorophenols were quantified in only six of the 51 soils analysed. Three forest soils contained 2,4,6-trichlorophenol to a maximum concentration of 8.2 μg kg^{-1}, one hill country pasture sample contained 2,4,5-trichlorophenol at a concentration of 10.1 μg kg^{-1}, and one provincial centre soil and one metropolitan centre soil had PCP residue concentrations of 2.1 μg kg^{-1} and 0.95 μg kg^{-1} respectively. No other forest, grassland, agricultural or urban soils had quantifiable levels of these or other chlorophenol residues analysed.

Because the organochlorine contaminant concentration data in New Zealand soils have been obtained for a variety of land types on the basis of an extensive and exact nation-wide sampling programme, it is reasonable to conclude that the concentrations of organochlorines measured in the forest, grassland and agricultural soils reflect typical country-wide concentrations for these environs. Similarly, the provincial and metropolitan centre data represent the concentrations of these contaminants that might typically be expected to be found in urban areas in New Zealand. However, because hill country and flat land soils were not analysed for organochlorine pesticide residues, it is not possible from this study to draw any conclusions on the extent of pesticide contamination of agricultural land in New Zealand.

5.1 PCDDs and PCDFs

5.1.1 New Zealand PCDD and PCDF soil data

Generally low concentrations of PCDDs and PCDFs were determined in all soils analysed (Tables 5.1 and 5.2, and Appendix D). For the forest, grassland and agricultural soils, concentrations determined were typically below 0.2 ng I-TEQ kg^{-1} when half LOD values were excluded, although this I-TEQ level increased markedly when half LOD values were included for non-detected PCDD and PCDF congeners. The incorporation of half LOD values for non-detected congeners also had a noticeable effect on I-TEQ levels for the provincial and metropolitan centre soils.

Table 5.2 Concentrations of PCDDs and PCDFs in New Zealand soils

Land type	Sum of PCDDs and PCDFs[1] (ng kg^{-1} DW)		PCDD and PCDF I-TEQ[1] (ng I-TEQ kg^{-1} DW)	
	Min.	Max.	Min.	Max.
Indigenous forest	17.1	306	0.17	1.99
Indigenous grassland	26.9	101	0.35	0.85
Hill country pasture	13.1	121	0.37	0.90 (9.14)[2]
Flat land pasture	15.8	372	0.17	0.74
Provincial centre	71.2	1200	0.72	3.73 (33.0)[2]
Metropolitan centre	50.6	2850	0.26	6.67

[1] Includes half LOD values for non-detected congeners.
[2] Single outlier in parenthesis.

The sum of PCDD and PCDF congener concentrations were generally at similar levels for the grassland and agricultural soils (Tables 5.1 and 5.2, and Figure 5.1). For the forest sites, slightly higher concentrations were found. This observation is consistent with earlier reports on higher PCDD and PCDF concentrations in forest soils compared to agricultural soils (Rotard *et al.*, 1994; Weiss *et al*., 1993). The sum of PCDD and PCDF concentrations for the provincial centre and metropolitan centre soils were also noticeably higher than the concentrations measured in the forest, grassland and agricultural soils (Figure 5.1).

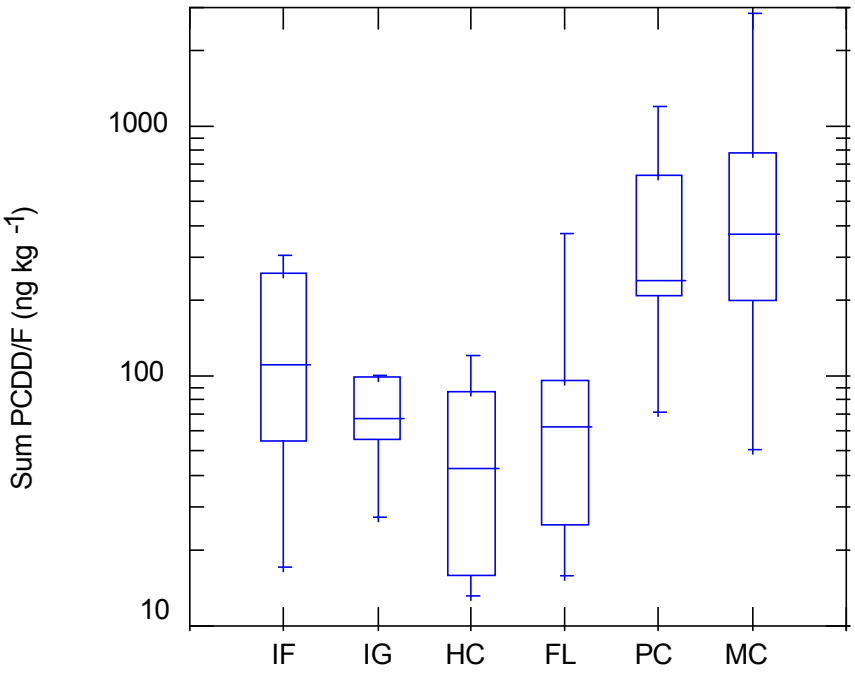


Figure 5.1 Box plot for sum of PCDD and PCDF concentrations in New Zealand soils
[IF = Indigenous forest; IG = indigenous grassland; HC = hill country pasture; FL = flat land pasture; PC = provincial centre; MC = metropolitan centre. Data include half LOD values for non-detected congeners].
In a box plot, the centre horizontal line represents the *median* of the sample data set. The edges of the box, called *hinges*, mark the first and third quartiles. The median splits the ordered data set in half, and the hinges split the remaining halves in half again, such that the central 50% of the data set falls within the range of the box. The *Hspread* is the absolute value of the difference between the values of the two hinges. The *whiskers* show the range of values that fall within 1.5 Hspreads of the hinges. *Outside values* and *far outside values* are plotted as asterisks and circles respectively.

This observation of higher PCDD and PCDF concentrations in urban soils compared with forest, grassland and rural soils is also evident when the data are presented as TEQ concentrations (Figure 5.2). The trend is observed regardless of whether or not half LOD values for non-detected PCDD and PCDF congeners are included in the calculation of the TEQ level.

In general, PCDD and PCDF concentrations in agricultural soils were extremely low, with a median contaminant concentration for hill country pasture of 0.58 ng I-TEQ kg^{-1} (including half LOD

values) and a median concentration for flat land pasture of 0.54 ng I-TEQ kg^{-1}. These results are consistent with the recent finding of low dietary exposures of the New Zealand population to PCDDs and PCDFs (Buckland *et al*., 1998b).

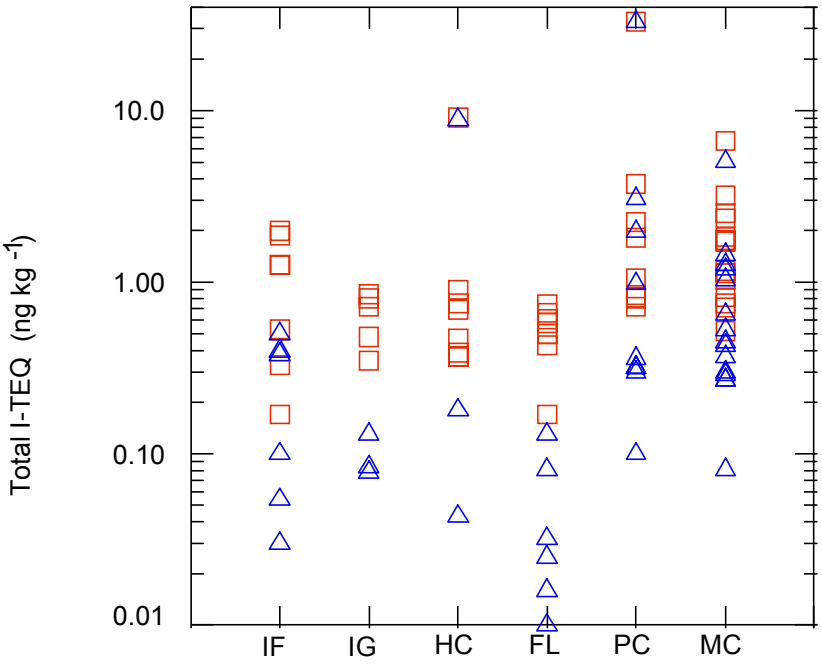


Figure 5.2 PCDD and PCDF I-TEQ concentrations in New Zealand soils
[Includes half LOD values, Δ excludes half LOD values. Zero I-TEQ results are not shown. Land codes are as given in Figure 5.1].

The Northland hill country pasture sample had a significantly elevated PCDD and PCDF concentration (9.14 ng I-TEQ kg^{-1}) compared to all other pastoral samples collected (Table D3, Appendix D). The profile of the contamination, arising predominantly from 2,3,7,8-TCDD, is characteristic of that which occurs from the herbicide 2,4,5-T. Historically, 2,4,5-T has been used on hill country pastoral land in New Zealand for the control of brush weeds (Coster *et al*., 1986). Although the manufacture of 2,4,5-T ceased in New Zealand in 1987, it is understood that many Northland farmers purchased stockpiles of the herbicide for gorse control. It is believed that currently there are still reasonable quantities of 2,4,5-T being used by farmers in the Northland region (Northland Regional Council, 1998). Of all the samples analysed in the current study, the Northland hill country pastoral soil was the only soil that contained measurable concentrations of 2,4,5-trichlorophenol, presumably from the hydrolysis of 2,4,5-T.

Whilst these data are consistent with the Northland contamination arising from 2,4,5-T, the intentional application of 2,4,5-T to the land, at recommended application rates, cannot account for the level of 2,3,7,8-TCDD contamination found. A possible alternative explanation that could explain the contamination observed is that some part of the sample (i.e. one or more of the soil cores) had been taken from an area where a 2,4,5-T concentrate or mixed formulation had been

diluted in preparation for land application, and that some spillage of the concentrate/formulation had occurred.

If this explanation is correct, it is likely that there will be other similar localised areas of soil contamination throughout the farming lands of New Zealand where 2,4,5-T was historically used. However, no other hill country pastoral soils collected in the current study had detectable concentrations of 2,3,7,8-TCDD. Limits of detection for 2,3,7,8-TCDD at these sites were typically in the range 0.2 - 0.4 ng kg^{-1}.

PCDD and PCDF concentrations for provincial centre soils were in the range 0.72 - 3.73 ng I-TEQ kg^{-1} (including half LOD values) with the exception of one sample which had a concentration of 33.0 ng I-TEQ kg^{-1} (Table 5.2, Figure 5.2 and Table D5, Appendix D). The median TEQ level for provincial centre soils was 1.05 ng I-TEQ kg^{-1}. The provincial centres studied have residential populations[7] ranging from 108,428 (Hamilton) to 10,191 (Greymouth), and would be typical of urban townships in New Zealand.

One park from New Plymouth was found to have the highest PCDD and PCDF concentration measured in the current study at 33.0 ng I-TEQ kg^{-1} (Figure 5.3). This sample was taken from Mt Moturoa Domain, a reserve adjacent to a major chemical plant which, until 1987, manufactured 2,4,5-T. The predominant PCDD congener quantified in the soil was 2,3,7,8-TCDD (31.2 ng kg^{-1}, 95% contribution to I-TEQ level), characteristic of the PCDD and PCDF microcontaminant profile for 2,4,5-T. It should be noted that this particular sample was taken closer to an industrial complex than any other sample collected in urban areas in the current study. Previous measurements of 2,3,7,8-TCDD concentrations in soils collected (April 1985) from around this plant were in the range 20 - 140 ng kg^{-1}, consistent with the current result (Pilgrim, 1986).

Analysis of a second sample from New Plymouth (composite of soil cores taken from three other parks – Chruchill Heights, Western Park; Marsland Hill; Brooklands Park) gave a PCDD and PCDF concentration of 2.23 ng I-TEQ kg^{-1}, which is within the range observed for other provincial centre soils (Figure 5.3). The data point for this composite sample should be considered as being more representative of PCDD and PCDF soil contamination for the New Plymouth urban area than that obtained from the Mt Moturoa Domain sample.

Excluding the New Plymouth 'outlier'[8], Greymouth, which has the lowest population of all the provincial centres studied, was found to have the highest PCDD and PCDF soil concentration (3.73 ng I-TEQ kg^{-1}) observed for provincial centres (Table D5, Appendix D, and Figure 5.3). There are no obvious industrial sources of PCDDs and PCDFs in Greymouth that can account for this raised contaminant concentration level. Ambient air concentrations of PCDDs and PCDFs measured in Greymouth during the winter of 1996 were also amongst the highest recorded in New Zealand (Buckland *et al*., 1999). In contrast, much lower air concentrations were measured during the summer of 1996/97. Air pollution events frequently occur during the winter months in Greymouth, primarily from the burning of coal, along with some wood, for domestic heating. It is likely therefore that the source of the PCDDs and PCDFs measured in the Greymouth soil is primarily of domestic origin.

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7 Population data from the 1996 Census of Population and Dwellings (Statistics New Zealand).

8 The term 'outlier' is used solely in the context of this study when comparing the results of this sample with data from other provincial and metropolitan centres.

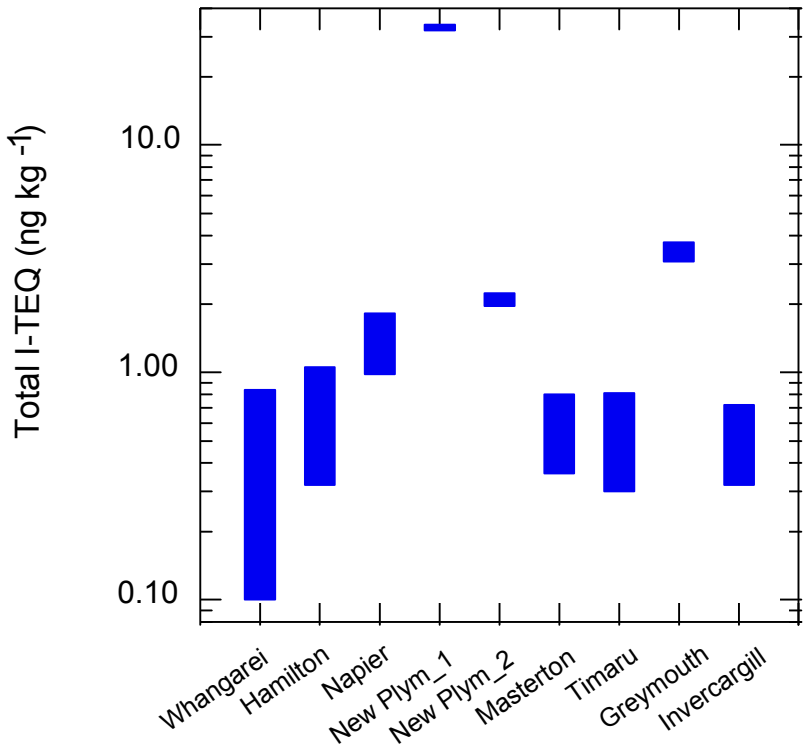

Figure 5.3 Minimum and maximum PCDD and PCDF I-TEQ concentrations in provincial centre soils

[New Plym_1 = sample collected from Mt Moturoa Domain adjacent to chemical plant; New Plym_2 = composite sample collected from three other New Plymouth parks]. The minimum value is taken as the I-TEQ concentration calculated excluding half LOD values. The maximum value is taken as the I-TEQ concentration calculated including half LOD values.

PCDD and PCDF concentrations determined in the two metropolitan centres were comparable to concentrations determined in provincial centres. For Auckland, concentrations (including half LOD values) were in the range 1.03 - 6.67 ng I-TEQ kg^{-1} (median = 1.76 ng I-TEQ kg^{-1}), and for Christchurch 0.26 - 1.84 ng I-TEQ kg^{-1} (median = 0.79 ng I-TEQ kg^{-1}) (Tables D6 and D7, Appendix D). There appears to be no marked difference in I-TEQ concentrations for samples that were collected from areas described as being predominantly residential and from areas described as commercial/light industrial, (Figure 5.4). Thus, in Auckland, three of the seven residential soils had I-TEQ levels in excess of the maximum I-TEQ level determined for commercial/light industrial soils from this centre.

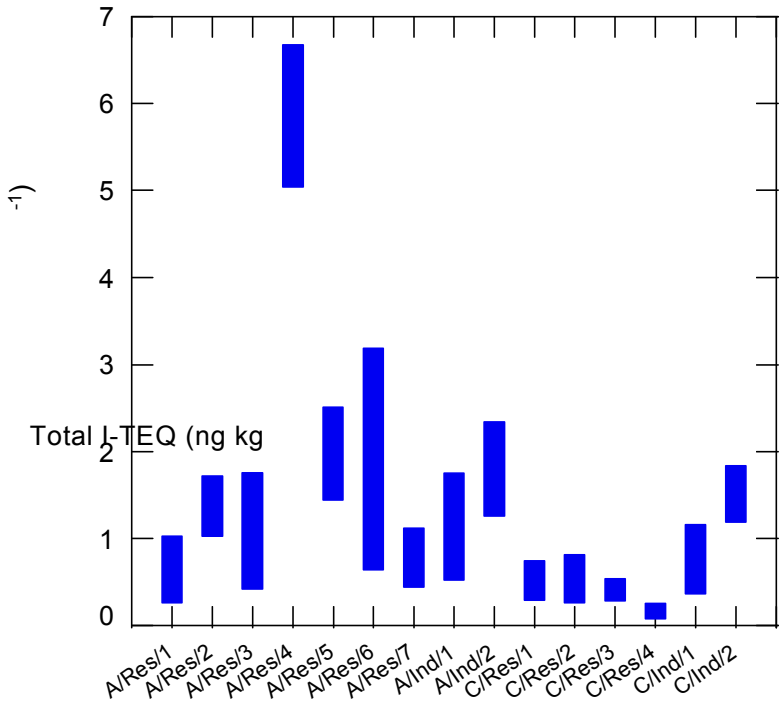

Figure 5.4 Minimum and maximum PCDD and PCDF I-TEQ concentrations in metropolitan centre soils

[A = Auckland; Res = Residential; 1 = North Shore; 2 = North Shore; 3 = Western; 4 = Mt Eden/Mt Roskill; 5 = Tamaki/Maungakiekie; 6 = Hobson/Eastern Bays; 7 = Manukau City. Ind = Commercial/Light Industrial; 1 = Western and Tamaki/Maungakiekie; 2 = Hobson/Eastern Bays. C = Christchurch; Res = Residential; 1 = Merivale/Shirley; 2 = Spreydon/Halswell; 3 = Avonhead/Burnside, 4 = Port Hills; Ind = Commercial/Light Industrial; 1= City/Woolston; 2 = Hornby/Birmingham Drive]. The minimum value is taken as the I-TEQ concentration calculated excluding half LOD values. The maximum value is taken as the I-TEQ concentration calculated including half LOD values.

Irrespective of land type, for almost all samples, the more highly chlorinated PCDD congeners were the most abundant and most frequently detected of all the PCDDs and PCDFs. As a result, the major contributors to I-TEQ levels were typically 1,2,3,4,6,7,8-HpCDD and OCDD. Collectively, these two congeners contributed on average 75% or more of the I-TEQ level when calculated excluding half LOD values for non-detected PCDD and PCDF congeners.

The homologue profiles for forest soils (Figure 5.5) and for urban soils (Figure 5.6) show clearly the dominance of the HpCDDs and OCDD in the total PCDDs and PCDFs present in a sample. Within each of these two land types, the homologue profiles are generally the same. However, although the HpCDD and OCDD homologue groups dominate, a subtle difference in the profiles is apparent between the forest and urban soils.

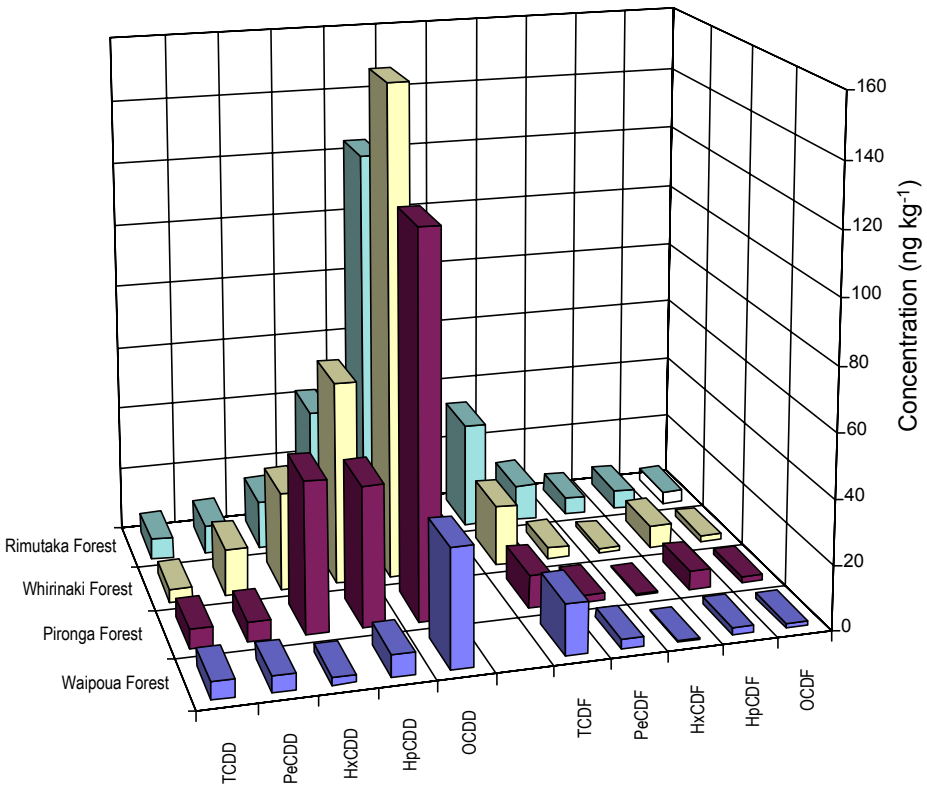

Figure 5.5 PCDD and PCDF homologue profiles for indigenous forest soils

The homologue profiles show that the forest soils contain relatively greater concentrations of the less highly chlorinated congeners, most notably the TCDFs, when compared to the urban soils. The enhanced accumulation of the less highly chlorinated PCDDs and PCDFs in forest soils has also been observed from studies in Germany (Hagenmaier and Krauβ, 1993). Here it was found that the difference in concentrations between forest soils and agricultural soils was much higher for the less highly chlorinated congeners than for the more highly chlorinated congeners. Homologue profile analysis of soils collected in the current study from agricultural lands was not meaningful due to the very high proportion of 'non-detect' measurements in these samples.

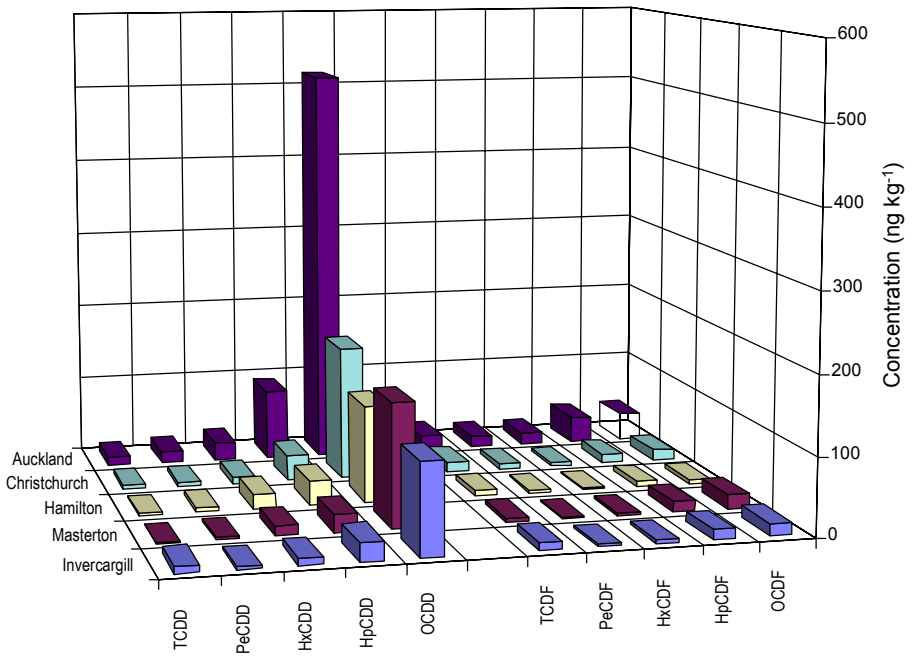

Figure 5.6 PCDD and PCDF homologue profiles for urban soils

The current environmental survey of organochlorine concentrations in New Zealand has also involved the sampling of ambient air at several urban locations (Buckland *et al*., 1999). Provincial and metropolitan centres from which both air and soil samples were collected included Hamilton, Masterton and Christchurch. The ambient air homologue profiles for the mean annual sample data set from these three centres are reasonably consistent (Figure 5.7). Significantly, these profiles more closely resemble the homologue profiles obtained for forest soils (Figure 5.5) than they do the profiles for any of the urban soils collected from the same centres (Figure 5.6). This observation is consistent with evidence that atmospheric deposition processes play an important role in producing elevated levels of PCDDs and PCDFs in forest soils compared to non-forested soils (Horstmann *et al*., 1997). Other studies have further investigated the role of forests on PCDD and PCDF soil concentrations (Horstmann and McLachlan, 1998; McLachlan and Horstmann, 1998).

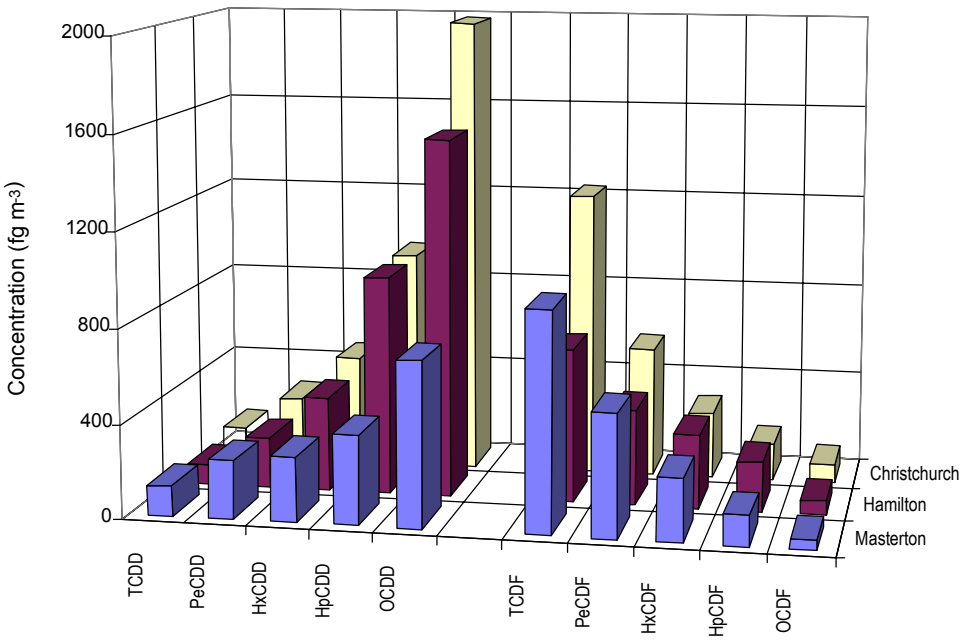

Figure 5.7 PCDD and PCDF homologue profiles for ambient air in urban centres
Data is the mean concentration of all samples collected from each centre.

To investigate contaminant profile variability in urban soils, principal component analysis (SYSTAT for Windows version 6.0) has been applied to the PCDD, PCDF and PCB data sets for all provincial and metropolitan centre samples. Analysis was carried out using data for the 2,3,7,8-PCDDs, 2,3,7,8-PCDFs, non 2,3,7,8-PCDD and non 2,3,7,8-PCDF homologue group totals, and for 20 PCB congeners, giving a total of 45 variables. Data were pre-treated by standardisation using the congener mean and standard deviation. The first five principal components explained a total of 91% of the variation in the original data set. PC1, PC2 and PC5, explaining 35%, 22% and 6% of the variation respectively are illustrated in Figure 5.8. PC1 is weighted towards the PCB congeners, PC2 is weighted towards the more highly chlorinated PCDDs and PCDFs, and PC5 is weighted towards the less highly chlorinated 2,3,7,8-PCDD congeners.

One central cluster contained greater than 75% of the total data points for urban soils, indicating limited variability in the PCDD, PCDF and PCB profiles for this group of samples. This finding is consistent with general diffuse background emissions of these contaminants across most metropolitan and provincial centres in New Zealand.

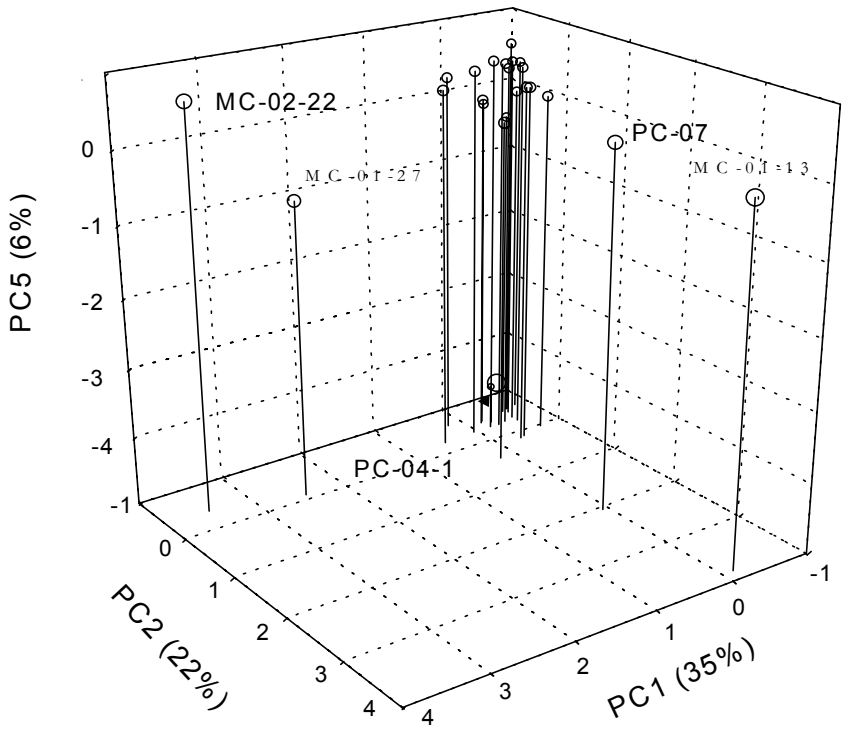

Figure 5.8 Principal components analysis of PCDD, PCDF and PCB levels for provincial centre and metropolitan centre soils
[PC-04-1 = New Plymouth (Mt Moturoa Domain); PC-07 = Greymouth; MC-01-13 = Mt Eden/Mt Roskill, Auckland; MC-01-27 = Hobson/Eastern Bays, Auckland; MC-02-22 = City/Woolston, Christchurch].

Five soils were observed that were out from the central cluster, with each of the soils having a slightly different signature profile. This would indicate that impacts from some localised source(s) of emissions have occurred at the sites from where these samples were collected. Two of these soils (MC-01-27 and MC-02-22) were separated from the cluster along PC1. One was from the Hobson/Eastern Bays commercial/light industrial area in Auckland (MC-01-27), and the other from the City/Woolston commercial/light industrial area in Christchurch (MC-02-22). These two samples had the highest PCB concentrations measured at 7.71 μg kg^{-1} (1.33 ng TEQ kg^{-1}; Hobson/Eastern Bays) and 9.74 μg kg^{-1} (0.67 ng TEQ kg^{-1}; City/Woolston) of all urban soil samples.

Two soils, from Greymouth (PC-07) and the Mt Eden/Mt Roskill residential area in Auckland (MC-01-13), were separated from the cluster along PC2. These two samples had the highest HpCDD and OCDD concentrations recorded of all provincial or metropolitan centre samples.

The fifth soil (PC-04-1) was separated from the cluster along PC5. This particular soil sample was collected from Mt Moturoa Domain, a reserve adjacent to a major chemical plant in New Plymouth that had historically manufactured 2,4,5-T. Organochlorine contaminant analysis of this sample showed markedly elevated concentrations of 2,3,7,8-TCDD.

Comparative overseas data

To assist in the interpretation of the organochlorine contaminant concentration data found in the current study, a comparison has been made with overseas soil concentration data published in the literature. In undertaking this comparison, care has been taken to select studies that:

- are as comparable as possible to the current study;
- provided sufficient experimental information to demonstrate data quality.

A summary of relevant comparative data is reported in:

Appendix H	PCDDs and PCDFs
Appendix I	PCBs
Appendix J	Organochlorine pesticides

There are always limitations in comparing data from different studies. In this regard, the following points should be noted:

1. Since environmental residue data are typically non-Gaussian, standard parametric methods of data analysis are inappropriate. This has been recognised in compiling the tables of comparative data where ranges have been quoted. While median values would be desirable, they can seldom be extracted from the information available.
2. The current study focused on the determination of contaminant levels in New Zealand's environment which is relatively unimpacted compared to the northern hemisphere. Therefore, overseas studies aimed at determining contaminant levels in similar situations are the main focus of the comparative data. For this reason overseas data that related to heavily impacted environments (e.g. contaminated industrial sites) were not considered. However, it must be recognised that much of the available data comes from industrial regions of the world.
3. In any soil survey, contaminant concentrations are highly sensitive to the soil depth to which samples are taken. Most of the comparative data reported here involved the collection of cores to at least 5 cm, with typical sampling depths between 10 to 20 cm. The current study involved sampling to a depth of 10 cm, allowing a reasonable comparison with international data to be made.
4. In reviewing overseas data, it was not always possible to clearly distinguish between background samples remote from areas of known contamination and sites known to have received inputs of organochlorines. Particular care therefore needs to be taken, and the uncertainties recognised, when comparing the data from the current study with data compiled and summarised from the published literature.
5. Wherever possible, the most up to date data has been included. However, some of the studies reporting PCDD and PCDF concentrations are from work done in the late 1980s and early 1990s. In these instances, it must be kept in mind that levels in industrialised environments have fallen during the last decade due to many government restrictions that have been enforced since the eighties.
6. A compounding factor in reporting data for PCDDs and PCDFs is the inconsistency in the treatment of non-detectable congeners for the calculation of TEQ levels. Some studies derive TEQ data on the assumption that non-detected congeners were present at half the LOD, others assume they were present at the level of detection, and still others assumed a non-detection equated to a concentration level of zero. Where possible this information, and the specific TEF scheme used, are tabulated with the comparative data in Appendix H.

In spite of the constraints imposed by these issues, a comparison with international data remains useful to provide a benchmark for placing the concentrations of organochlorines observed in soils in the current study into perspective.

5.1.2 Overseas PCDD and PCDF soil data

Few comprehensive surveys of PCDD and PCDF concentrations in soils have been reported overseas. Frequently studies have been conducted to establish the extent of contamination from known or suspected sources, including those associated with chemical manufacture or use, and incinerator emissions. However, not all of these provide data which are directly comparable to the current study. A number of, primarily European, studies have been reported that detail general background PCDD and PCDF concentration levels in non-urban and urban environments. A summary of these overseas studies is provided in Table 5.3 and Table H1 (Appendix H).

In general, the concentrations of PCDDs and PCDFs measured in New Zealand forest, grassland, agricultural and urban soils are consistently lower, in some instances by an order of magnitude or more, than concentrations measured overseas for similar land types (Figure 5.9).

Table 5.3 Concentrations of PCDDs and PCDFs in overseas soils

Country	Location type	Concentration (ng TEQ kg^{-1} DW)[1] Min.	Max.	Reference
Reference/pristine				
Austria, Salzburg	Alpine, meadow	1.3		Boos *et al.*, 1992
Brazil, Amazon basin	Forest	0.02	0.4	Krauβ *et al.*, 1995
Czechoslovakia	High mountain forest	16.8	26.6	Holoubek *et al.*, 1994
Germany	Forest	5.9	112	Rotard *et al.*, 1994
Switzerland, Rheinfelden	Forest	2.9	11.2	Gälli *et al.*, 1992
	Remote soils	0.7	1.3	Gälli *et al.*, 1992
Rural/agricultural				
Austria, Salzburg	Rural meadows	1.6	3.8	Boos *et al.*, 1992
Canada, BC	Various background sites	0	57.0	Van Oostdam and Ward, 1995
Germany	Rural area	0.6	11.1	NRW, 1991
Germany, Baden-Württemberg	Rural/suburban grassland	0.02	7.6	Nobel *et al.*, 1993
Germany	Grassland	0.4	29.5	Rotard *et al.*, 1994
	Plowland	0.3	3.7	Rotard *et al.*, 1994
Germany, Saxony-Anhalt	Farmland/grassland/gardens	0.6	9.5	Feist *et al.*, 1995
Netherlands	Grassland sites	1.8	16.4	Van den Berg *et al.*, 1994
Sweden, Stockholm	Arable land, major roads	13	49	Broman *et al.*, 1990
	Arable land, no major roads	9	32	Broman *et al.*, 1990
Switzerland, Rheinfelden	Rural fields	0.5	2.5	Gälli *et al.*, 1992
UK	Rural sites	0.78	17.5	HMIP, 1995
US, Mississippi	Various rural sites	0.08	22.9	Fiedler *et al.*, 1995
Urban/industrial				
Australia, Melbourne	Urban parks and gardens	1.8	8.2	Sund *et al.*, 1993
	Industrial sites	0.09	2.1	Sund *et al.*, 1993
Austria, Linz	Industrial/urban	1.6	14.4	Weiss *et al.*, 1994
Austria, Salzburg	Urban meadows and parks	2.0	8.6	Boos *et al.*, 1992
	Industrial sites	4.1	12.5	Boos *et al.*, 1992
Brazil, Rio de Janeiro	Recreation areas	0.03	1.8	Krauβ *et al.*, 1995
	Industrial regions	15	654	Krauβ *et al.*, 1995
Brazil, Cubatão	Forest soil near industries	11	341	Krauβ *et al.*, 1995
Germany	Urban area	0.84	27.3	NRW, 1991
Germany, Baden-Württemberg	Grassland near incinerator	2.1	10.2	Nobel *et al.*, 1993
Switzerland, Rheinfelden	Urban lawn soil	1.3	26.8	Gälli *et al.*, 1992
	Urban meadow	1.1	16.0	Gälli *et al.*, 1992
UK	Urban sites	4.88	87.3	HMIP, 1995
US, Ohio	Urban background	3	33	Lorber *et al.*, 1996

[1] All data are I-TEQ except Sweden (Nordic TEQ) and Switzerland (BGA TEQ).

A survey of soils from the federal state of Salzburg, Austria, involved the collection of 24 samples from alpine, rural and urban meadows and from meadows in the vicinity of potential industrial sources (Boos *et al*., 1992). The remote alpine site had the lowest PCDD and PCDF concentration (1.3 ng I-TEQ kg^{-1}), whilst the highest concentration (12.5 ng I-TEQ kg^{-1}) was found in one of the industrial locations. Similar results were observed for grassland sites around the industrialised and densely populated urban area of Linz, Upper Austria. PCDD and PCDF concentrations were in the range 1.6 - 14.4 ng I-TEQ kg^{-1}, with a median level of 3.3 ng I-TEQ kg^{-1} (Weiss *et al*., 1994).

In an extensive study from the northern region of Switzerland, 33 soil samples were collected from forests, lawns, meadows and agricultural areas, along with three samples taken from remote regions (Gälli *et al*., 1992). The background levels of PCDDs and PCDFs were between 0.7 - 1.3 ng BGA TEQ kg^{-1} as measured in the remote soils (BGA refers to TEFs proposed by the German Health Office). The concentrations in all other soils were in the range 0.5 - 26.8 ng BGA TEQ kg^{-1}, with an average concentration of 4.9 ng BGA TEQ kg^{-1}.

Soils from 32 grassland sites distributed over the Netherlands had PCDD and PCDF concentrations in the range 1.8 - 16.4 ng I-TEQ kg^{-1} (Van den Berg *et al*., 1994, as reported by Liem and Theelen, 1997). On the basis of this study, it was estimated that general background levels in Dutch soils varied from 2 - 10 ng I-TEQ kg^{-1}, with a maximum concentration of 20 ng I-TEQ kg^{-1}.

A major survey of PCDD and PCDF contamination in soils from sampling sites away from urban and industrial regions in Germany has been reported by Rotard *et al*. (1994). The highest concentrations were measured in deciduous forest soils (5.9 - 102 ng I-TEQ kg^{-1}, mean 38.0 ng I-TEQ kg^{-1}), and in coniferous forest soils (11.1 - 112 ng I-TEQ kg^{-1}, mean 36.9 ng I-TEQ kg^{-1}). In grassland soils, PCDDs and PCDFs were in the range 0.4 - 4.8 ng I-TEQ kg^{-1} (mean 2.3 ng I-TEQ kg^{-1}), with a single outlier of 29.5 ng I-TEQ kg^{-1} at a site previously used as an irrigation field. The lowest contaminant levels were measured in plowland soil (0.3 - 3.7 ng I-TEQ kg^{-1}, mean 1.7 ng I-TEQ kg^{-1}). This finding of elevated PCDD and PCDF concentrations in forest soils compared to agricultural soils has been documented in an extensive study involving several hundred soil samples in the Baden-Württemberg province of southern Germany (Hagenmaier and Krauβ, 1993).

Soils collected from rural/suburban grasslands in the Baden-Württemberg province were found to contain levels of PCDDs and PCDFs in the range 0.02 - 7.6 ng I-TEQ kg^{-1}, but in the vicinity of a municipal solid waste incinerator, levels were 2.1 - 10.2 ng I-TEQ kg^{-1} (Nobel *et al*., 1993). These results are consistent with a much larger German study that measured concentrations of PCDDs and PCDFs between 0.6 - 11.1 ng I-TEQ kg^{-1} for rural areas and between 0.84 -27.3 ng I-TEQ kg^{-1} for urban areas (NRW, 1991). Comparable results were found in the Saxony-Anhalt region of Germany, where PCDD and PCDF concentrations in the range 0.6 - 9.5 ng I-TEQ kg^{-1} were measured in farmland, grassland and allotment gardens (Feist *et al*., 1995).

An extensive soil database including 1,594 samples from rural, urban and industrial settings in Germany shows the difference between urban and rural soils (BLAG, 1992, as reported by Fiedler *et al*., 1995). The soil PCDD and PCDF levels in rural settings ranged from 1 - 5 ng I-TEQ kg^{-1}, with relatively higher concentrations being measured in the top organic layer of forest soils (up to 46 ng I-TEQ kg^{-1}). In urban areas typical PCDD and PCDF soil concentrations ranged between 10 - 30 ng I-TEQ kg^{-1}, whereas in industrial areas the concentrations ranged up to 100 ng I-TEQ kg^{-1}. PCDD and PCDF concentrations near point sources of contamination were markedly higher.

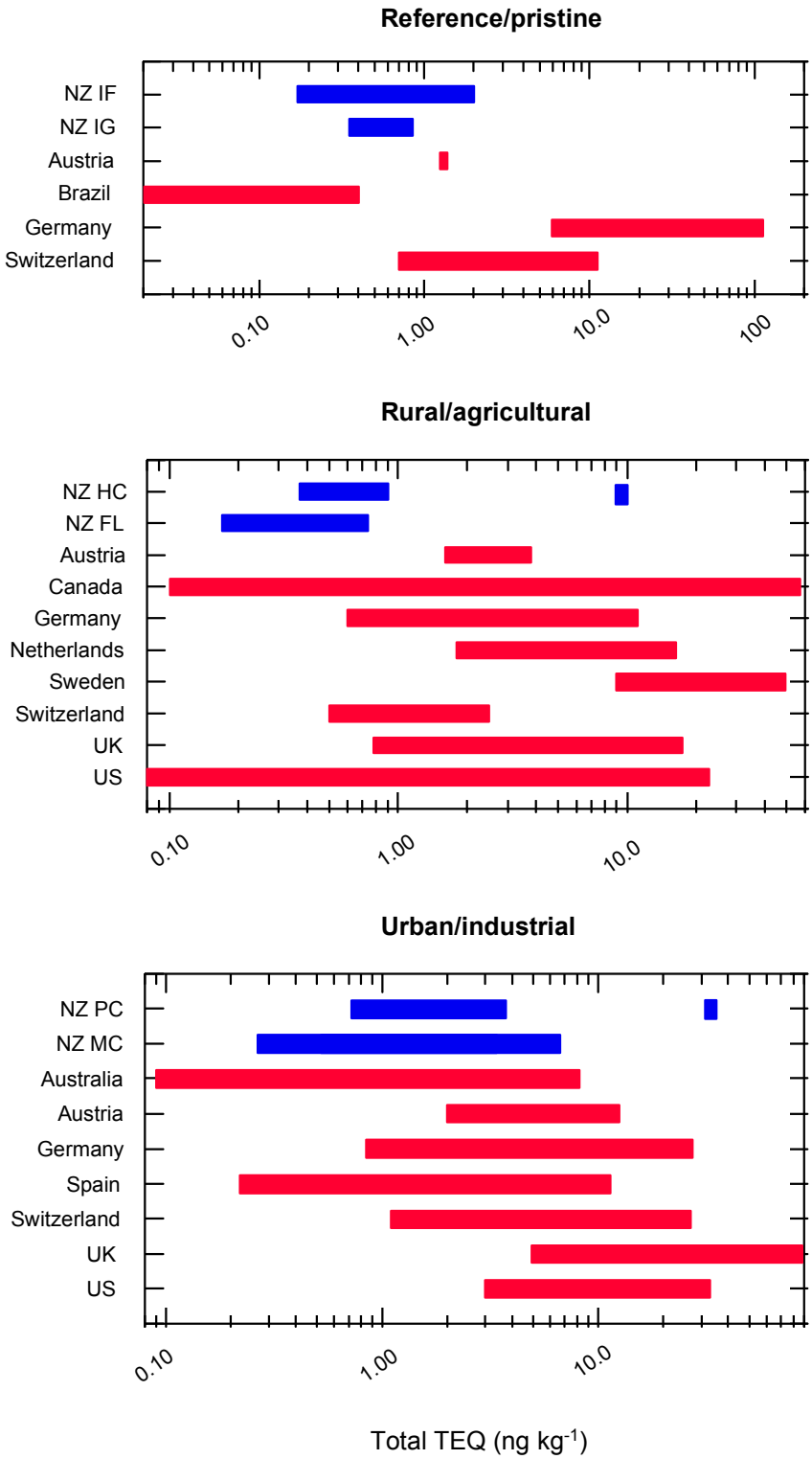

Figure 5.9 Concentrations of PCDDs and PCDFs in New Zealand and overseas soils
NZ IF = New Zealand indigenous forest; IG = indigenous grassland; HC = hill country pasture; FL = flat land pasture; PC = provincial centre; MC = metropolitan centre].
NZ I-TEQ data include half LOD values for non-detected congeners. Outliers for HC and PC data are shown separately. Overseas data are taken from literature cited in Tables 5.3 and H1. All results are I-TEQ, except for Sweden (Nordic TEQ) and Switzerland (BGA TEQ). Data for Canada and Sweden exclude LOD values in TEQ calculation, for Austria and the US (urban/industrial) include half LOD values and for the UK include full LOD values for non-detected congeners. For all other studies, handling of limits of detection was not specified; refer to Table H1 (Appendix H).

A study of high mountain forest soils from the Krkonose National Park on the Czech-Polish border gave similar results to those of German forest soils (Holoubek *et al*., 1994). Concentrations of PCDDs and PCDFs were 16.8 - 26.6 ng I-TEQ kg^{-1}, with a median concentration of 21.8 ng I-TEQ kg^{-1}.

In Sweden, a series of soil samples were collected from arable soils at increasing distance from the centre of Stockholm (Broman *et al*., 1990). PCDD and PCDF concentrations for soil samples taken close to major roads varied between 13 - 49 ng Nordic TEQ kg^{-1} organic weight (o.w.), whilst concentrations in samples collected at a distance from major roads were in the range 9 - 32 ng Nordic TEQ kg^{-1} o.w. The urban area of Stockholm was considered to have a significant impact on the concentration of PCDDs and PCDFs observed. Organic matter was reported as 46-49% of the soil dry weight.

Two surveys in Spain have looked at PCDD and PCDF concentrations in industrial soils. The first study in Tarragona, Catalonia, involved the collection of 24 samples from 12 sites between 250 metres and 1 km distance from a municipal solid waste incinerator (Schuhmacher *et al*., 1996). Concentrations were measured in the range 0.22 - 1.26 ng I-TEQ kg^{-1}. In a similar study in Madrid, 14 soil samples were collected at up to 3 km from a clinical waste incinerator (Jiménez *et al*., 1996). Other potential PCDD and PCDF emission sources were also located in the general area. PCDD and PCDF concentrations measured in these soils were 0.69 - 11.4 ng I-TEQ kg^{-1}. Samples taken from two 'control' sites 4.5 km from the incinerator gave a mean soil concentration of 0.70 ng I-TEQ kg^{-1}.

An assessment of PCDDs and PCDFs in the UK terrestrial environment has been undertaken in two major studies. In the first study, 78 soil samples were collected at the intersects of a 50 km grid over England, Wales and lowland Scotland (HMIP, 1989; Creaser *et al*., 1989). The sampling sites fell mainly in rural and semi-rural locations, and provided, in the main, information on background levels of PCDDs and PCDFs away from industrial and urban locations. Following on from this study, a second study was undertaken involving the collection of 27 soils from Birmingham, Gateshead, London, Leeds, Manchester, Port Talbot and Sheffield (HMIP, 1995; Creaser *et al*., 1990). Initial results from these studies were reported solely on the basis of homologue group concentrations. Subsequently a subset of samples was re-analysed and the data reported as TEQs (HMIP, 1995). For the rural soils, PCDD and PCDF concentrations were 0.78 - 17.5 ng I-TEQ kg^{-1}, with a mean of 5.17 ng I-TEQ kg^{-1}. The urban soils had PCDD and PCDF concentrations of 4.88 - 87.3 ng I-TEQ kg^{-1}, with a mean of 28.4 ng I-TEQ kg^{-1}.

Stenhouse and Badsha (1990) reported baseline levels of PCDDs and PCDFs for a suburban environment near Doncaster. Concentrations in the soil were 3 - 20 ng I-TEQ kg^{-1}, with a mean of 8 ng I-TEQ kg^{-1}. Studies in other UK urban areas have reported levels of PCDDs and PCDFs between 2.4 - 9.6 ng I-TEQ kg^{-1} (Belfast), 7.7 - 230 ng I-TEQ kg^{-1} (Widnes) and 2.0 - 21 ng I-TEQ kg^{-1} (Wigan) (HMIP, 1996).

A recent study has reported elevated levels of PCDDs and PCDFs (up to 163 ng I-TEQ kg^{-1}) in soils near four municipal waste incinerators in Hampshire (Environment Agency, 1997). The background levels in rural soils in Hampshire were 1.72 - 3.52 ng I-TEQ kg^{-1}. Levels of PCDDs and PCDFs have also been measured in 42 soils collected from residential areas in the Panteg District, South Wales, and around a major waste incinerator in the district (Foxall *et al*., 1997).

Median PCDD and PCDF concentrations at a heavily impacted site were 112 ng I-TEQ kg^{-1}, in residential areas 19 ng I-TEQ kg^{-1} and at background sites 6.3 ng I-TEQ kg^{-1}.

A major assessment of PCDDs and PCDFs in British Columbia (Van Oostdam and Ward, 1995) included the collection and analysis of 53 background soils, along with soils collected from areas impacted by a variety of PCDD and PCDF emissions. Background samples were collected from areas thought not to be impacted by any immediate source of PCDDs and PCDFs and were believed to reflect ambient levels of PCDDs and PCDFs in the British Columbia environment. PCDD and PCDF concentrations measured in the background soils were 0 - 57.0 ng I-TEQ kg^{-1}, with a mean of 5.0 ng I-TEQ kg^{-1}. Much higher PCDD and PCDF concentrations were measured in soils taken from the impacted sites.

PCDD and PCDF concentrations have been reported for 97 soil samples collected from rural, urban and industrial sites in Ontario and some Midwest US states (Birmingham, 1990). Only isomer group totals were measured, and TEQ values were calculated using factors from isomer-specific data for other environmental media. On this basis, concentrations for rural soils were estimated to be 0.16 - 2.2 ng I-TEQ kg^{-1}, with a mean of 0.4 ng I-TEQ kg^{-1}. In urban soils the concentration range estimated was 0.1 - 78.5 ng I-TEQ kg^{-1}, with a mean of 11.3 ng I-TEQ kg^{-1}; and for industrial soils 1.7 - 101.8 ng I-TEQ kg^{-1}, with a mean of 40.8 ng I-TEQ kg^{-1}. HpCDD and OCDD were the dominant congeners present.

Background levels of PCDDs and PCDFs in soil were measured at Elk River, Minnesota, a semi-rural location (Reed *et al*., 1990). No major industrial or commercial activity occurred in the area at the time of the study, although a coal-fired electricity generating station had previously operated. PCDD and PCDF concentrations found in arable soils were 0.82 - 9.2 ng I-TEQ kg^{-1}. Data collected from Columbus, Ohio, reported PCDD and PCDF concentrations in rural soils between 0.99 and 1.95 ng I-TEQ kg^{-1} (Lorber e*t al*., 1996). Levels between 3 and 33 ng I-TEQ kg^{-1} were found in urban soils within a 2 km radius of a former municipal solid waste incinerator.

In Southern Mississippi, 36 soil samples were collected from sampling sites that were not directly impacted by human activities to determine baseline concentrations of PCDDs and PCDFs (Fiedler *et al*., 1995). Concentrations measured were 0.08 - 22.9 ng I-TEQ kg^{-1}, with a median and mean concentration of 0.77 and 3.1 ng I-TEQ kg^{-1} respectively.

As part of the dioxin reassessment, the US EPA have reviewed the PCDD and PCDF soil concentration data published in the literature (US EPA, 1994). Based on the available data, 95 samples were selected as representing background conditions in the United States. The mean TEQ level was estimated to be 8 ng TEQ kg^{-1} assuming values below the LOD were present at half the LOD. Similarly, 133 background samples were selected from the European studies, and a mean background estimated for Europe of 9 ng TEQ kg^{-1}.

PCDD and PCDF concentrations in soils have been reported for only a few countries outside Europe and North America. A series of Brazilian forest soils in remote, recreational and industrial areas provides particularly relevant Southern Hemisphere data (Krauβ *et al*., 1995). Soils collected from five sites in the Amazon basin had low PCDD and PCDF levels (0.02 - 0.4 ng I-TEQ kg^{-1}). Only HpCDD and OCDD were found at levels close to the detection limit. Samples taken from recreational forest areas close to Rio de Janeiro had concentrations of 0.03 - 1.8 ng I-TEQ kg^{-1}.

More elevated PCDD and PCDF concentrations were found in samples taken as close as possible to forests or small woods in industrial areas of Rio, up to a maximum concentration of 654 ng I-TEQ kg^{-1}. Similarly elevated levels were measured in forest soils close to industrial areas of Cubatão, southeast São Paulo.

Background soil concentrations of PCDDs and PCDFs have been reported for the Melbourne metropolitan area, Australia (Sund *et al*., 1993). Samples were collected from urban parks and gardens and from industrial areas. Concentrations were 0.09 - 8.2 ng I-TEQ kg^{-1}, with the highest TEQ level being recorded at one of the three urban sites. PCDD and PCDF concentrations between 2.2 - 38.5 have been reported for soils collected from conservation areas following major bush fires in Australia in 1994 (Buckland *et al*., 1994). There did not appear to be any major difference in soil concentrations between samples collected from burnt and un-burnt areas. The study also reported a soil concentration of 42.6 ng I-TEQ kg-1 for a sample collected from a high traffic volume area in metropolitan Sydney.

In Japan, a PCDD and PCDF concentration of 19.7 ng I-TEQ kg^{-1} has been reported for a single urban soil collected from Tokyo (Sakurai *et al*., 1996). The same study also reported a PCDD and PCDF concentration of 2.53 ng I-TEQ kg^{-1} for a single sample collected from a paddy field.

5.1.3 Regulatory approaches to PCDDs and PCDFs

Soil acceptance criteria for PCDDs and PCDFs have been published as part of the *Health and Environmental Guidelines for Selected Timber Treatment Chemicals* (Ministry for the Environment and Ministry of Health, 1997). The acceptable residual PCDD and PCDF concentrations for a number of land uses, encompassing agricultural, residential and industrial use are summarised in Table 5.4. The criteria were developed using a risk assessment model based primarily on the protection of human health, and incorporating the WHO tolerable daily intake for PCDDs and PCDFs of 10 pg/kg body wt/day.

Table 5.4 New Zealand health and environmental guidelines for PCDDs and PCDFs: summary of soil acceptance criteria

	Agricultural	Residential	Industrial		
			Unpaved	Paved	Maintenance
PCDDs/Fs (ng I-TEQ kg^{-1})	10	1500	18000	90000	21000

The New Zealand soil criteria are generally in line with guidelines that have been developed for PCDDs and PCDFs by several overseas regulatory agencies.

Reference values for PCDDs and PCDFs and recommended action for agricultural and horticultural land uses and soil remediation have been established in Germany since 1991 (Table 5.5) (Basler, 1994). The reference values include a target to reduce dioxin concentrations in soils used for agricultural purposes to below 5 ng I-TEQ kg^{-1} dry weight. Limitations on the cultivation of certain foodstuffs are recommended if the PCDD and PCDF concentration exceeds 40 ng I-TEQ kg^{-1} soil. Guideline values were also established for children's playgrounds, and for urban and industrial areas.

Table 5.5 Reference values and recommended action for land use and remediation of contaminated soil in Germany

PCDD and PCDF (ng I-TEQ kg^{-1} DW)	Recommended action
< 5	Target value
5 - 40	Unrestricted cultivation of foodstuffs. Avoidance of critical land uses (e.g. grazing management) if increased PCDD and PCDF levels are found in food produce
> 40	Limitation to defined agricultural and horticultural land uses. Unlimited cultivation only of plants with minimal dioxin transfer (e.g. cereals)
> 100	Remediation of contaminated soil (sealing, decontamination or exchange) in playgrounds
> 1000	Remediation of contaminated soil in urban areas
> 10000	Remediation of contaminated soil in industrial areas

In the Netherlands, two guidance levels were proposed in 1987 for PCDD and PCDF residues in soils (Zorge and Liem, 1994): a level of 1000 ng I-TEQ kg^{-1} dry weight for residential areas and for agricultural purposes, and 10 ng I-TEQ kg^{-1} dry weight for dairy farming.

The US Public Health Service, Centres for Disease Control and Prevention, have established a 1,000 ng 2,3,7,8-TCDD kg^{-1} dry weight level of concern for residential areas (Kimbrough *et al*., 1984). They conclude that this is 'a reasonable level at which to begin consideration of action to limit human exposure for contaminated soil'. 'Preliminary remediation goals' for 2,3,7,8-TCDD in soil have been established by the United States Environment Protection Agency (US EPA) Region 9 (US EPA, 1996c). A preliminary remediation goal in residential soils has been set at 3.8 ng kg^{-1}, whilst in industrial soils the remediation goal is 24 ng kg^{-1}. Significantly, the Federal EPA (Office of Solid Waste and Emergency Response) has subsequently issued a directive that 1000 ng kg^{-1} is the appropriate criterion to use for PCDDs and PCDFs in residential soil (US EPA, 1998b). They strongly urge the various EPA regions to follow this guidance and do not believe it is prudent to establish new, and possibly varying, precedents for PCDD and PCDF levels in soil prior to the release of the dioxin reassessment report.

The United States Agency for Toxic Substances and Disease Register has established an interim policy guideline for PCDDs and PCDFs in residential soils (De Rosa *et al*., 1997). The guideline applies to human exposure for direct ingestion of soils contaminated with PCDDs and PCDFs in residential areas, and may not be appropriate for other exposure scenarios. The guideline specifies a soil screening level of ≤ 50 ng TEQ kg^{-1}, an evaluation level of > 50 but < 1,000 ng TEQ kg^{-1} and an action level of ≥1,000 ng TEQ kg^{-1}.

Canadian environmental quality criteria for contaminated sites include interim remediation criteria for PCDDs and PCDFs in soils (CCME, 1991). For agricultural soils, the criterion is 10 ng TEQ kg^{-1}, and for residential/parkland soils the criterion is 1000 ng TEQ kg^{-1}.

5.2 Polychlorinated biphenyls

5.2.1 New Zealand PCB soil data

All soils were analysed for 25 PCB congeners, including the non *ortho*-PCBs, #77, #126 and #169. The concentrations measured for each land type, quantified as either the sum of PCB congeners or as PCB TEQs, are summarised in Table 5.6.

Table 5.6 Concentrations of PCBs in New Zealand soils

Land type	Sum of PCB congeners[1] (μg kg^{-1} DW)		PCB TEQ[1] (ng TEQ kg^{-1} DW)	
	Min.	Max.	Min.	Max.
Indigenous forest	0.14	1.20	0.065	0.16
Indigenous grassland	0.13	0.25	0.065	0.29
Hill country pasture	0.12	0.18	0.065	0.12
Flat land pasture	0.12	0.37	0.065	0.13
Provincial centre	0.30	3.38	0.067	0.23
Metropolitan centre	0.23	9.74	0.087	1.33

[1] Includes half LOD values for non-detected congeners.

No PCB congeners were quantified in grassland or hill country pastoral soils (Tables E2 and E3, Appendix E), and only a limited number of congeners were quantified in three of seven forest soils (Table E1) and two of eight flatland pastoral soils (Table E4). Limits of detection for individual congeners were typically 0.001 - 0.003 μg kg^{-1} for non *ortho*-PCBs, and 0.01 - 0.03 μg kg^{-1} for all other congeners. The maximum sum of PCB concentrations measured were 1.20 μg kg^{-1} for forest soils and 0.37 μg kg^{-1} for flat land pastoral soils (including half LOD values). For the few congeners that were detected in non-urban areas, the highest individual congener concentrations were found in forests. The low analytical limit of detection and the high rate of non-detect values for forest, grassland and agricultural soil attest to an almost total absence of PCB contamination in most non-urban terrestrial environments in New Zealand.

For forest, grassland and agricultural soils, PCB TEQ levels were dominated by the inclusion of half LOD values for non-detected congeners, such that, in general, non-detected congeners contributed greater than 90% of the TEQ level determined. Typically, the PCB TEQ levels were an order of magnitude lower than the corresponding PCDD and PCDF I-TEQ levels.

In urban areas, PCB concentrations, quantified as the sum of PCB congeners, were generally higher than in non-urban soils (Tables E5 to E7, Appendix E). Maximum concentrations (including half LOD values) determined were 3.38 μg kg^{-1} for provincial centre soils and 9.74 μg kg^{-1} for metropolitan centre soils. Similarly, generally higher TEQ levels were measured in provincial and metropolitan centre soils compared with soils from forest, grassland and agricultural areas (Figure 5.10).

For provincial centres, PCB TEQ levels (including half LOD values) were 0.067 - 0.23 ng TEQ kg^{-1}, with a median level of 0.16 ng TEQ kg^{-1}. Metropolitan centre soil PCB TEQ levels were 0.087 - 1.33 ng TEQ kg^{-1}, with a median level of 0.26 ng TEQ kg^{-1}, for Auckland, and 0.14 - 0.67 ng TEQ kg^{-1}, with a median level of 0.17 ng TEQ kg^{-1}, for Christchurch.

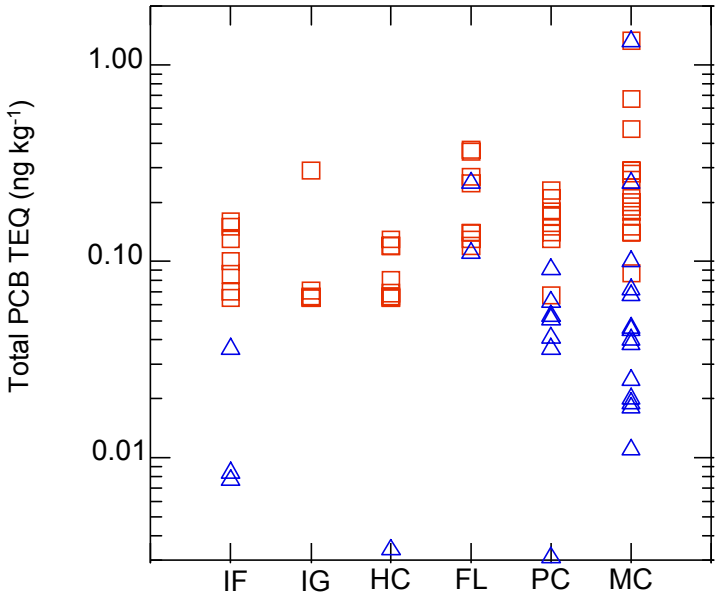

Figure 5.10 PCB TEQ concentrations in New Zealand soils
[Includes half LOD values, Δ excludes half LOD values. Zero I-TEQ results are not shown. Land type codes are as given in Figure 5.1].

In both Auckland and Christchurch, the highest sum of PCB congener concentrations (7.71 and 9.74 μg kg^{-1} respectively) were found in soils collected from commercial/light industrial areas. Principal component analysis separates these two metropolitan soils from all other urban soils (Figure 5.8). The sample with the highest PCB concentration found in the current study (9.74 μg kg^{-1}) was for soil taken from parks and reserves in the City/Woolston area of Christchurch. Woolston was at one time the largest industrial area in New Zealand. It is also probable that one of the sampling sites (Palinurus Road) for this sample was located over an old landfill (Canterbury Regional Council, 1998). Whilst one of the criteria for the selection of parks and reserves in urban areas was that no sampling should be undertaken on old landfills or industrial sites (Section B2.2, Appendix B), historic land use information was not always accessible at the time of sampling. In these instances, the selection criteria may not always have been met. Nevertheless, whilst the concentration for the sum of PCB congeners quantified in the City/Woolston sample is the highest for all samples collected in the current study, it is low compared with PCB concentrations typically measured in industrial areas overseas (Section 5.2.2, and Table I1, Appendix I).

The PCB congener profiles for the various land types are shown in Figure 5.11. In each case, the sample with the highest PCB concentration is presented. The profiles detected in provincial and metropolitan centres are consistent, with PCB congeners #153 and #138 being the most abundant and most frequently detected. These two congeners accounted for approximately 45% of the sum

of PCB congeners measured, and together with PCB #101, #118, #187, #180 and #170, accounted for approximately 85% of the sum of PCBs measured.

In forest soils, PCB congeners #153 and #138 were again the most abundant. For grassland and agricultural soils, the high frequency of non-detect measurements for all PCB congeners precludes any interpretation of the profile.

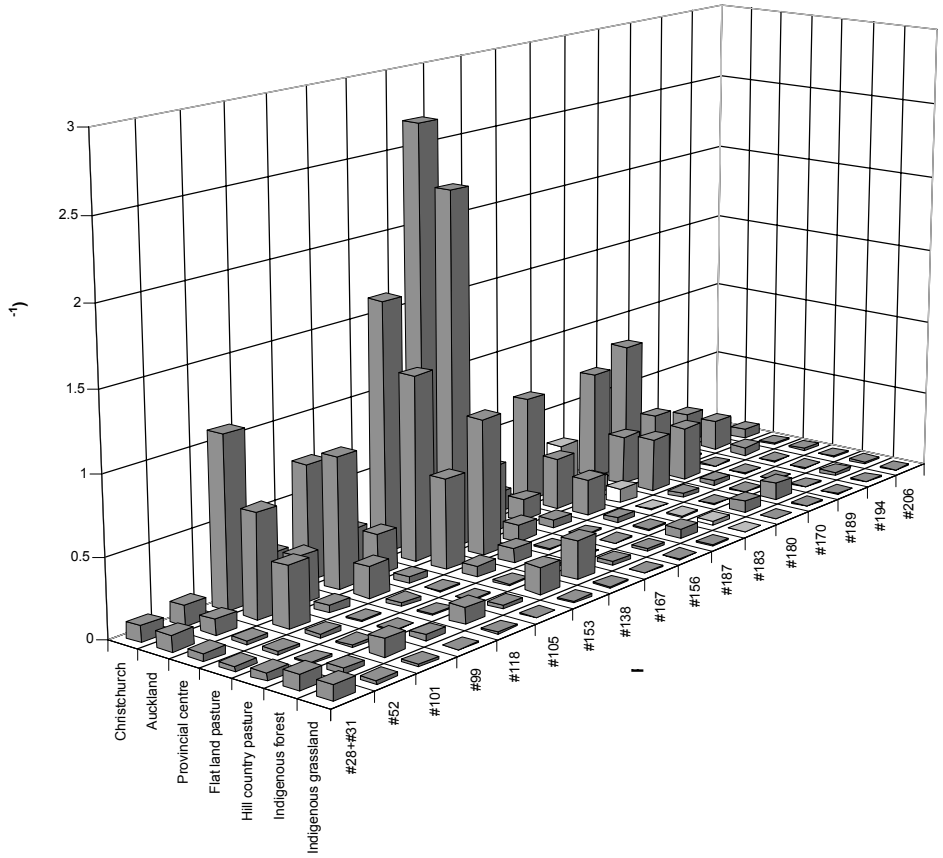

Figure 5.11 PCB congener profiles for New Zealand soils

5.2.2 Overseas PCB soil data

Relevant overseas studies on the occurrence of PCBs in soils are provided in Appendix I. Most of these studies report the contaminant concentration data as 'total PCB' measurements. To a great extent this reflects analytical methodologies and regulatory actions, which, for the most part, are usually based on total PCB estimates. Nonetheless, it is valid to make a comparison between these overseas data and the current New Zealand data presented as the sum of the 25 PCB congeners determined. The New Zealand study quantified those PCB congeners that are usually the most environmentally prevalent, and which as a consequence make the greatest contribution to total PCB measurements.

Concentrations of PCBs in New Zealand soils are markedly lower than those reported from overseas locations (Table 5.7 and Figure 5.12; Table I1, Appendix I). The soils from the current study showed minimum PCB concentrations of considerably less than 0.5 μg kg^{-1}, even in

provincial and metropolitan centres. The lowest concentrations of PCBs measured in 'pristine' areas of the world, such as the polar regions and remote areas of Eurasia, are at similar levels. In the Canadian Arctic, analysis of soils collected from background sites could not detect PCBs to a limit of 0.5 μg kg^{-1} (Bright *et al.*, 1995), whilst the lowest PCB concentration measured in four upland forest soils from Vietnam was 1.4 μg kg^{-1} (Thao *et al.*, 1993b).

Table 5.7 Concentrations of PCBs in overseas soils

Country	Location type	Concentration[1] (μg kg^{-1} DW) Min.	Max.	Reference
Reference/pristine				
Antarctica	Various	1	23	Morselli *et al*., 1991
Brazil	Forest	0.1	7.7	Krauβ *et al*., 1995
Canadian Arctic	Background	< 0.5		Bright *et al*., 1995
Czechoslovakia	High mountain	31	137	Holoubek *et al*., 1994
Norway	Remote woodlands	5.3	30	Lead *et al*., 1997
Spain	National Park and surrounds	0.46	18.6	Fernandez *et al*., 1992
Vietnam	Upland forest	1.4	4.2	Thao *et al*., 1993b
Rural/agricultural				
Ireland	Agricultural	1.25	6.63	McGrath, 1995
Jordan	Various	2.4	15	Alawi and Heidmann, 1991
Russia	Agricultural	3.2	2470	Galiulin and Bashkin, 1996
Taiwan	Paddy fields/gardens	1.6	49	Thao *et al*., 1993b
Thailand	Paddy fields/gardens	1.1	6.2	Thao *et al*., 1993b
Uzbekistan	Agricultural	0.1	433	Galiulin and Bashkin, 1996
Vietnam	Paddy fields	0.61	320	Thao *et al*., 1993b
Urban/industrial				
Austria	Industrial/urban	6.4	95	Weiss *et al*., 1994
Brazil	Recreational/industrial areas	0.26	232	Krauβ *et al*., 1995
Czechoslovakia	Urban and rural	9	35	Holoubek *et al*., 1990
Ireland	Urban/industrial	0.24	9.39	McGrath, 1995
Italy	Close to motorway	13.2	82.3	Benfenati *et al*., 1992
Taiwan	Roadside	13	960	Thao *et al*., 1993b
Thailand	Road side	1.4	2.9	Thao *et al*., 1993b
UK, Doncaster	Urban/rural	2.1	11.1	Stenhouse and Badsha, 1990
National surveys				
Scotland		21	362	Bracewell *et al*., 1993
Switzerland		6.5	29	Berset and Holzer, 1995
Wales, South		1.9	1210	Eduljee *et al*., 1987

[1] Measured as either total PCB or sum of PCB congeners. Refer Table I1 (Appendix I).

Other background sites in Norway (Lead *et al*., 1997) and Czechoslovakia (Holoubek *et al*., 1990) had minimum PCB concentrations that matched or exceeded the highest PCB concentrations measured in New Zealand urban centres.

Minimum PCB concentrations, of typically between 1 and 5 μg kg^{-1}, have been recorded in agricultural soils in Europe (McGrath, 1995; Galiulin and Bashkin, 1996) and Asia (Thao *et al*., 1993b), and up to 10 μg kg^{-1} in European urban/industrial centres (Weiss *et al*., 1994; Holoubek *et al*., 1990; Stenhouse and Badsha, 1990). These minimum levels are approximately an order of magnitude higher than the minimum concentrations measured in agricultural and urban/industrial soils in New Zealand in the current study.

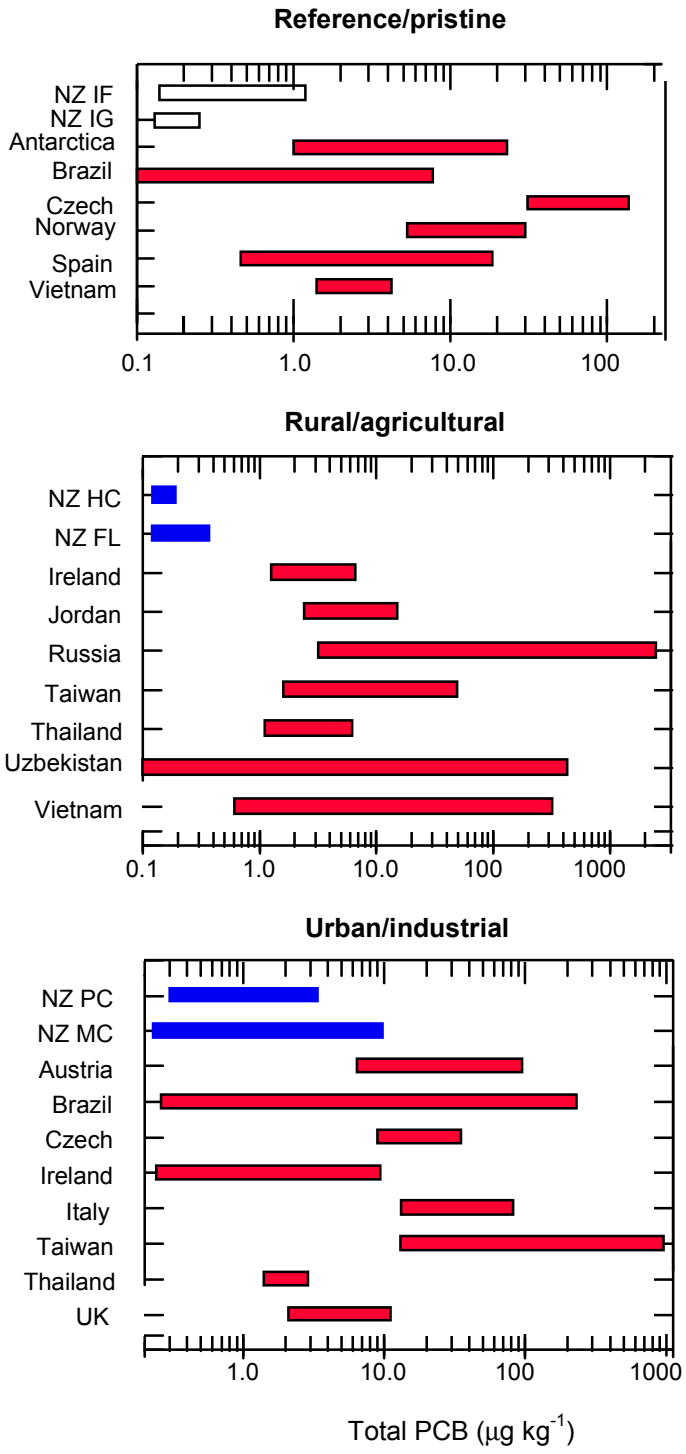

Figure 5.12 **Concentrations of PCBs in New Zealand and overseas soils**
[NZ IF = New Zealand indigenous forest; IG = indigenous grassland; HC = hill country pasture; FL = flat land pasture; PC = provincial centre; MC = metropolitan centre]. NZ data include half LOD values for non-detected congeners. Overseas data taken from literature cited in Tables 5.7 and I1 (Appendix I).

Maximum 'background' concentrations of PCBs in soils need to be interpreted more carefully than minimum values. Although areas may be defined as unimpacted, some unidentified input is possible. This is almost certainly the case in some of the agricultural soils of the former USSR where PCB concentrations ranged up to 2470 μg kg^{-1} (Galiulin and Bashkin, 1996). Other rural sites, most notably in Czechoslovakia (Holoubek *et al*., 1994), and Asia (Thao *et al*., 1993b) had maximum PCB concentrations that were markedly higher than the maximum PCB level of 9.74 μg kg^{-1} measured in the New Zealand soils in the current study. In this light the PCB contaminant concentrations measured in New Zealand soils compare very favourably with concentrations measured in the rest of the world.

Much less congener-specific PCB data is available for soils that can be used for comparative purposes (Tables I2 to I7, Appendix I). These include studies which related to the presence of PCBs in soils previously treated with sewage sludge (Alcock *et al.,* 1995; Alcock *et al.,* 1993). These data sets generally contained monitoring data for control plots which have been used for comparison to the current New Zealand data.

As with total PCB concentrations, the concentrations of individual PCB congeners in New Zealand soils are generally lower than those measured in other parts of the world (Figure 5.13).

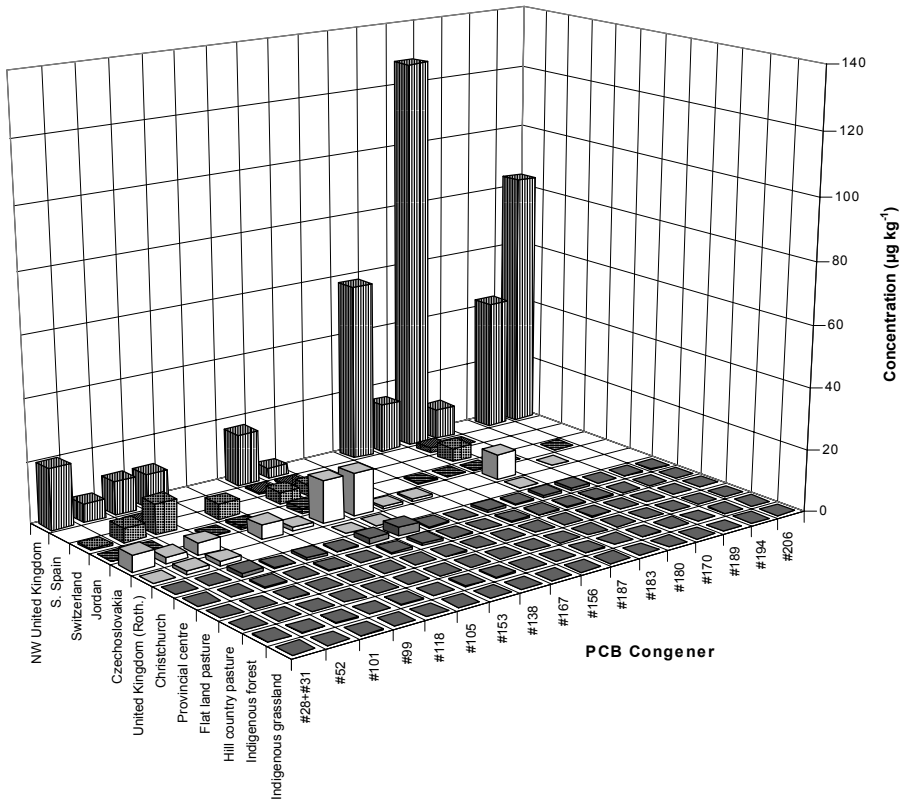

Figure 5.13 PCB congener profiles from New Zealand and overseas soils

Data for the non *ortho*-PCB congeners #77, #126 and #169 have been reported for mountain soils in the Czech Republic (Holoubek *et al*., 1994) and urban/rural soils in Japan (Ohsaki and

Matsueda, 1994). Of the three congeners, #77 was the most abundant followed by #126 and then #169.

In the current study, non *ortho*-PCB congeners were only detected in soils from metropolitan centres. PCB #77 was detected in only two of 15 metropolitan centre samples to a maximum concentration of 0.028 μg kg^{-1}, and PCB #126 was detected in only one metropolitan centre sample (0.011 μg kg^{-1}). PCB #169 was not detected in any samples above a typical detection limit of 0.002 μg kg^{-1}.

5.2.3 Regulatory approaches to PCBs

The US EPA Office of Solid Waste and Emergency Response has released criteria for the screening of soil contamination (US EPA, 1996a; US EPA, 1996b). These criteria are based on the inclusion of considerable site-specific data and therefore provide site-specific criteria. More widely applicable 'Generic Soil Screening Levels' (SSLs) were derived by assuming conservative default values for the various parameters. The generic SSL for total PCBs in soil is 1000 μg kg^{-1} based on soil ingestion (US EPA, 1996a). This has been set based on EPA guidance for PCB contamination at superfund sites (US EPA, 1990). The US EPA concludes that 'Since these SSLs are based on conservative default values they are likely to be protective at most locations'.

Based on a human cancer endpoint, US EPA Region 9 has established preliminary remediation goals for total PCBs of 66 μg kg^{-1} for residential soils and 340 μg kg^{-1} for industrial soils (US EPA, 1996c). Values based on non-cancer endpoints are more permissive at 1400 μg kg^{-1} and 19000 μg kg^{-1} for Aroclor 1254 in residential and industrial soils respectively.

The soil PCB concentrations determined in the current study (0.12 - 9.74 μg kg^{-1}) are clearly well below the current US EPA soil guidelines. It should be noted, however, that both the US EPA guidelines are based upon levels to which contaminated soils need to be remediated to minimise risk to humans and therefore represent a 'worst case scenario'.

5.3 Organochlorine pesticides

5.3.1 New Zealand organochlorine pesticide soil data

The current study analysed only indigenous forest, indigenous grassland, provincial centre and metropolitan centre soils for organochlorine pesticides. Soils collected from hill country and flat land pastoral sites were not analysed for pesticide residues because it was considered that the sampling programme was not sufficiently robust (i.e. had insufficient sampling points) to provide accurate and representative contaminant data for agricultural soils where an organochlorine (e.g. DDT) might have been intentionally applied to the land.

It was assumed that the indigenous forest and indigenous grassland sampling sites had received no direct organochlorine pesticide applications and were sufficiently distant from treated sites so that organochlorine inputs would be almost entirely from long-range transport. These sites therefore represent reference levels for New Zealand, although some variation between sites might be expected due to differing deposition patterns as a result of climatic factors.

In forest and grassland soils, with the exception of DDT residues, HCB and dieldrin, compounds were generally at or below the level of detection (Tables F1 and F2, Appendix F). HCB and dieldrin were consistently detected but never exceeded 1.0 µg kg^{-1} (Figure 5.14). The concentrations of pp'-DDT and pp'-DDE showed greater variability, particularly for the forest soils. Residues were present to a maximum concentration of approximately 3 µg kg^{-1} (Figure 5.14), but this concentration is well below that which would be expected if direct pesticide applications had occurred.

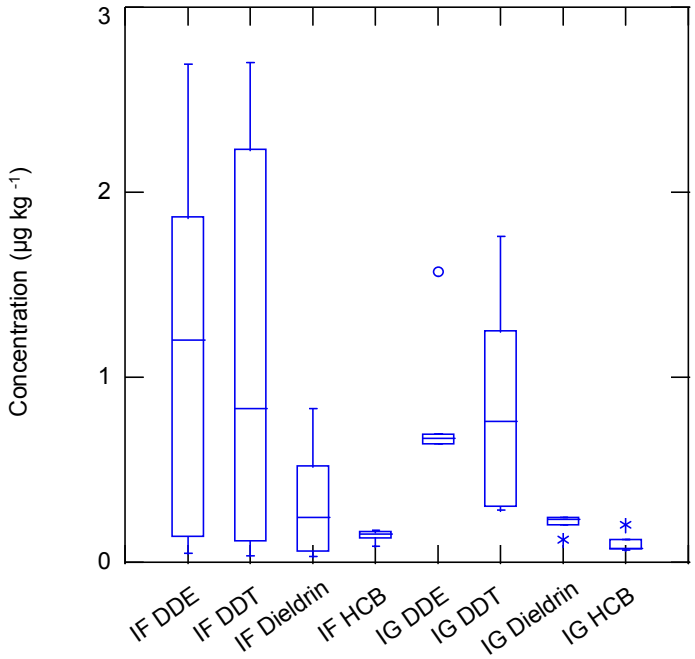

Figure 5.14 **Box plot for HCB, Dieldrin, pp'-DDE and pp'-DDT concentrations in indigenous forest and grassland soils**
[IF = indigenous forest; IG = indigenous grassland].
For explanation of box plot, see Figure 5.1.

For provincial and metropolitan centres, HCH, aldrin and heptachlor were rarely quantified at limits of detection typically at or below 0.02 µg kg^{-1} (Tables F3 to F5, Appendix F). This finding is comparable with the data recorded for the same pesticides in forest and grassland soils, and compares very favourably with concentrations reported in urban soils in Ireland and the United States (Section 5.3.2).

Heptachlor epoxide was not detected in any of the provincial centre sites, but was present in three of the 15 metropolitan centre samples. In only one of these three samples was the level markedly elevated (12.1 µg kg^{-1}) above the analytical detection limit of 0.01 - 0.03 µg kg^{-1} routinely achieved in this study for heptachlor epoxide. This sample also had the highest chlordane

concentrations detected in soil in this study, but relatively low heptachlor levels, suggesting that chlordane use was the source of the heptachlor epoxide detected.

The pesticides, HCB, dieldrin and chlordane, were more frequently detected in urban New Zealand sites. The maximum contaminant concentrations (Table 5.8) were above those observed for forest and grassland sites, but were still much lower than concentrations reported for agricultural soils overseas (Appendix J).

Table 5.8 Concentrations of dieldrin, HCB and chlordane isomers in New Zealand soils (μg kg^{-1}, dry wt basis)

Pesticide	Provincial centres (n=8)	Auckland (n=9)	Christchurch (n=6)
HCB	< 0.04 - 1.16 (3)[1]	0.050 - 1.22 (9)	0.056 - 0.12 (6)
Dieldrin	0.15 - 2.17 (8)	0.23 - 42.1 (9)	0.21 - 1.85 (6)
α-Chlordane	< 0.02 - 0.14 (1)	< 0.04 - 0.33 (5)	< 0.02 - 1.11 (1)
γ-Chlordane	< 0.01 - 0.15 (1)	< 0.03 - 0.13 (9)	< 0.02 - 1.72 (1)

[1] Value in parentheses is the number of sites at which that pesticide was present.

DDT residues (pp'-DDT, pp'-DDE, pp'-TDE, op'-DDT) were measured at all provincial and metropolitan centres over a broad range of concentrations. For provincial centre sites, the lowest concentration for pp'-DDT was measured at Hamilton (0.80 μg kg^{-1}). Concentrations in other centres were typically at or below 15 μg kg^{-1} (Figure 5.15, and Table F3, Appendix F), although a concentration of 121 μg kg^{-1} was measured in Invercargill. Subsequent information (Southland Regional Council, 1998) indicated that one of the sampling locations (Queens Park) has a golf course over most of its area, and that this site was likely subject to applications of DDT over a considerable period of time.

The two metropolitan centres studied were very different with respect to the levels of DDT residues observed. Auckland had comparable concentrations (0.53 - 30.1 μg kg^{-1}) to the provincial centres sampled, but Christchurch concentrations (78.8 - 340 μg kg^{-1}) were consistently greater (Figure 5.15, and Tables F4 and F5, Appendix F). Concentrations of pp'-DDE were generally similar to those of pp'-DDT, being measured in the range 0.58 - 86.9 μg kg^{-1} for provincial centre soils, 0.96 - 38.4 μg kg^{-1} for Auckland soils and 119 - 469 μg kg^{-1} for Christchurch soils.

It is possible to place these concentrations in context by estimating the contamination arising from a single DDT application. An application of DDT at the recommended rate of 2.2 kg ha^{-1} would give a soil level of 1000 μg kg^{-1} (assuming a soil bulk density of 1.1 g/cm^3, with applied DDT contained and evenly distributed in the upper 200 mm of soil). With a half life of 15 years in soil, one might expect residues in excess of 100 μg kg^{-1} today. It is probably not unreasonable to assume therefore that where DDT residues are well below 100 μg kg^{-1} the site was not directly treated with this pesticide.

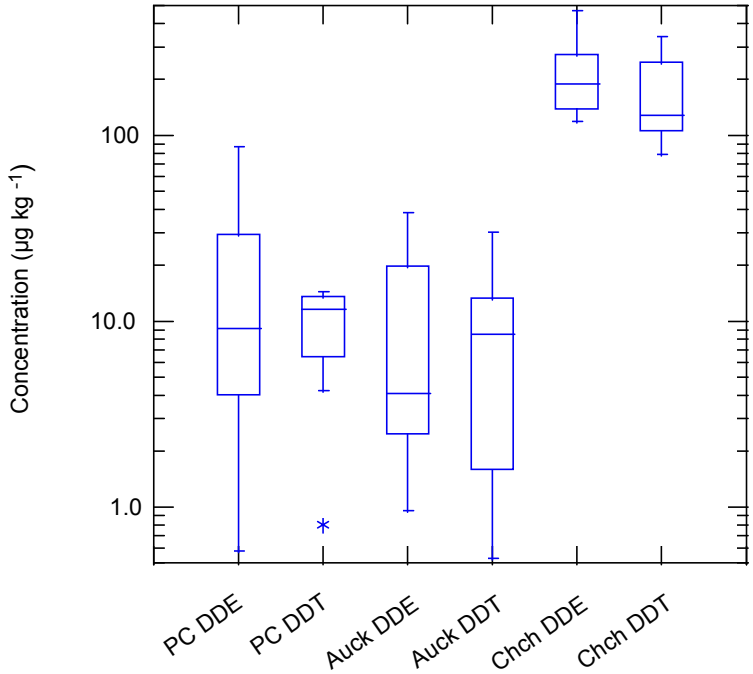

Figure 5.15 Box plot for pp'-DDE and pp'-DDT concentrations in urban soils
[PC = provincial centre; Auck = Auckland; Chch = Christchurch].
For explanation of box plot, see Figure 5.1.

On this basis, the results for samples collected from provincial centres suggest that, with some exceptions, DDT usage was historically low. The observed concentrations are certainly low compared to overseas data reported for agricultural sites (Table J1, Appendix J). Christchurch concentrations, on the other hand, suggest multiple applications of DDT have historically occurred, probably to control grass grub in lawns. Christchurch DDT residue concentrations are within the range of many of the agricultural sites reported overseas.

5.3.2 Overseas organochlorine pesticide soil data

Available data on relevant overseas background concentrations of organochlorine pesticides in soils is sparse. A brief summary of published concentrations for DDT residues, HCH isomers, aldrin, dieldrin, chlordane, heptachlor and heptachlor epoxide is provided in Appendix J.

In the United States, generally higher DDT concentrations to that found in the current study have been reported for a New Hampshire forest site not known to have been treated with DDT (Smith *et al*., 1993). The site was reasonably remote, but amenity areas within the forest had been treated with DDT. Dimond and Owen (1996) monitored both DDT treated and untreated forests in Maine USA over a 30 year period. In 1967, shortly after the spraying of treated forests, unsprayed forests 3-10 km away had total DDT soil residues of 67-110 µg kg^{-1}. By 1993 these areas had residues of

less than 11 μg kg^{-1}. All these values are lower than the 120 μg kg^{-1} 'background' recognised by the Ontario Ministry for the Environment and Energy (Webber and Wang, 1995).

DDT residue levels in high mountain forest soils from Czechoslovakia have been measured in the range 25 - 111 μg kg^{-1}, with a median of 56 μg kg^{-1} (Holoubek *et al*., 1994). The same study also reported HCB levels of 0.47 - 4.8 μg kg^{-1}, with a median level of 3.7 μg kg^{-1}. These levels are consistently above those measured in soils from the New Zealand forest and grassland sites.
A study of pesticides in soils from the Doñana National Park, Spain, gave dieldrin and total DDT residues at concentrations similar to those measured at forest and grassland sites in the current study (Fernandez *et al*., 1992). HCH residues were frequently detected in these soils. γ-HCH was measured in the range 0.38 - 1.94 μg kg^{-1}, with a median concentration of 0.97 μg kg^{-1}. In contrast, no HCH was measured in any of the New Zealand forest or grassland soils to a maximum limit of detection of 0.05 μg kg^{-1}.

For urban soils, high concentrations of aldrin (up to 2,000 μg kg^{-1}) and heptachlor (up to 130 μg kg^{-1}) have been reported for United States metropolitan cities (Carey *et al*., 1979). Similarly, urban soils in Ireland had HCH concentrations up to a maximum of 12 μg kg^{-1}, markedly above those determined in the current study (McGrath, 1995).

In the same study, McGrath (1995) reported total DDT concentrations for 'urban amenity', 'industrial' and 'suburban garden' soils similar to those measured for the New Zealand forest and grassland soils, suggesting that these sites had not received direct DDT applications or significant inputs from local contaminated areas.

5.4 Chlorophenols

4.5.1 New Zealand chlorophenol soil data

No chlorophenols were detected in 45 of the 51 soil samples collected. Analytical limits of detection were typically 3 - 5 μg kg^{-1} for the trichlorophenols, 2 μg kg^{-1} for the tetrachlorophenols and 0.6 - 1 μg kg^{-1} for PCP.

2,4,6-Trichlorophenol was measured in soils from Waipoua Forest, Pirongia Forest Park and Rimutaka Forest Park, to a maximum concentration of 8.2 μg kg^{-1}. This chlorophenol was not measured in any samples for any of the other land types. 2,4,5-Trichlorophenol was found only in the Northland hill country pasture sample, at a concentration of 10.1 μg kg^{-1}. This sample also showed an elevated PCDD and PCDF I-TEQ result (Table D3, Appendix D), with a profile characteristic of contamination arising from the herbicide 2,4,5-T. Application of 2,4,5-T to the land, and subsequent hydrolysis, would account for the presence of 2,4,5-trichlorophenol in the soil. No other trichlorophenols or any tetrachlorophenols were detected in any of the samples.

PCP was quantified only in two soils from Greymouth (2.1 μg kg^{-1}) and from the Hornby/Birmingham Drive commercial/light industrial area in Christchurch (0.95 μg kg^{-1}). The Greymouth sample had the highest concentration of OCDD measured of all provincial centre soils (693 ng kg^{-1}), and, significantly, also had the highest concentration of OCDD recorded in ambient air in New Zealand (Buckland *et al*., 1999). Similarly, the Hornby/Birmingham Drive sample had the highest OCDD concentration measured of any of the samples collected from Christchurch, at a

concentration of 594 ng kg^{-1}. In comparison, the highest OCDD concentration measured in New Zealand soil (2020 ng kg^{-1}) was found in the Mt Eden/Mt Roskill residential area of Auckland, yet no PCP was quantified in this sample to a limit of detection of 0.7 μg kg^{-1}.

4.5.2 Overseas chlorophenol soil data

Comparative overseas data on chlorophenols in soils are very limited. This dearth of background information has been noted by others (WHO 1989; Wild *et al*., 1992). Most published studies on the concentrations of chlorinated phenols in soils have been performed on sites where these compounds have been used for timber protection or preservation (Valo *et al*., 1984; Kitunen *et al*., 1987; Bundesamt für Umweltschutz, 1983). In most cases, such sites have a soil contamination spectrum varying from acute contamination in areas used for formulation application and storage of dripping timber, to significantly lesser contamination as distances from the treatment and storage areas increase.

Of the few background studies of chlorophenol concentrations in soils published, the most often cited study involved the analysis of two samples from a provincial town in the United States (Harrad *et al*., 1991). The average trichlorophenol, tetrachlorophenol and PCP concentrations of 2.1, 1.0 and 2.5 μg kg^{-1} respectively are broadly similar to the few samples from the current study that had measurable concentrations of these contaminants. The current New Zealand data also compare favourably with a PCP concentration of 35 μg kg^{-1} measured at a background site in Switzerland (Bundesamt für Umweltschutz, 1983), and with concentrations of 100 μg kg^{-1} and 10 μg kg^{-1} measured in agricultural soils in Germany (Gebefuegi, 1981) and the Netherlands (Teekens, 1985) respectively.

Although there is limited overseas information with which to compare the New Zealand data, it is reasonable to make a broad conclusion regarding the general state of the New Zealand environment with respect to chlorophenol contamination. There are localised areas of soil contamination at industrial sites where chlorophenols, and in particular PCP, have been used, some of which have been extensively studied (Ministry for the Environment and Department of Health, 1992; Royds Garden Environmental Services and CMPS&F, 1994). In contrast, the results from this environmental survey show very few forest, grassland, rural or urban (excluding industrial) sites where chlorophenols could be measured, and, where they were present, the level of contamination was generally extremely low. This would attest to a general absence of chlorophenol contamination of the broad-scale New Zealand terrestrial environment.

5.5 Extraneous matter and total organic carbon

The soil composition of each sample was measured with respect to extraneous matter and total organic carbon. Extraneous matter was determined as the percentage of sample that was 2 mm in size or greater. Total organic carbon was measured as total carbon excluding calcium carbonate.

Individual sample results for extraneous matter and total organic carbon are reported in the Organochlorines Programme Environmental Survey. This database is available from the Ministry's website (http://www.mfe.govt.nz/issues/waste/organo.htm). A summary of extraneous matter for each land type is given in Table 5.9.

Table 5.9 Extraneous matter content of New Zealand soils (%, wet wt basis)

	Indigenous forest	Indigenous grasslands	Hill country pasture	Flat land pasture	Provincial centre	Metropolitan centre
Median	12.9	10.2	7.4	6.8	5.5	2.9
Mean	11.5	13.6	10.3	6.8	5.7	3.7
Range	6.9 - 15.3	6.9 - 27.2	2.3 - 30.1	1.0 - 14.3	1.8 - 8.6	1.5 - 11.2

Total organic carbon results are summarised for each land type in Table 5.10. Generally similar organic carbon levels were observed for agricultural and urban soils, with consistently higher organic carbon levels being measured in forest and grassland soils.

Table 5.10 Total organic carbon content of New Zealand soils (%, dry wt basis)

	Indigenous forest	Indigenous grasslands	Hill country pasture	Flat land pasture	Provincial centre	Metropolitan centre
Median	13.7	11.1	6.4	5.0	4.8	4.8
Mean	11.7	11.0	6.1	6.5	5.2	4.9
Range	7.8 - 20.3	3.9 - 17.9	3.3 - 7.9	3.1 - 13.3	3.2 - 8.8	3.7 - 6.0

All organochlorine contaminant concentration data contained in this report are given on a weight per dry soil weight basis. The information on percentage extraneous matter and total organic carbon is provided primarily to enable future processing of the data (e.g. normalised to organic carbon content) by readers and other end users of this report.

5.6 Data quality

The organochlorine contaminant concentration data found in this current study are supported by comprehensive field and laboratory quality control (QC) data. These QC data are included in the relevant appendices and the Organochlorines Programme Environmental Survey database (http://www.mfe.govt.nz/issues/waste/organo.htm).

Field QC involved the collection of field blanks and equipment rinsate blanks. Blind duplicate samples were also collected as a check on the laboratory performance.

A single field blank was collected from each of forest, hill country pasture, flat land pasture, provincial centre and metropolitan centre soils. Two equipment rinsate blanks were collected from provincial centre soils (Table B3, Appendix B). No organochlorines were quantified in any of these QC samples (Appendices D to G).

Laboratory QC involved ongoing monitoring for laboratory contamination, together with soil replicates, matrix spikes and split cross-check analyses. Strict QC criteria were established for the identification and quantification of analytes (Appendix C). These included criteria with respect to analyte signal to noise, chlorine cluster ratios and laboratory blank contamination.

Recoveries of the ^{13}C surrogate standards from the PCDD and PCDF, PCB and organochlorine pesticide analyses were monitored for all samples. Generally excellent ^{13}C recoveries were obtained that were well within the 25-150% criteria established for analyte quantification. Mean ^{13}C recoveries for samples from the same land type are reported in Appendices D to F. ^{13}C recoveries for individual samples are reported in the Organochlorines Programme Environmental Survey database.

Method precision data from soil replicate and matrix spike analyses are reported in Table C5 (Appendix C). Replicate analysis of a soil laboratory control sample contaminated with low concentrations of organochlorines gave, for PCDD and PCDF, and PCB analyses confidence intervals of ±18% and ±30% of the mean (at the 95% confidence level) when measured as I-TEQ and PCB TEQ respectively. The low concentrations of PCDD, PCDF and PCB congeners in the sample, the variability in their frequency of detection and the analytical limits of detection achieved, and how limits of detection were handled in the TEQ calculation markedly affected the confidence intervals obtained. Much narrower confidence intervals were obtained for specific contaminants that were present at concentrations approximately 5-10 times the analytical detection limit, and that were regularly quantified. For example, from the same soil replicate analyses data set, the confidence interval for OCDD was ±7% of the mean, for PCB #153 ±10%, and for dieldrin ±3% (95% confidence level).

Analysis of blind duplicates was undertaken on samples collected from indigenous forest, hill country pasture, provincial centre and metropolitan centre soils. Split primary soil samples were also prepared and analysed by an independent cross-check laboratory. The results of the blind duplicate and split cross check analyses (Appendices D to G) were generally in excellent agreement, particularly given the low concentrations of organochlorine contaminants found in the New Zealand soils.

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Appendix A Status of organochlorines in New Zealand

This appendix provides a brief chronology and a summary of relevant New Zealand legislation for the polychlorinated biphenyls (PCBs) and organochlorine pesticides which are being studied as part of the Organochlorines Programme. Its purpose is solely to provide background information to the reader. It is not a comprehensive history of PCBs or persistent organochlorine pesticides in New Zealand.

Table A1 Summary of relevant New Zealand legislation for PCBs from 1979 to present

Year	Legislation/Publication	Regulatory status	Comments
1979	Toxic Substances Act	Establishes Toxic Substances Board: provides advice to Minister and Director-General of Health on wide range of matters associated with human health and the environment in relation to toxic substances within various schedules, and advises the Minister accordingly on matters relating to the scheduling, sale, labelling, storage, licensing and importation of toxic substances.	No immediate effect on PCBs, but see later regulations under the Act.
1984	The Electrical Supply Regulations	Labels required on equipment containing PCBs with cautions to handle with care; transformers that had previously been filled with PCB required to have details of time and name of substance replacing the PCB, the date of the treatment to reduce PCB residues, and the tested level of PCB residue remaining in ppb.	The Electrical Supply Regulations revoked April 1993 by s. 173(3) of the Electricity Act 1992.
1984	United Nations	UN recommendations on the Transport of Dangerous Goods identified PCBs under Class 9 No. 2315. Interdepartmental group agreed, in 1985, that Class 9 is inappropriate for PCBs and recommended PCBs be classified as Class 6: toxic substance packing group 2.	This specified the type of hazard warning label required in New Zealand when transporting PCBs, applied to the truck carrying PCBs as well as to each PCB container or drum during transport.
1986	The Toxic Substances Regulations 1983, Amendment No. 1	Controls placed on importation of PCBs.	Customs Department prohibits importation of PCBs in March 1986 and the import controls were incorporated into Amendment No. 1 in December 1986.
1987	OECD and UNEP Guidelines	NZ is obliged to meet OECD and UNEP guidelines on use and disposal of PCBs.	
1988	The Toxic Substances Regulations 1983, Amendment No. 3	Imposed controls on PCBs. Owners of PCBs were required to notify the Medical Health Officer up until 1 June 1989. Strict safety criteria on storage and disposal of PCBs (and continued prohibition on importation). Controls on PCBs were to ensure that all PCBs were phased out over the next five years, with prohibition on both use and storage effective from 1 January 1994 (but see below for extensions of this date). Code of practice "*Safe Management of PCBs*" was released by the Department of Health.	On application, the Director of the Toxic Substances Act 1979 may exempt companies from the use and storage prohibition on PCBs. However, storage and handling of PCBs must conform at all times with the code of practice "*Safe Management of PCBs*" in order to qualify for the exemption.
1988	The Toxic Substances Regulations 1983, Amendment No. 3, Sec. 54A.	The legislation (s.54) provides people who adhere to the code of practice "*Safe Management of PCBs*" a special defence against conviction under the PCB regulations relating to storage, use, transportation and disposal of PCBs. Transportation of all PCB material must comply with the requirements of NZS: *5433 "Code of Practice for the Transportation of Hazardous Substances on Land*".	

Year	Legislation/Publication	Regulatory status	Comments
1993	The Toxic Substances Regulations 1983, Amendment No. 4	Use of PCBs is prohibited from 1 January 1994. Storage of PCBs is prohibited effective from 1 August 1994. Disposal and storage of PCBs must comply with the Code of Practice.	The Code of Practice "*Safe management of PCBs*" was reprinted in 1993. A revision of the disposal policy resulted in the disposal of small amounts of PCB at suitable landfills being considered to be environmentally unacceptable.
1994	The Toxic Substances Regulations 1983, Amendment No. 5	PCB storage deadline extended by one year, to 1 August 1995, to give owners of PCB-containing equipment more time to safely dispose of their PCB holdings.	The Basel convention in 1992, covering the control of trans-boundary movement of hazardous wastes and their disposal, led to delay in export of PCBs from New Zealand to France for destruction. This effectively meant there was no disposal option for PCB owners in New Zealand between 1992 and 1994, hence the need to extend the storage deadline.

Table A2 Status of organochlorine pesticides in New Zealand

Included substances	Year	Legislation/Publication	Regulatory status	Comments
All potential stock remedies	1934	The Stock Remedies Act	Appoints a board of control, The Stock Remedies Registration Board. All remedies must be registered with details of properties attached to packages; inspectors given powers to sample and analyse.	A stock remedy is defined as any substance used to prevent or cure disease, or to destroy pests in stock, or to improve stock health (not including food).
All stock remedies and pesticides	1934	The Agricultural (Emergency Powers) Act	Regulates marketing and production of agricultural products and provides provision for financing the use of substances for the eradication of disease in dairy herds under special circumstances.	
Aldrin, Chlordane, DDT, Dieldrin, Endrin, HCB, PCP, Toxaphene	1934	The Poisons Act (Schedule 4)	General controls on registration and carriage of substances listed in the Act schedules. Only licensees can sell these substances at wholesale, and only professionals can sell them at retail.	Schedule 4 was reprinted (as S.R. 1952/45) specifying these pesticides and other chemicals.
All agricultural and horticultural pesticides and weed killers	1937	The Poisons (General) Regulations (Schedule 3)	Under the Poisons Act 1934. General controls on sales, importation, carriage and use: stringent labelling, packaging, invoicing requirements; Governor-General given powers to regulate aspects of sale, importation, carriage and use.	Removes the agricultural/horticultural chemicals under schedule 4 of the Act and places them under schedule 3. Stronger regulations thus apply.
DDT	1945		Early trials as a pesticide.	
DDT	1947		Residue results published.	
DDT	1951		Use as pesticide mixtures with fertiliser widespread for treatment of pasture.	
Aldrin, Dieldrin	1954	Under the Stock Remedies Act (1934)	Introduced to NZ and licensed as stock remedies.	
Agricultural chemicals	1959	Agricultural Chemicals Act	Establishes Agricultural Chemicals Board. All agricultural chemicals required to be registered including stringent requirements on labelling, packaging, sales, advertising, warranties; registrations able to be revoked for substances likely to prejudice health and safety of humans, stock or beneficial species.	This Act covers all agricultural chemicals defined as substances or mixtures sold for the purpose of controlling insect pests, plant diseases and weeds in agriculture and horticulture and for influencing plant growth or behaviour.

Included substances	Year	Legislation/Publication	Regulatory status	Comments
Aldrin, Dieldrin	1961	*Gazette*, March 1961	Department of Agriculture (under The Stock Remedies Act) advises that it intends to revoke licences for all preparations containing aldrin or dieldrin. The revocation, however, is unable to be implemented without changing the legislation.	The Agricultural (Emergency Powers) Act (1934) still allows limited finance for the rehabilitation of the dairy industry and some other emergencies.
DDT	1961	The Agricultural Chemicals (Insecticides) Regulations	Specifies strict terms for application of DDT on farm land: only pelleted formulations allowed; application required to be in accord with strict limits to acreage, pasture type, time and rate of application.	
Specified organochlorine insecticides	1961	The Agricultural Chemicals (Insecticides) Regulations	Permit required from Department of Agriculture to use organochlorine pesticides on farm land.	Still legal to use for non-agricultural (i.e. residential, horticultural) pest control without permits. Industrial pest control and timber treatment uses not within the scope of the Act.
DDT	1961	The Agricultural Chemicals (Insecticides) Notice	Placed more stringent permit requirements on use of DDT: specifies dry/dust application only, application forbidden on pasture where stock are grazing, specifies stand down periods for when pasture can subsequently be grazed, specifies strict acreage controls and packages containing DDT formulations required to have clear instructions attached.	
All pesticides	1961	The Stock (Insecticides and Oestrogens) Regulations	Under the Agricultural (Emergency Powers) Act, 1934, all uses of stock treatments subject to general regulations. Users must supply on general request, to the Director-General of Agriculture, information on intended use, and details of the substance.	
Aldrin, Dieldrin, DDT, Lindane (BHC)	1961	*Gazette*, September 1961	Prohibition of selected substances as active ingredients in stock treatments under the Stock (Insecticides and Oestrogens) Regulations 1961.	
BHC (mixed isomers)	1962	*Gazette*, June 1962	Last product withdrawn.	

Included substances	Year	Legislation/Publication	Regulatory status	Comments
DDT	1963	The Agricultural Chemicals (DDT Pellets) Notice	Further restrictions on types of formulations and terms of application allowed: no dust formulations; liquid and wettable powders subject to permits and restricted to commercial horticultural use.	
DDT	1964	The Agricultural Chemicals (Insecticides) Notice	Further restrictions on allowable pellet formulations and terms of application.	
Aldrin, Dieldrin	1963-1964			Disposed of by spraying on Government Land and Survey blocks in 6 areas around New Zealand.
Aldrin, Dieldrin	1964	*Gazette*, January 1964	Application in dust form no longer permitted.	Disposal by spraying of Land and Survey blocks ceased but some special dispensations were allowed.
Aldrin, Dieldrin	1966		Agricultural Chemicals Board recommends no further permits for use on agricultural land. By November 1966 no more permits were issued for agricultural use by the Department of Agriculture.	
Animal remedies	1967	Animal Remedies Act	Establishes Animal Remedies Board. Consolidates and amends the Stock Remedies Act (1934); prohibition on manufacturing, selling, importing, using an animal remedy without a licence; stringent labelling, container, advertising requirements; accuracy of information required.	An animal remedy is defined as any substance used to cure or treat disease, to destroy or prevent parasites, to maintain or improve health in animals.
All OC pesticides	1968	The Agricultural Chemicals Regulations	General controls on sales, permits, transport, storage; powers given to inspectors.	
Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Toxaphene	1968	The Agricultural Chemicals Regulations	14 week withholding period for livestock from pasture treated with these pesticides.	
DDT	1968	The Agricultural Chemicals Regulations	Restrictions on amount of DDT allowed in packages for home garden use; 12 week withholding period placed on livestock.	

Included substances	Year	Legislation/Publication	Regulatory status	Comments
Lindane	1968	The Agricultural Chemicals Regulations	6 week withholding period for livestock from pasture treated with these pesticides.	
DDT	1968	The Agricultural Chemicals Notice, June 1968	Further limits placed on DDT formulations including stricter control on permits, pasture types allowed, dry conditions, pellet sizes, abrasion criteria on pellets and acreage allowable. Use on dairy land is prohibited.	Permits were required for use on dairy land but none were issued (an effective prohibition). For other uses a permit was required but few permits were issued.
Aldrin, Chlordane, Dieldrin, DDT, Lindane	Up to 1970		Non-agricultural uses (timber and industrial pest control) not within the scope of the Agricultural Chemicals Act.	Heavy use of these substances for non-agricultural, industrial purposes during this period, also in timber treatment for borer control (dieldrin, DDT, chlordane). Lindane used as timber preservative.
Heptachlor, Endrin, Toxaphene	Up to 1970			Limited use only, from the time of introduction of products containing these substances, up to 1970.
DDT, Lindane	1970	The Agricultural Chemicals (Pelleted Insecticides Specification) Notice	Specifies sizes, densities, abrasion criteria to be met, and standard testing methods for these.	
DDT	1970	Revocation of Agricultural Chemical Notice 1968	All remaining DDT purchase and use subject to Department of Agriculture permit.	Permits then issued only for limited horticulture use where non-organochlorine pesticides were ineffective.
Heptachlor	1971	*Gazette*, September 1971	Last product withdrawn.	
HCB	1972	*Gazette*, October 1972	HCB deregistered for use as a horticultural pesticide, making it no longer legal to sell, manufacture or use HCB as a pesticide; thus effectively banned.	Between 1970 and 1972 HCB had only limited registration.
Aldrin, Dieldrin	1975		Agricultural Chemicals Board recommends the cessation of permit issuing for any use. The Department of Agriculture ceases issuing permits. This amounts to an effective ban for agricultural usage because usage required a permit in most cases.	It is not certain whether any more permits were in fact issued or not by the Department of Agriculture, unofficial sources suggest that indeed none were issued after this date.

Included substances	Year	Legislation/Publication	Regulatory status	Comments
Endrin	1976	*Gazette*, October 1976	Last product withdrawn.	
All pesticides	1979	Pesticides Act	Establishes Pesticides Board. No sales can be made unless the substance is registered with Pesticides Board; the Board can revoke registration; stringent requirements placed on labels, packaging, warranties, advertising, transport, and application methods.	The Agricultural Chemicals Board had had a confirmed policy to phase out all OC pesticides a policy which is endorsed by the now appointed Pesticides Board.
OC pesticides	From 1979	Pesticides Act		The phasing out of OC pesticides was managed gradually by the Pesticides Board. First by permit control and then by deregistering of specific products containing OC formulations.
Refer to schedules under the Regulations	1979	Toxic Substances Act	Establishes Toxic Substances Board. Empowers Department of Health to classify substances; sales restricted; Minister of Health can prohibit imports, sales, manufacture, possession and use; stringent requirements placed on labelling, packaging, advertisement, storage, invoices. Importers must notify Department of Health Officers and provide Customs with details of the substances.	Enforcement of importation restrictions has been largely up to the vigilance and discretion of Customs officers.
All OC pesticides	1983	The Pesticides Regulations	Permits are required to sell or use scheduled pesticides with exceptions for chlordane, DDT and lindane. No livestock are allowed near premises where pesticides are kept.	The Board polices the phase out of all OCs as suitable alternatives become available. Carry-over of earlier restrictions and extension of these to cover non-agricultural uses (e.g. timber treatment and industrial pest control).
Chlordane, DDT, Lindane	1983	The Pesticides Regulations	Allowed without permit for domestic use.	
Chlordane	1983	The Toxic Substances Regulations (Schedules 3-4)	Licensees must specify usage and nature of substances sold or purchased. Other stringent controls on handling, carriage, importation, labelling etc. apply. Information must be supplied to Officers (of the Act) under request. There are restrictions on who can act as an agent for the licensees.	Schedules 3 and 4 are classified as "standard poisons" and "harmful substances" respectively. Electrical equipment has exemptions.
Aldrin, DDT, Dieldrin, Lindane, PCP	1983	The Toxic Substances Regulations (Schedules 1-2)	Sales of these substances must be recorded in a "Sale of Poisons" book. Stricter criteria on advertising, storing, labelling also apply to substances in this schedule.	Schedule 1 are "deadly poisons" and Schedule 2 are "dangerous poisons".

Included substances	Year	Legislation/Publication	Regulatory status	Comments
Aldrin	1985	*Gazette*, September 1985	Last product withdrawn.	
PCP	1988			PCP use ceased voluntarily in the timber treatment industry.
DDT	1989	*Gazette*	The last remaining products containing DDT deregistered by the Pesticides Board, effective as from 31 December 1989.	This means it is illegal to use DDT as a pesticide. Other novel uses are legal, subject to existing legislation (e.g. Toxic Substances Regulations), (e.g. as an anti-cancer agent in the 1970s).
Dieldrin	1989	*Gazette*	The last remaining dieldrin products deregistered by the Pesticides Board.	This means it is illegal to use dieldrin as a pesticide.
Chlordane	1989		Application for registration of chlordane products declined by the Pesticides Board.	It is illegal to sell, manufacture or import chlordane for use as a pesticide.
Lindane	1990	*Gazette*, December 1990	Last remaining lindane products deregistered and the substance effectively banned.	
PCP	1991	*Gazette*	The last remaining PCP product deregistered by the Pesticides Board.	This makes it illegal to use PCP as a pesticide, but other uses are presumably allowable subject to Toxic Substances Regulations.
PCP	1992	*Gazette*, May 1992	Pesticides Board agrees in principle to the tightly controlled use of PCP in timber treatment plants subject to stringent environmental protections, particularly of waste materials. The agreement to use in principle required a "closed circuit" of PCP and PCP product to be maintained.	Conditions set by the Pesticides Board have not been taken up and currently no PCP-based products are registered. Thus PCP use as a pesticide is not permitted, and it is effectively banned.

Appendix B Sampling programme

This appendix provides an overview of the soil sampling programme. It details:

- Sampling areas
- Sampling site selection
- Sampling strategy
- Sample collection
- Site-specific data

B1 Sampling strata

Soil sampling was undertaken from eight areas ('strata') defined on the basis of geography, climate and geology. The strata generally conformed with current administrative (Regional Council) boundaries. The eight strata and their attributes are outlined in Table B1.

Table B1 Sampling strata for the organochlorines soil sampling programme

Stratum	Soil parent rocks and landforms	Climate
Northland	(Old) Paleozoic, Mesozoic and Tertiary sedimentary and igneous rocks, and coastal sands.	Warm humid summers, mild winters. 1000 - 2400 mm mean annual rainfall (m.a.r.), with winter maximum.
Waikato-Bay of Plenty	Rhyolitic and andesitic volcanic ash, tertiary hill country, greywacke and argillite.	Warm and very warm humid summers, mild winters. 1000-1800 mm m.a.r. with winter maximum.
Taranaki-Southwest Waikato	Andesitic volcanic ash and tertiary sedimentary rocks.	Warm humid summers, mild winters. 1500-2400 mm m.a.r. dropping to 900 mm in South Taranaki.
Hawke's Bay-East Coast	Terraces and river flats, tertiary hill country, greywacke and argillite.	Very warm summers and moderate winters. Warm NW winds. 600-1500 mm m.a.r. Lower spring and summer rainfall.
Wellington-Wanganui	Alluvium and loess on terraces, river flats, and coastal sands. Tertiary hill country and greywacke soils.	Warm summers and mild winters. 900-1300 mm m.a.r. evenly distributed, and 1300-2000 mm at higher elevations.
Marlborough-Canterbury	Greywacke/argillite, schist, some Tertiary hill country, alluvium on terraces and river flats.	Warm summers, cool winters. Warm NW winds. 500-1500 mm m.a.r. Snow inland.
West Coast-Tasman	Glacial and post-glacial terrace deposits (loess, alluvium and till), plutonic igneous rocks, metamorphic rocks and greywacke-argillite.	Mild temperatures. Prevailing SW winds. 900-2000 mm m.a.r. with winter minimum.
Otago-Southland	Metamorphic rocks (schist), greywacke and argillite, basalt, and loess and alluvium on terraces and river flats.	Warm summers and cool winters. 600-1500 mm m.a.r. even throughout year. Snow, and cool, wet upland climates. Dry inland basins (<500 mm).

Within each stratum the following land types were recognised:

- indigenous forest;
- indigenous grassland;
- pasture on hill country land;
- pasture on flat land;
- urban residential land in provincial centres (municipal parks and reserves).

Samples from forest and grassland sites were collected from National Parks and Department of Conservation estate land in remote areas. Two composite samples were collected from the larger strata, but only one composite sample was collected from the smaller strata, giving a total of four forested and three grassland sites from the North Island, and three forested and two grassland sites

from the South Island (Table B2). For hill country pasture, flat land pasture and provincial centres, a single composite sample for each land type was collected from each strata.

Fifteen samples were also collected from throughout two major metropolitan centres, Auckland and Christchurch (Table B2). To ensure that the sampling programme covered a variety of urban locations and land uses within these centres, samples were collected from areas that could be described as either: predominantly residential; or commercial/light industrial.

Table B2 Summary of soil samples collected

Stratum	Indigenous forest	Indigenous grassland	Flat land pasture	Hill country pasture	Provincial centre	Metropolitan centre
Northland	1	-	1	1	1 (Whangarei)	-
Waikato-Bay of Plenty	2	-	1	1	1 (Hamilton)	-
Hawke's Bay-East Coast	-	1	1	1	1 (Napier)	-
Taranaki-SW Waikato	-	1	1	1	1 (New Plymouth)	-
Wellington-Wanganui	1	1	1	1	1 (Masterton)	-
Marlborough-Canterbury	1	1	1	1	1 (Timaru)	-
West Coast-Tasman	1	-	1	1	1 (Greymouth)	-
Otago-Southland	1	1	1	1	1 (Invercargill)	-
Auckland	-	-	-	-	-	9
Christchurch	-	-	-	-	-	6

B2 Sampling site selection

B2.1 Forest, grassland and agricultural sampling sites

Sampling sites were chosen randomly from within National Parks and other Department of Conservation estate lands for the forest and grassland soils, and from agricultural land. All NZMS 1:250,000 scale topographical maps that covered a particular region (stratum) were selected, and 40 or more easting and northing co-ordinates were entered from these maps into a QUATTRO PRO spreadsheet. A QUATTRO PRO random number generator was used to select 20 easting and 20 northing co-ordinates which when combined provided 20 randomly selected grid squares each measuring 10 km by 10 km. Within each stratum, a 'sampling station' from within a grid square was then identified.

The sampling team for each stratum was instructed to position the sampling station as close as possible to the centre of the first randomly selected grid square. If this was not possible, for example for reasons of poor access, then the top left quarter of the grid square was to be tried next. If this failed, for whatever reason, the top right, bottom left, and bottom right quarters were to be tried in this order. If the whole grid square failed then the next randomly generated grid square on the list was to be tried, and so on. When a sampling station was assigned to one of the 20 randomly selected 10 km

by 10 km grid squares, no more sampling stations were assigned to that grid square, and the next on the list was selected.

Prior to sampling, permission was sought from the Department of Conservation who issued the required permits, and from individual land owners for sampling from pastoral land.

B2.2 Provincial and metropolitan centre sampling sites

Within provincial and metropolitan centres, samples were collected from public parks or reserves. Sampling from these areas was preferred over other land types (for example private residential properties) as it was possible to obtain information on the history of potential sampling sites from the local authority concerned. Sites were chosen that had undergone minimal disturbance or replacement of topsoils in preference to areas where the soil surface had been significantly disturbed. To aid in the selection of suitable parks or reserves, the following criteria were applied. The sites should:

- ideally be a well known or easily identifiable park (for example, a local landmark area);
- be of sufficient size to accommodate the sampling procedure as detailed in the quality assurance project plan;
- provide for a good geographical spread across the city;
- ideally, the top soil layer to have had minimal disturbance for approximately the last 30 years. It was recommended that senior sports pitches (rugby/soccer grounds etc.) or frequently manicured areas of lawn were avoided (likely to have been modified, for example, through the addition of topsoil);
- allow for sampling to be taken away from buildings (preferably at least 20 m) or other structures;
- not have been farmed;
- not be susceptible to regular flooding;
- not have been built on an old landfill or industrial site;
- provide for a balance of parks that were located in primarily residential neighbourhoods and in commercial/light industrial areas of the city (for metropolitan centres only).

Sites were selected in consultation with district and city council Parks Department staff who were contacted for information on these criteria relating to parks and reserves in their control, and for the necessary approvals to sample. Grid references for the sampling positions were recorded typically using NZMS 271 1:12,500 scale 'Streetfinder' maps or, in a few cases, NZMS 260 1:50,000 scale topographical maps.

B3 Sampling strategy

B3.1 Forest, grassland and agricultural soil sampling

Soil sampling was undertaken from each sampling station identified within a grid square. For forest and grassland, hill country pasture and flat land pasture sites, a 'triangular sampling station' approach was followed. This involved the collection of individual soil cores from equidistant points along the sides of an equilateral triangle with sides measuring 1.5 km. Each side of the triangle had 10 soil cores collected from it, with common cores at the corners, so that 27 unique cores were collected per

triangle. The triangular sampling approach had the advantage of returning the sampling team to their original starting point after collecting the last soil core (Figure B1). For forest areas where it was not possible to keep to a triangular sampling station (when sampling in dense bush), straight-line transects uphill were used.

Each soil sample was collected from a single sampling station for forest and grassland sites. Particular care was taken to ensure that sampling was undertaken well away from areas affected by human activities. Sampling criteria required that:

- no sample was collected within 1 km of any road or track carrying motor vehicles, or within 1 km of any recreational area;
- any sampling point accessed from a walking track was no closer than 40 m from the track.

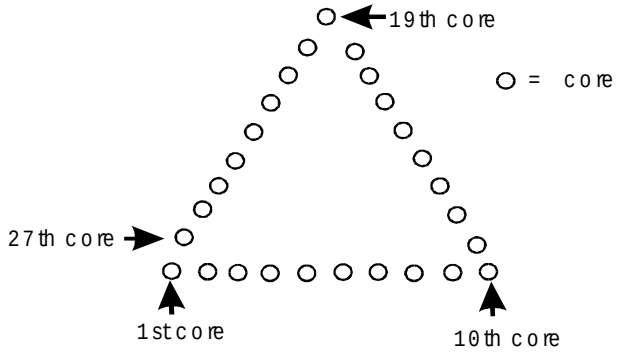

Figure B1 Schematic of the triangular sampling station methodology

In hill country pasture and flat land pasture, each sample was collected from two sampling stations taken from separate randomly selected grid squares, giving a total of 54 soil cores which were later composited for analysis. Soil cores taken from different sampling stations were collected into separate sample collection jars. This allowed for the analysis of soil from any single sampling station if subsequently required. Sampling criteria required that:

- each sampling station was restricted to a single farm property;
- no samples were to be collected within 1 km of a major state highway, 500 m of a secondary sealed road or 200 m of an unsealed road;
- no soil cores were to be collected within 5 m of any wooden building or structure (including fences and telegraph poles).

B3.2 Provincial and metropolitan centre soil sampling

For provincial and metropolitan centres, samples were collected from, typically, four parks or reserves. Nine soil cores were collected as a 3 x 3 grid from each park or reserve in provincial centres, giving a total of 36 soil cores per centre. Twelve soil cores were collected typically as a 4 x 3 grid from each park or reserve in Auckland and Christchurch, giving a total of typically 48 soil cores per sample. The spacing between the cores was dependent upon the size of each particular park, but was at least 25 m, and cores were no further than 50 m from each other. If necessary, the shape of the

grid was modified to suit a particular park or reserve, for example, to a 6 x 2 grid for a metropolitan park. If required, random sampling was undertaken, but in such cases, no soil core was taken any closer than 25 m to another core. In all cases, no soil cores were collected closer than 10 m from any park boundary, fence line or building. All soil cores collected from different parks or reserves were collected into separate sample collection jars. This allowed for the analysis of soil from any single park or reserve if subsequently required.

B4 Sample collection

All sampling equipment used, including a stainless steel coil corer (25 mm diameter), stainless steel scissors for trimming grass over the sample and a stainless steel spoon for compacting samples in the jar were cleaned thoroughly by washing in water followed by rinsing with acetone and hexane. Equipment was cleaned at the commencement of a day's sampling, between sampling stations, and between parks and reserves. Soil cores were collected into precleaned (water, acetone, hexane) 1 litre glass sample collection jars with aluminium foil (hexane rinsed) lined lids.

After a sampling station was chosen from the randomly selected list and the start point located for the sampling triangle, the previously cleaned stainless steel soil corer was used to collect typically 5 cores, all of which were discarded. This procedure added one more "cleaning" step to the process. The same cleaning procedure was used when sampling from parks and reserves.

Prior to sample collection, any grass over the sampling area was trimmed to ground level. In forests, all overlaying fresh or weakly decomposed organic matter (leaves and twigs etc.: L horizon) and stones were removed. Well decomposed litter (H horizon), often mixed with mineral matter, was collected together with the underlying mineral A horizon. In grasslands, including urban parks and reserves, fresh and weakly decomposed pasture litter (F horizon) was removed and the soil cores were collected mainly from within the mineral A horizon, but including any thin layer of decomposed pasture litter overlying the A horizon after the fresh litter was removed.

Particular care was taken to avoid any possible contamination of the sample. Procedures included:

- no contact of the sample with plastic material;
- minimising any direct contact of the sample during the sampling processes with any item other than the soil corer;
- avoiding any exposure of the samples once collected with any materials other than the sampling containers;
- rigorous cleaning procedure of the soil corer and other sampling items between the collection of soil cores from different sampling locations or parks and reserves.

Soil cores were 25 mm in diameter, and taken to a depth of 100 mm. Following collection, each soil core was immediately placed in a precleaned glass collection jar. Once all soil cores had been collected from a sampling station or park and reserve, the sample was given a unique identification number, the jars labelled, and a custody seal fixed over the screw cap. Jars were each sealed in a plastic bag to prevent contamination by meltwater from ice used to keep the samples cool during the day, packed in polystyrene boxes and sent, along with chain of custody forms, by overnight courier to the primary analytical laboratory.

Simultaneously with the collection of primary soil samples, a series of quality control samples consisting of field blanks (6 samples), equipment field rinsate blanks (2 samples) and blind duplicates (6 samples) were also collected (Table B3). Primary and quality control samples were collected in accordance with the study quality assurance project plan.

Table B3 Soil sampling quality control samples

QC sample	Collected from (land type, stratum)
Field blanks	Indigenous forest, Northland Hill country pasture, Otago-Southland Flat land pasture, Marlborough-Canterbury Provincial centre (Masterton), Wellington-Wanganui Metropolitan centre, Auckland Metropolitan centre, Christchurch
Equipment field rinsate blanks	Provincial centre (Napier), Hawke's Bay-East Coast Provincial centre (Greymouth), West Coast-Tasman
Blind duplicates	Indigenous forest, Otago-Southland Hill country pasture, Taranaki-SW Waikato Provincial centre (Hamilton), Waikato-Bay of Plenty Provincial centre (Timaru), Marlborough-Canterbury Metropolitan centre, Auckland Metropolitan centre, Christchurch

B5 Site data

A field log was completed for each sample collected. This was used to record site data and any deviations from the sampling procedure specified in the quality assurance project plan. Site data and other field log information are detailed in Tables B4 (indigenous forest), B5 (indigenous grassland), B6 (hill country pasture), B7 (flat land pasture), B8 (provincial centres), B9 (metropolitan centre: Auckland) and B10 (metropolitan centre: Christchurch).

Table B4 Indigenous forest site data

Stratum	Location	Grid reference[1]	Soil type	Date sampled	Sampling deviations
Northland	Waipoua Forest, east of Waipoua Forest Village	NZMS 260 O06/633,174	Waipoua hill soils	26/03/96	-
Waikato-Bay of Plenty	Pirongia Forest Park	NZMS 260 S15/984,549	Karioi soils	13/03/96	(2)
	Whirinaki Forest Park	NZMS 260 V18/226,702	Pukurimu soils	19/03/96	-
Wellington-Wanganui	Orongorongo Valley, Rimutaka Forest Park	NZMS 260 R27/748,826	Ruahine soils	24/03/96	-
Marlborough-Canterbury	Near footbridge across Paratu Stream, Arthur's Pass National Park	NZMS 260 K33/957,235	Otira steepland soils	11/04/96	-
West Coast-Tasman	Near Punakaiki River road bridge, Paparoa National Park	NZMS 260 K30/739,965	Punakaikai soil set (Lowland yellow-brown earths and related steepland soils)	01/04/96	(3)
Otago-Southland	Catlins Forest	NZMS 260 G46/348,159	Owaka soil set	27/02/96	-

(1) NZMS 260 series (1:50,000 scale).
(2) Straight-line transect sampling.
(3) V-shaped transect adjacent to walking track.

Table B5 Indigenous grassland site data

Stratum	Location	Grid reference	Soil type	Date sampled	Sampling deviations
Hawke's Bay-East Coast	Ruahine Forest Park near Lessongs Monument	NZMS 260 U21/900,752	Ruahine soils	25/03/96	-
Taranaki-SW Waikato	Manganui Ski Field, Mount Egmont National Park	NZMS 260 P20/032,114	Un-named subalpine soils	06/03/96	-
Wellington-Wanganui	Tabletop, Otaki Forks, south-west Tararua Forest Park	NZMS 260 S26/007,303	Alpine soils	21/03/96	(1)
Marlborough-Canterbury	Beeby's Knob, St Arnaud, Nelson Lakes National Park	NZMS 260 N29/044,442	Pelorus steepland soil	06/04/96	(2)
Otago-Southland	Beaumont, Blue Mountains	NZMS 260 G44/743,300	Maungatua soil set	02/04/96	-

(1) Combination of triangle and straight-line sampling (grassland area not large enough to accommodate triangle).
(2) Straight-line transect at Beeby's Knob (upland grassland area not large enough to accommodate 1.5 km wide triangle).

Table B6 Hill country pasture site data

Stratum	Grid reference	Location	Land use	Soil type	Date sampled	Sampling deviations
Northland	NZMS 260 Q08/351,739	Brookes Road, 30 km south of Whangarei	Dairy farming	Mata clay	23/03/96	-
	NZMS 260 P05/894,644	Maungaparerua, 8 km west of Kerikeri	Sheep and beef farming	Waiotu friable clay and Komo clay loam	24/03/96	-
Waikato-Bay of Plenty	NZMS 260 R17/855,843	Ohura Road, Aria, 36 km south-west of Te Kuiti	Sheep and beef farming	Onaio soils	29/03/96	-
	NZMS 260 U15/937,492	Te Waerenga Road, Hamurana, 3 km north of Lake Rotorua	Sheep farming with beef and deer	Pohaturoa steepland soils	04/03/96	-
Hawke's Bay-East Coast	NZMS 260 T25/348,443	Jacksons Line, Mauriceville West, RD 2, 20 km north-east of Masterton	Sheep and beef farming	Pahiatua soils	14/03/96	-
	NZMS 260 U25/712,649	Rimu Road, RD 9, Pahiatua. 60 km north-east of Masterton	Sheep and beef farming	Mahoenui soils	15/03/96	-
Taranaki-SW Waikato	NZMS 260 Q20/341,960	Rawhitiroa Road, RD 19, Eltham, 11 km east of Eltham	Sheep farming	Whangamomona steepland soils	05/03/96	-
	NZMS 260 R20/535,123	Mangaehu Road, RD 22, Makahu. 32 km east-north-east of Stratford	Sheep farming	Whangamomona steepland soils	07/03/96	-
Wellington-Wanganui	NZMS 260 S22/148,381	Galpins Road, RD 2, Marton. 32 km east of Wanganui City	Sheep farming	Hunterville soils	27/02/96	-
	NZMS 260 S21/124,688	Te Hue Road, Kakatahi, RD 3, 40 km north-east of Wanganui City	Sheep and cattle farming	Mangatea soils	11/03/96	-
Marlborough-Canterbury	NZMS 260 J38/313,724	McLeans Road, 6 km west of Fairlie	Sheep and cattle farming	Hurunui hill soils	26/03/96	-
	NZMS 260 J37/680,950	Peel Forest, RD 22, Geraldine	Sheep and beef farming	Hurunui hill soils	27/03/96	(1)
West Coast-Tasman	NZMS 260 K31/031,795	Ikamatua Golf Links Road, Ikamatua	Sheep and beef farming with some cropping	Ahaura soils - well drained soils on low glacial outwash terraces	31/03/96	-
	NZMS 260 K29/922,325	Bald Hill Farm, Cape Foulwind, RD 2, Westport	Sheep and beef farming	Addison soil set	09/04/96	-
Otago-Southland	NZMS 260 H42/837,448	Roberts Road, RD 4, Ranfurly	Sheep farming	Blackstone soils	22/02/96	-
	NZMS 260 I41/222,698	Mt Dasher Station, Five Forks Road, 30 km west-north-west of Oamaru	Sheep and beef farming	Kakahu soils	26/02/96	-

(1) Two narrower triangles back to back used, as farm too narrow to accommodate one wide triangle.

Table B7 Flat land pasture site data

Stratum	Grid reference	Location	Land use	Soil type	Date sampled	Sampling deviations
Northland	NZMS 260 R09/512,313	Old Kaipara Rd, Kaipara Flats, Warkworth[1]	Dairy farming	Kara silt loam	22/03/96	-
	NZMS 260 Q08/456,633	Tara, Kaiwaka, RD 2, 40 km south of Whangarei	Dairy farming	Kara silt loam	25/03/96	-
Waikato-Bay of Plenty	NZMS 260 T14/365,854	Boltons Road, 7 km south-east of Morrinsville	Dairy and beef drystock farming	Tirau soils	12/03/96	-
	NZMS 260 S14/199,834	Kirou Road, Eureka, 10 km north-east of Hamilton City	Dairy farming (previously beef)	Otakairangi soils	21/03/96	-
Hawke's Bay-East Coast	NZMS 260 T26/393,259	Whangaehu Road, RD 6, Masterton, 6 km east of Masterton	Sheep and beef farming with some crops	Tokomaru soils	13/03/96	-
	NZMS 260 U21/409,733	Chesterhope, Pakowhai, 20 km south-west of Napier City	Sheep and beef farming	Recent soils from alluvium	18/03/96	-
Taranaki-SW Waikato	NZMS 260 Q20/148,966	Eltham Road, RD 21, Stratford, 7 km west of Eltham	Dairy farming	Stratford soils	05/03/96	-
	NZMS 260 Q20/265,972	Rawhitiroa Road, RD 18, Eltham, 5 km east-north-east of Eltham	Dairy farming	Eltham soils	12/03/96	(2)
Wellington-Wanganui	NZMS 260 S24/052,985	Rosina Road, Tangimoana, 27 km west-north-west of Palmerston North	Sheep and cattle farming with some cropping	Carnarvon - Foxton soil association	26/02/96	-
	NZMS 260 S25/939,559	Pekapeka Road off Waikawa Beach Road, 12 km south-west of Levin	Dairy farming	Carnarvon soils	28/02/96	-
Marlborough-Canterbury	NZMS 260 M34/879,775	Terrace Road, RD 1, Amberley	Mixed sheep and crop farming	Mairaki and Kairaki soils	04/04/96	-
	NZMS 260 P28/749,614	Waihopai Valley road, RD 6, 15 km west-south-west of Blenheim	Sheep and beef farming	Renwick soils (Yellow-brown earths)	12/04/96	-
West Coast-Tasman	NZMS 260 K29/863,288	Virgin Flat, 12 km south-west of Westport	Beef farming	Addison soil set	30/03/96	-
	NZMS 260 K32/817,541	Blair's Farm, Nelson Creek, Greymouth	Sheep and beef farming	Maimai soil set	30/03/96	-
Otago-Southland	NZMS 260 J42/402,480	Maheno, Kakanui Road, 20 km south-west of Oamaru, RD 5, Oamaru	Sheep and cattle farming	Eyre - Paparua soil set	14/02/96	(3)
	NZMS 260 J41/354,736	O'Neill Road, Enfield, 16 km north-west of Oamaru	Mixed dairying and cropping	Otama and Ngapara soils	21/02/96	-

(1) The Warkworth site is officially part of the Auckland region, approximately 30 km south of the Auckland/Northland regional boundary. However, for the purposes of this study, this sample was included in the Northland composite soil samples prepared.
(2) Two straight-line transects used, each up either side of the central farm race.
(3) Two straight-line transects used, as property to small to accommodate triangular sampling.

Table B8 Provincial parks and reserves site data

Provincial centre (stratum)	Location	Map reference	Date sampled	Sampling pattern[2]
Whangarei (Northland)	Tarewa Park, Otaika Road	NZMS 271-39 292,062	25/03/96	G
	Onerahi Domain	NZMS 271-39 345,050	27/03/96	G
	Beazley Park	NZMS 271-39 309,127	27/03/96	G
	Barge Park	NZMS 271-39 263,057	27/03/96	G
Hamilton (Waikato-Bay of Plenty)	Fairfield Park, Clarkin Road	NZMS 271-09 115,793	15/04/96	G
	Hayes Paddock, Wellington Street	NZMS 271-09 128,757	16/04/96	R
	Lake Domain, Ruakiwi Road	NZMS 271-09 107,760	08/05/96	G
	Minogue Park, Garnett Avenue	NZMS 271-09 084,791	08/05/96	G
Napier (Hawke's Bay-East Coast)	Napier Botanical Gardens	NZMS 260 V21/455,832	19/03/96	R
	Clive Square Memorial Park	NZMS 260 V21/465,829	19/03/96	R
	Marine Parade Gardens	NZMS 260 V21/471,826	19/03/96	R
	Kennedy Park Rose Garden	(1)	19/03/96	R
New Plymouth (Taranaki-SW Waikato)	Mt Moturoa Domain	NZMS 260 P19/992,374	08/03/96	R
	Churchill Heights, Western Park	NZMS 260 P19/021,373	08/03/96	R
	Marsland Hill	NZMS 260 P19/376,029	08/03/96	R
	Brooklands Park	NZMS 260 P19/037,365	08/03/96	R
Masterton (Wellington-Wanganui)	Cameron and Soldiers Memorial Park	NZMS 271-17 335,242	01/03/96	G
	South Park, High Street	NZMS 271-17 323,240	01/03/96	G
	Douglas Park, Cole Street	NZMS 271-17 327,256	01/03/96	G
	Oxford Street Reserve	NZMS 271-17 343,259	01/03/96	G
Timaru (Marlborough-Canterbury)	Maori Park	NZMS 260 J39/455,701	25/03/96	G
	Gleniti Park	NZMS 260 J39/451,662	25/03/96	G
	West End Park	NZMS 260 J39/447,686	26/03/96	G
	Alexandra Square	NZMS 260 J39/436,711	27/03/96	R
Greymouth (West Coast-Tasman)	Karoro Domain	(1)	02/04/96	G
	McLean Domain	(1)	02/04/96	G
	Dixon Park	(1)	02/04/96	R
	Recreation Ground, High St	(1)	03/04/96	G
Invercargill (Otago-Southland)	Queens Park	NZMS 260 E46/531,126	08/03/96	G
	Otakaro Park	NZMS 260 E46/532,120	08/03/96	G
	Elizabeth Park	NZMS 260 E46/551,103	08/03/96	G
	Russell Square	NZMS 260 E46/533,102	08/03/96	G

(1) Not recorded on field log.
(2) G = grid, R = random sampling.

Table B9 Auckland parks and reserves site data

Metropolitan centre: Auckland (Land use)[1]	Location	Map reference	Date sampled	Sampling pattern[2]
North Shore City (Residential)	Mt Victoria, Devonport	NZMS 271-22 708,846	16/04/96	R
	Stancich Reserve, Northcote	NZMS 271-22 658,883	16/04/96	R
	Kauri Point Domain, Chatswood	NZMS 271-22 616,859	17/04/96	R
	Wainoni Park, Wainoni	NZMS 271-22 598,913	17/04/96	G
North Shore City (Residential)	Eskdale Reserve, Hillcrest	NZMS 271-22 642,884	10/05/96	R
	Normanton Reserve, Glenfield	NZMS 271-22 647,905	10/05/96	R
	Manuka Reserve, Glenfield	NZMS 271-22 621-902	10/05/96	R
	Centennial Park, Campbells Bay	NZMS 271-22 674,927	10/05/96	R
Western (Residential)	Western Park, Ponsonby Road	NZMS 271-02 665,812	26/04/96	G
	Point Erin Park, St Marys Bay	NZMS 271-02 657,834	26/04/96	G
	Blockhouse Bay Road Recreation Reserve	NZMS 271-02 623,746	30/04/96	G
	Craigavon Park, Blockhouse Bay	NZMS 271-02 718,736	30/04/96	G
Mt Eden/Mt Roskill (Residential)	Manukau Domain, Lynfield	NZMS 271-02 635,728	30/04/96	G
	Potters Park, Balmoral	NZMS 271-02 664,779	30/04/96	G
	Melville Park, Epsom	NZMS 271-02 679,778	30/04/96	R
Tamaki/Maungakiekie (Residential)	Jellicoe Park, Royal Oak	NZMS 271-02 691,744	03/05/96	G
	Hamlin Park, Mt Wellington	NZMS 271-02 740,753	03/05/96	G
	Mt Wellington War Memorial Park, Panmure	NZMS 271-02 776,762	03/05/96	R
Western and Tamaki/Maungakiekie (Commercial/Light industrial)	Western Springs, Auckland City	NZMS 271-02 643,802	26/04/96	G
	One Tree Hill Domain, Auckland City	NZMS 271-02 691,765	26/04/96	G
	Murphy Park, Otahuhu	NZMS 271-02 749,715	26/04/96	R
	Meloa Park, West Auckland	NZMS 271-02 636,813	30/04/96	R
Hobson/Eastern Bays (Residential)	Point England Reserve, Pt England	NZMS 271-02 767,784	03/05/96	G
	Glover Park, St Heliers	NZMS 271-02 768,822	03/05/96	G
	Waiatarua Reserve, Remuera	NZMS 271-02 709,787	07/05/96	G
	MJ Savage Memorial Park, Mission Bay	NZMS 271-02 733,824	07/05/96	G
Hobson/Eastern Bays (Commercial/Light industrial)	Merton Park, St Johns	NZMS 271-02 753,785	03/05/96	G
	Dove Myer Robinson Park, Parnell	NZMS 271-02 697,822	07/05/96	G
	Auckland Domain, Carlton Road	NZMS 271-02 686,804	07/05/96	R
Manukau City (Residential)	Vine St Reserve, Manukau City	NZMS 271-15 728,698	01/05/96	G
	Old School Site, Kirkbride Road, Manukau City	NZMS 271-15 702,678	01/05/96	G
	Mangere Domain, Manukau City	NZMS 271-15 694,712	01/05/96	G
	Waterlea Park, Manukau City	NZMS 271-15 684,713	01/05/96	G

(1) Samples collected from areas that could be described as either: predominantly residential or commercial/light industrial.
(2) G = grid, R = random sampling.

Table B10 Christchurch City parks and reserves site data

Metropolitan centre: Christchurch City (Land use)	Location	Map reference	Date sampled	Sampling pattern[2]
Merivale/Shirley (Residential)	Elmwood Park	NZMS 271-05 786,439	05/04/96	G
	Malvern Park	NZMS 271-05 802,447	05/04/96	G
	MacFarlane Park	NZMS 271-05 821,449	06/04/96	R
	Richmond Park	NZMS 271-05 828 438	06/04/96	G
	St James Park	NZMS 271-05 781,454	06/04/96	G
City/Woolston (Commercial/Light industrial)	Latimer Square	NZMS 271-05 811,418	08/04/96	G
	Edmonds Park	NZMS 271-05 830,408	08/04/96	G
	Palinurus Road	NZMS 271-05 849,395	08/04/96	G
Spreydon/Halswell (Residential)	Simeon and Addington School	NZMS 271-05 791,398	06/04/96	R
	Barrington Park	NZMS 271-05 792,391	06/04/96	G
	Hoon Hay Park	NZMS 271-05 773,383	07/04/96	G
	Halswell Domain	NZMS 271-05 753,365	07/04/96	R
Hornby/Birmingham Drive (Commercial/Light industrial)	Goulding Avenue	NZMS 271-05 714,402	07/04/96	G
	Leslie Street	NZMS 271-05 703,402	07/04/96	G
	Hornby High School (Carmen Road)	NZMS 271-05 717,411	07/04/96	G
	Marylands Place	NZMS 271-05 769,402	08/04/96	R
Avonhead/Burnside (Residential)	Crosbie Park	NZMS 271-05 736,433	05/04/96	G
	Burnside Park	NZMS 271-05 747,448	05/04/96	G
	Grant Armstrong Park	NZMS 271-05 761,461	05/04/96	G
	Nunweek Hockey Field	NZMS 271-05 751,467	05/04/96	G
Port Hills (Rural)[1]	Victoria	NZMS 271-05 823,342	17/04/96	G
	Bowenvale	NZMS 271-05 824,356	17/04/96	G
	Mt Vernon	NZMS 271-05 828,364	17/04/96	G
	Mt Pleasant	NZMS 271-05 889,362	17/04/96	G

(1) Rural area on outskirts of Christchurch.
(2) G = grid, R = random sampling.

Appendix C Analytical methods

This appendix describes the methods of analysis of soil samples, including the determination of the following organochlorines:

- Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)
- Polychlorinated biphenyls (PCBs)
- Organochlorine pesticides
- Chlorophenols

C1 Organochlorine contaminants

C1.1 Sample preparation

Samples were stored at 4 ºC pending analysis. Each soil sample consisted of 1 or more individual sample jars depending on how many sampling stations or parks and reserves the sample was collected from. For each jar, the soil was sieved through a 6 mm sieve then homogenised by cone and quartering. An equal portion of sieved, homogenised soil from each jar was composited, sieved through a 2 mm sieve and mixed thoroughly (Figure C1). Pre-drying of the soil was not required to facilitate sieving.

Analysis for organochlorine contaminants was carried out on field moist material. Moisture determinations were carried out on both the individual sample jars and the composite sample. The moisture content was determined by oven drying at 105 ºC to constant weight.

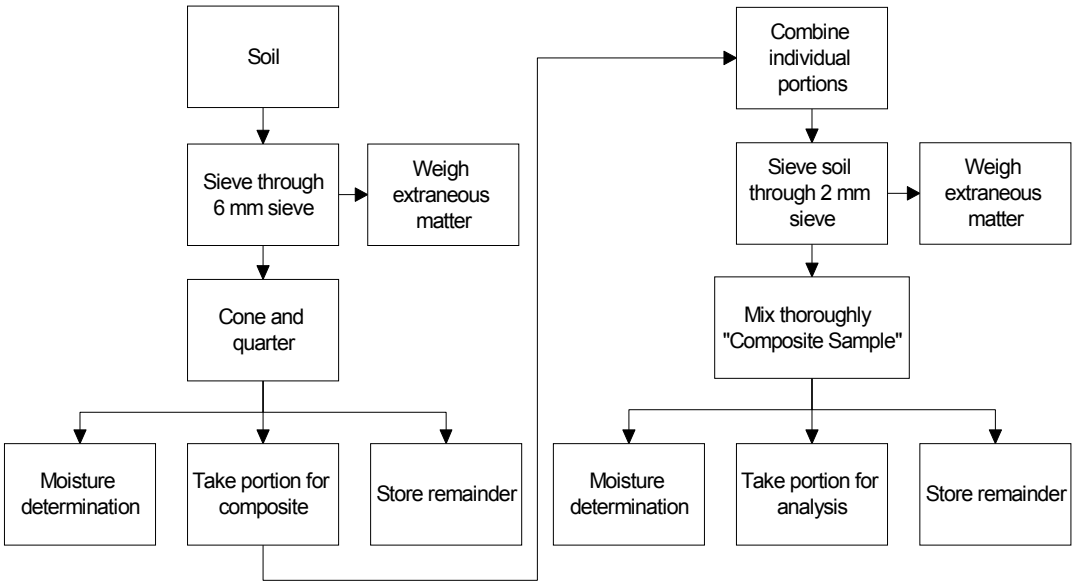

Figure C1 Preparation of composite soil samples

C1.2 Sample extraction

PCDDs, PCDFs, PCBs and organochlorine pesticides

A weight (20 g) of prepared soil (2 mm fraction, wet weight) was taken, loaded into an accelerated solvent extractor cell and spiked with a range of isotopically labelled PCDD, PCDF, PCB and organochlorine pesticide standards (Cambridge Isotope Laboratories, Massachusetts, USA). The nominal amounts of each surrogate standard added are given in Table C1. The soil was extracted by accelerated solvent extraction (ASE) (Dionex 200) with acetone/hexane (1:1) followed by toluene. Both extracts were reduced using rotary evaporation, combined, solvent exchanged into dichloromethane, (DCM) washed with water, dried (anhydrous Na_2SO_4), and solvent exchanged into hexane. This extract was then split: 40% for PCDD and PCDF analysis, 40% for PCB and organochlorine pesticide analysis and 20% reserve (Figure C2).

Table C1 Nominal amounts of isotopically labelled surrogate standards added to samples

$^{13}C_{12}$ PCDD congener	ng added	$^{13}C_{12}$ PCDF congener	ng added
2,3,7,8-TCDD	0.5	2,3,7,8-TCDF	0.5
1,2,3,7,8-PeCDD	0.5	1,2,3,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDD	0.5	2,3,4,7,8-PeCDF	0.5
1,2,3,6,7,8-HxCDD	0.5	1,2,3,4,7,8-HxCDF	0.5
1,2,3,4,6,7,8-HpCDD	0.5	1,2,3,6,7,8-HxCDF	0.5
OCDD	1	2,3,4,6,7,8-HxCDF	0.5
		1,2,3,7,8,9-HxCDF	0.5
		1,2,3,4,6,7,8-HpCDF	0.5
		1,2,3,4,7,8,9-HpCDF	0.5
$^{13}C_{12}$ PCB congener	**ng added**	**^{13}C OC pesticide**	**ng added**
#28	20	γ-HCH	10
#52	10	HCB	5
#77	10	Dieldrin	10
#101	10	pp'-DDE	10
#126	10	pp'-DDT	20
#153	20		
#169	10		
#180	10		
#202	20		

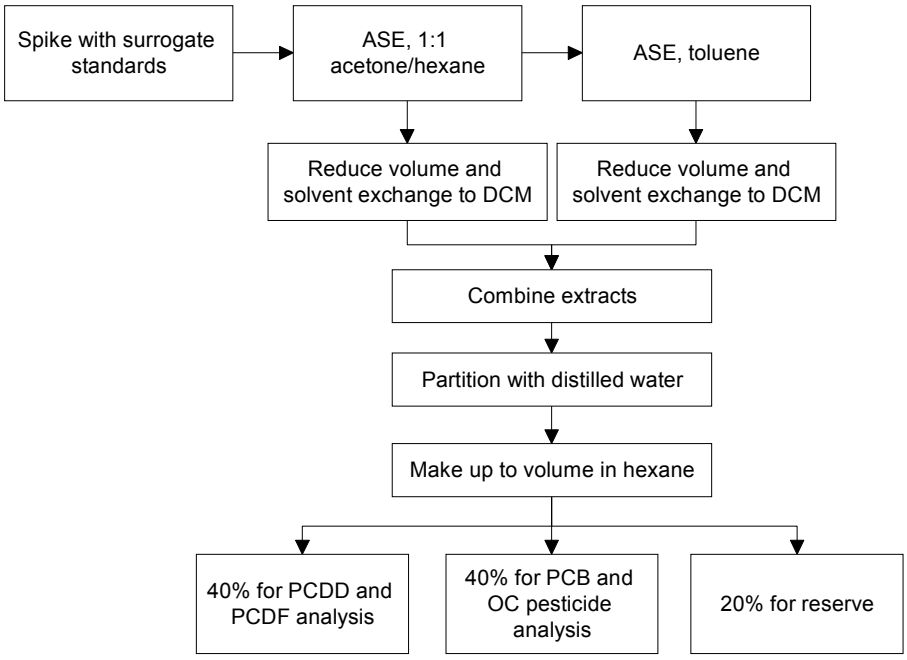

Figure C2 Extraction of soil for PCDD, PCDF, PCB and organochlorine pesticide analysis

Chlorophenols

A weight (10 g) of prepared soil (2 mm fraction, wet weight) was taken and spiked with surrogate standard (2,6-dibromo-4-methyl phenol, 25 ng). The sample was acidified and extracted with acetone/hexane using sonication followed by shaking. Water was added and the upper layer was removed following centrifugation.

C1.3 Sample purification

PCDDs and PCDFs

The PCDD and PCDF split was partitioned with concentrated sulphuric acid, washed with water, dried (anhydrous Na_2SO_4) and reduced by rotary evaporation. The extract was further purified by column chromatography as follows:

- acid and base modified silica gel (eluent: hexane)
- alumina (neutral) (eluent: hexane, 1:20 diethyl ether/hexane, diethyl ether)
- Carbopack C (18% dispersed on Celite 545) (eluent: hexane, 1:1 DCM/cyclohexane, 15:4:1 DCM/methanol/toluene, toluene)

A volume of $^{13}C_{12}$ labelled syringe spike (1,2,3,4-TCDD and 1,2,3,7,8,9-HxCDD) in tetradecane was added and the extract was reduced by rotary evaporation, blown down gently under a stream of nitrogen, and transferred to a vial for analysis using capillary gas chromatography-high resolution mass spectrometry (GCMS).

PCB and organochlorine pesticides

The PCB and organochlorine pesticide split was reduced by rotary evaporation, filtered (0.45 µm pore size) and purified by gel permeation chromatography (Bio-Beads SX-3, 1:1 ethyl acetate/hexane eluent). The extract was further purified by Florisil column chromatography (eluent: hexane 1:15 diethyl ether/hexane), which also effected the fractionation of the non *ortho*-PCBs (#77, #126 and #169) from the *ortho*-substituted PCB congeners. Each fraction was reduced by rotary evaporation, then blown down gently under a stream of nitrogen. A volume of $^{13}C_{12}$ labelled syringe spike (PCB #80 and #141) was added and each fraction was transferred to a vial for analysis for *ortho*-PCB and non *ortho*-PCB congeners by GCMS. The *ortho*- and non *ortho*-PCB fractions were subsequently recombined for GCMS analysis for organochlorine pesticides.

Chlorophenols

Sample extracts were purified by treatment with concentrated sulphuric acid, extracted into aqueous base and derivatised using phase transfer acetylation in preparation for analysis by gas chromatography using electron capture detection (GC-ECD).

C1.4 Sample analysis

PCDDs and PCDFs

Extracts were analysed by GCMS on an HP5890 Series II Plus GC interfaced to a VG-70S high resolution mass spectrometer (resolution 10,000). All extracts were run on an Ultra2 capillary column. If a peak was detected at the correct retention times for 2,3,7,8-TCDF, 2,3,7,8-TCDD, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF or 1,2,3,7,8,9-HxCDD, the extract was re-analysed on a SP2331 capillary column for full congener-specific quantification. Chromatographic conditions are given on the following page, and the mass spectral ions monitored are detailed in Table C2.

Column	25 m Ultra2	60 m SP2331
Carrier gas head pressure	150 kPa	200 kPa
Injector temperature	260 °C	260 °C
Injection	2 µl splitless	2µl splitless
Temperature programme	Initial temp 210 °C (hold 4 min), 3° C min^{-1} to 275 °C (11 min).	Initial temp 170 °C (hold 1 min), 10 °C min^{-1} to 210 °C (1 min), 3 °C min^{-1} to 250 °C (30 min).

Table C2 Ions monitored for PCDDs and PCDFs

Congener group	^{12}C Quantification ion (m/z)	^{12}C Confirmation ion (m/z)	^{13}C Quantification ion (m/z)	^{13}C Confirmation ion (m/z)
TCDF	305.8987	303.9016	317.9389	315.9419
TCDD	321.8936	319.8965	333.9339	331.9368
PeCDF	339.8597	337.8626	351.9000	349.9029
PeCDD	355.8546	353.8575	367.8949	365.8978
HxCDF	373.8207	375.8178	385.8610	387.8580
HxCDD	389.8156	391.8127	401.8559	403.8530
HpCDF	407.7818	409.7788	419.8220	421.8191
HpCDD	423.7767	425.7737	435.8169	437.8140
OCDF	443.7398	441.7428		
OCDD	459.7347	457.7377	471.7750	469.7780

PCBs

Extracts were analysed by GCMS on an HP5890 Series II Plus GC interfaced to a VG-70S high resolution mass spectrometer (resolution typically 6,000). Chromatographic conditions are given below, and the mass spectral ions monitored are detailed in Table C3.

Column	25 m Ultra2
Carrier gas head pressure	100 kPa
Injector temperature	240 °C
Injection	1 µl splitless
Temperature programme	Initial temp 60 °C (hold 0.8 min), 40 °C min^{-1} to 170 °C (0.5 min), 5 °C min^{-1} to 250 °C (23 min).

Organochlorine pesticides

Extracts were analysed by GCMS on an HP5890 Series II Plus GC interfaced to a VG-70S high resolution mass spectrometer (resolution typically 6,000). Chromatographic conditions are given below, and the mass spectral ions monitored are detailed in Table C4.

Column	25 m Ultra2
Carrier gas head pressure	100 kPa
Injector temperature	180 °C
Injection	1 µl splitless
Temperature programme	Initial temp 60 °C (hold 0.8 min), 40 °C min^{-1} to 170 °C (0.5 min), 5 °C min^{-1} to 250 °C (13 min).

Table C3 Ions monitored for PCBs

Congener group	^{12}C Quantification ion (m/z)	^{12}C Confirmation ion (m/z)	^{13}C Quantification ion (m/z)	^{13}C Confirmation ion (m/z)
Tri PCBs[1]	255.9613	257.9584	269.9986	271.9957
Tetra PCBs[2]	291.9194	289.9224	303.9597	301.9627
Penta PCBs[3]	325.8804	327.8775	337.9207	339.9178
Hexa PCBs[4]	359.8415	361.8385	371.8818	373.8788
Hepta PCBs[5]	393.8025	395.7995	405.8428	407.8398
Octa PCBs[6]	427.7635	429.7606	439.8038	441.8009
Nona PCBs[7]	463.7216	461.7245		

[1] PCB #28, #31
[2] PCB #52, #77
[3] PCB #101, #99, #123, #118, #114, #105, #126
[4] PCB #153, #138, #167, #156, #157, #169
[5] PCB #187, #183, #180, #170, #189
[6] PCB #202, #194
[7] PCB #206

Table C4 Ions monitored for organochlorine pesticides

Analyte	^{12}C Quantification ion (m/z)	^{12}C Confirmation ion (m/z)	^{13}C Quantification ion (m/z)	^{13}C Confirmation ion (m/z)
α-HCH	216.9145	220.9086		
β-HCH	216.9145	220.9086		
γ-HCH	216.9145	220.9086	227.9660	231.9601
HCB	285.8072	283.8102	291.8273	289.8303
Aldrin	262.8570	260.8599		
Dieldrin	262.8570	260.8599	268.8674	266.9704
Heptachlor	271.8102	273.8072		
Heptachlor epoxide	262.8570	260.8599		
α-Chlordane	372.8260	374.8230		
γ-Chlordane	372.8260	374.8230		
pp'-DDE	317.9351	315.9380	329.9753	327.9783
pp'-TDE	235.0081	237.0052		
op'-DDT	235.0081	237.0052		
pp'-DDT	235.0081	237.0052	247.0483	249.0453

Chlorophenols

Extracts were analysed by GC-ECD on a Varian 3500. All extracts were run on a 30 m DB17 capillary column with confirmation analyses carried out on a 25 m Ultra2 capillary column. Conditions are detailed below.

Column	30 m DB17	25 m Ultra2
Carrier gas head pressure	245 kPa	320 kPa
Injector temperature	250°C	240°C
Injection	1 μl splitless	1 μl splitless
Temperature programme	Initial temp 90 °C (hold 1 min), 20 °C min^{-1} to 160 °C (0 min), 5 °C min^{-1} to 224 °C (0 min), 50 °C^{-1} to 280 °C (5 min).	Initial temp 85 °C (hold 1 min), 40 °C min^{-1} to 150 °C (2 min), 2 °C min^{-1} to 220 °C (0 min), 50 °C min^{-1} to 300 °C (8.67 min).

C1.5 Analyte identification and quantification criteria

PCDDs and PCDFs

For positive identification and quantification, the following criteria must be met:

- The retention time of the analyte must be within 1 second of the retention time of the corresponding $^{13}C_{12}$ surrogate standard.
- The ion ratio obtained for the analyte must be ±10% of the theoretical ion ratio.
- The signal to noise ratio must be greater than 3:1.
- Levels of PCDD and PCDF congeners in a sample must be greater than 5 times any level found in the corresponding laboratory blank analysed (3 times the level in the blank for OCDD).
- Surrogate standard recoveries must be in the range 25-150%.

PCBs and organochlorine pesticides

For positive identification and quantification, the following criteria must be met:

- Where relevant, the retention time of the targeted analyte must be within 2 seconds of the corresponding ^{13}C surrogate standard. For congeners with no ^{13}C surrogate standard, the retention time must be within 2 seconds of the relative retention time for that congener as calculated from the calibration standards.
- The ion ratio obtained for the analyte must be ±20% of that obtained for the calibration standards.
- The signal to noise ratio must be greater than 3:1.
- Levels of PCB congeners and organochlorine pesticides in a sample must be greater than 5 times any level found in the corresponding laboratory blank analysed.
- Surrogate standard recoveries must be in the range 25-150%.

Chlorophenols

For positive identification and quantification, the following criteria must be met:

- The retention time of the targeted analyte on both GC columns must be within 2 seconds of the corresponding external standard.
- The peak shape of the targeted analyte on both GC columns must be sharp and with minimal tailing.
- The signal to noise ratio must be greater than 5:1.
- Surrogate standard recoveries must be in the range 25-150%.

C1.6 Quantification

PCDDs, PCDFs, PCBs and organochlorine pesticides

Quantification was by the isotope dilution technique using the surrogate standards listed in Table C1. Relative response factors (RRFs) were calculated for each targeted analyte from a series of calibration standards analysed under the same conditions as the samples. Non 2,3,7,8-substituted PCDD and PCDF congeners were quantified using the RRF of the first eluting surrogate standard in each mass spectral group. Targeting of all analytes was performed by the MS software (OPUS). Text files created by OPUS were electronically transferred to a customised spreadsheet for further data reduction and preparation of the final analytical report.

Chlorophenols

Quantification was by multi-point calibration using the Waters Millennium chromatography data system. Data was electronically transferred to a customised spreadsheet for further data reduction and preparation of the final analytical report.

C1.7 Limits of detection

PCDDs, PCDFs, PCBs and organochlorine pesticides

If no peak was distinguishable above the background noise at the retention time for a targeted analyte, the area was recorded as being less than the limit of detection. The limit of detection was calculated by multiplying by three the area of the section of baseline noise at the retention time of the analyte. If a peak was present at the correct retention time for the targeted analyte but failed to meet all analyte identification and quantification criteria, the area due to that analyte was recorded, and the calculated concentration was reported as a limit of detection.

Chlorophenols

Limits of detection were calculated according to the standard US EPA procedure based on standard deviation of low-level spikes.

C1.8 Surrogate standard recoveries

PCDDs, PCDFs, PCBs and organochlorine pesticides

The recovery of each isotopically labelled surrogate standard was calculated from the ratio of the area of the surrogate standard in the sample normalised to its syringe spike to the area of the surrogate standard in the calibration standards normalised to its syringe spike.

C1.9 Quality control

PCDDs, PCDFs, PCBs and organochlorine pesticides

- The batch size was typically 8-10 samples.
- A laboratory blank was analysed with each batch of samples.
- A soil laboratory control sample (LCS) was analysed with each batch of samples as a replicate to assess method precision.
- The GCMS resolution, performance and sensitivity were established for each MS run.
- The recoveries of all isotopically labelled surrogate standards were calculated and reported.
- Ten percent of all samples were analysed by an independent cross-check QC laboratory.

Chlorophenols

- The batch size was typically 8-10 samples.
- A laboratory blank was analysed with each batch of samples.
- A matrix spike was analysed with each batch of samples.
- The recovery of the surrogate standard was calculated and reported.
- Ten percent of all samples were analysed by an independent cross-check QC laboratory.

C1.10 Method precision data

Method precision data for organochlorine analyses are summarised in Table C5. Data were calculated from either replicate analysis of a soil LCS, or from matrix spike analyses.

Table C5 Method precision data for organochlorine analyses

Contaminant class	Measure	QC sample	n	Range Min.	Range Max.	Mean	Confidence interval[1]
PCDDs and PCDFs	Total I-TEQ[2] (ng kg^{-1})	LCS[4]	10	0.18	0.57	0.24	± 0.073
	Total I-TEQ[3] (ng kg^{-1})	LCS	10	0.88	1.78	1.21	± 0.22
	OCDD (ng kg^{-1})	LCS	10	61.1	87.0	71.8	± 4.87
PCBs	PCB TEQ[2] (ng kg^{-1})	LCS	9	0.0054	0.0094	0.0072	± 0.00085
	PCB TEQ[3] (ng kg^{-1})	LCS	9	0.070	0.20	0.092	± 0.028
	PCB #153 (µg kg^{-1})	LCS	9	0.079	0.13	0.095	± 0.098
OC pesticides	Dieldrin (µg kg^{-1})	LCS	9	0.33	0.38	0.36	± 0.0098
Chlorophenols	PCP (% recovery)	Matrix spike	15	89	155	118	± 10.1

1 95% confidence level.
2 Calculated excluding LOD values.
3 Calculated including LOD values.
4 Laboratory control sample.

C1.11 Data reporting

The bases of reporting for primary and quality control samples are given in Tables C6 and C7 respectively.

Concentration data are reported in Appendices D through to G. PCDD, PCDF, PCB and organochlorine pesticide data are corrected for recovery of ^{13}C surrogate standards. Chlorophenol data are uncorrected for recovery of surrogate standard. For all samples, data for quantified analytes are reported to 2 or 3 significant figures. Limit of detection data for non-quantified analytes are reported to 1 significant figure.

Table C6 Reporting basis for contaminant concentrations in soils

Contaminant class	Reporting basis
PCDDs and PCDFs	ng kg^{-1} on a dry weight basis. Total toxic equivalents (TEQs) were calculated using the International Toxic Equivalents Factors (I-TEFs).
PCBs	µg kg^{-1} on a dry weight basis. TEQs were calculated using the WHO/IPCS TEFs (Ahlborg *et al.*, 1994), and reported in ng kg^{-1}.
OC pesticides	µg kg^{-1} on a dry weight basis.
Chlorophenols	µg kg^{-1} on a dry weight basis.

Table C7 Reporting basis for quality control samples

QC sample	Reporting basis
Laboratory blanks	Calculated using the average dry weight of all samples analysed in the batch. Reported on a weight per weight basis.
Field blanks	Calculated using the dry weight of soil collected in a single jar for the corresponding field sample. Reported on a weight per weight basis.
Rinsate blanks	Calculated using the volume of rinsate analysed. Reported on a weight per volume basis.

C2 Miscellaneous analyses

Extraneous matter

Extraneous matter was measured as the material retained by both the 6 mm and 2 mm sieves from the initial sample preparation (Figure C1, Section C1.1). Extraneous matter was reported as a percentage of the total sample received.

Total organic carbon

Total carbon was determined using a LECO CNS-2000 analyser. In this analyser, the soil was combusted in the furnace at a temperature of 1050 ºC in pure oxygen. The evolved carbon dioxide was measured with an infra-red detector calibrated against a pure organic standard compound. Total organic carbon was calculated after correcting for the presence of any inorganic carbon (carbonate) in the sample.

Appendix D Concentrations of PCDDs and PCDFs in New Zealand soils

This appendix reports the levels of PCDDs and PCDFs in all soil samples collected as part of the Organochlorines Programme. Results from field quality control samples are also provided.

Congener-specific concentrations for all 2,3,7,8- PCDDs and PCDFs are reported, along with total concentrations for non 2,3,7,8- PCDDs and PCDFs for each homologue group. Total TEQ levels were calculated, both excluding LOD values and including half LOD values, using the International TEF scheme (Kutz *et al*., 1990).

PCDD and PCDF data are reported in the following tables:

Table D1 Concentrations of PCDDs and PCDFs in New Zealand indigenous forest soils (ng kg^{-1}, dry wt basis)

Congener	Waipoua Forest Northland	Pirongia Forest Park Waikato/Bay of Plenty	Whirinaki Forest Waikato/Bay of Plenty	Rimutaka Forest Park Wellington/Wanganui	Arthur's Pass National Park Marlborough/Canterbury	Paparoa National Park West Coast/Tasman	Catlins Forest Otago/Southland (n=2)[3]	Number of positives	Minimum	Maximum	Median	Mean[4,5]	Mean of ^{13}C surrogate standard recoveries, %, (n=8)
2,3,7,8 TCDD	< 0.6	< 0.6	< 0.6	< 0.5	< 0.1	< 0.2	< 0.4	0	< 0.1	< 0.6	< 0.5	-	84
Non 2,3,7,8 TCDD	5.47	6.03	3.85	6.52	2.11	1.38	6.03	7	1.38	6.52	5.47	4.48	
1,2,3,7,8 PeCDD	< 1	< 2	< 2	< 1	< 0.1	< 0.2	< 0.4	0	< 0.1	< 2	< 1	-	83
Non 2,3,7,8 PeCDD	4.80	6.24	14.5	8.90	< 1	< 0.4	< 2	4	< 0.4	14.5	4.80	-	
1,2,3,4,7,8 HxCDD	< 1	< 1	< 1	< 0.9	< 0.1	< 0.4	< 0.4	0	< 0.1	< 2	< 0.9	-	90
1,2,3,6,7,8 HxCDD	< 1	< 2	< 2	< 1	< 0.1	< 0.3	< 0.4	0	< 0.1	< 2	< 1	-	87
1,2,3,7,8,9 HxCDD	< 1	< 0.2	< 1	< 2	< 0.3	< 0.4	< 0.4	0	< 0.2	< 2	< 0.4	-	
Non 2,3,7,8 HxCDD	2.40	46.6	30.2	14.8	< 2	3.51	6.25	6	< 2	46.6	6.25	15.0	
1,2,3,4,6,7,8 HpCDD	3.65	22.3	27.6	19.2	< 1	< 2	1.98	5	< 1	27.6	3.65	10.9	80
Non 2,3,7,8 HpCDD	3.21	21.1	35.4	23.0	< 2	< 1	2.24	5	< 1	35.4	3.21	12.4	
OCDD	36.1	119	154	124	< 10	< 20	25.0	5	< 10	154	36.1	67.6	61
2,3,7,8 TCDF	< 1	< 0.9	< 0.5	< 0.1	< 0.1	< 0.1	< 0.3	0	< 0.1	< 1	< 0.3	-	80
Non 2,3,7,8 TCDF	15.8	10.4	18.8	33.1	4.97	9.95	60.0	7	4.97	60.0	15.8	21.9	
1,2,3,7,8 PeCDF	< 0.7	< 0.8	< 0.8	< 0.6	< 0.1	< 0.1	< 0.2	0	< 0.1	< 0.8	< 0.6	-	75
2,3,4,7,8 PeCDF	< 0.9	< 1	< 1	< 0.1	< 0.1	< 0.1	< 0.3	0	< 0.1	< 1	< 0.3	-	71
Non 2,3,7,8 PeCDF	2.82	< 2	3.57	11.2	< 0.9	3.67	2.80	5	< 0.9	11.2	2.82	3.64	
1,2,3,4,7,8 HxCDF	< 0.8	< 0.9	< 0.9	< 1	< 0.1	< 0.2	< 0.3	0	< 0.1	< 1	< 0.8	-	81
1,2,3,6,7,8 HxCDF	< 0.8	< 0.9	< 0.9	< 0.6	< 0.1	< 0.2	< 0.3	0	< 0.1	< 0.9	< 0.6	-	82
2,3,4,6,7,8 HxCDF	< 0.8	< 0.9	< 0.9	< 0.6	< 0.1	< 0.2	< 0.3	0	< 0.1	< 0.9	< 0.6	-	80
1,2,3,7,8,9 HxCDF	< 1	< 1	< 1	< 0.5	< 0.2	< 0.3	< 0.4	0	< 0.2	< 1	< 0.5	-	75
Non 2,3,7,8 HxCDF	< 0.8	< 0.9	< 3	5.24	< 0.1	< 0.5	< 1	1	< 0.1	5.24	< 0.9	-	
1,2,3,4,6,7,8 HpCDF	2.19	5.66	6.93	6.02	< 0.5	3.00	1.92	6	< 0.5	6.93	3.00	3.71	81
1,2,3,4,7,8,9 HpCDF	< 0.8	< 2	< 0.8	< 0.7	< 0.2	< 0.2	< 0.5	0	< 0.2	< 2	< 0.7	-	80
Non 2,3,7,8 HpCDF	< 0.6	< 2	< 2	< 2	< 0.2	< 0.3	< 0.7	0	< 0.3	< 2	< 0.7	-	
OCDF	< 3	< 4	< 4	4.01	< 0.7	< 1	< 2	1	< 0.7	4.01	< 3	-	
Sum of PCDD/Fs (inc)[1]	84.3	249	306	262	17.1	35.6	111		17.1	306	111	152	
Sum of PCDD/Fs (exc)[2]	76.4	237	295	256	7.08	21.5	105		7.08	295	105	143	
Total I-TEQ (inc)[1]	1.26	1.87	1.99	1.26	0.17	0.33	0.53		0.17	1.99	1.26	1.06	
Total I-TEQ (exc)[2]	0.095	0.40	0.50	0.38	0	0.030	0.054		0	0.50	0.095	0.21	

1 = Including half LOD values
2 = Excluding LOD values
3 = Mean of primary and blind duplicate samples (Table D8)
4 = Mean value reported only if a PCDD/F congener detected on more than 66% of occasions (minimum of 5 positive determinations)
5 = For any individual congener, calculation of the mean includes half LOD values

Table D2 Concentrations of PCDDs and PCDFs in New Zealand indigenous grassland soils (ng kg^{-1}, dry wt basis)

Congener	Ruahine Forest Park Hawke's Bay/East Coast	Mount Egmont National Park Taranaki/SW Waikato	Tararua Forest Park Wellington/Wanganui	Nelson Lakes National Park Marlborough/Canterbury	Blue Mountains Otago/Southland	Number of positives	Minimum	Maximum[3]	Median	Mean[4]	Mean of ^{13}C surrogate standard recoveries, %, (n=5)
2,3,7,8 TCDD	< 0.3	< 0.4	< 0.2	< 0.4	< 0.4	0	< 0.2	< 0.4	< 0.4	-	87
Non 2,3,7,8 TCDD	29.9	< 0.6	1.49	< 0.4	44.2	3	< 0.4	44.2	1.49	-	
1,2,3,7,8 PeCDD	< 0.3	< 0.8	< 0.2	< 0.7	< 0.7	0	< 0.2	< 0.8	< 0.7	-	93
Non 2,3,7,8 PeCDD	< 1	< 0.8	< 0.5	< 0.7	12.2	1	< 0.5	12.2	< 0.8	-	
1,2,3,4,7,8 HxCDD	< 0.3	< 0.6	< 0.3	< 0.8	< 0.6	0	< 0.3	< 0.8	< 0.6	-	97
1,2,3,6,7,8 HxCDD	< 0.5	< 1	< 0.3	< 0.7	< 0.5	0	< 0.3	< 1	< 0.5	-	89
1,2,3,7,8,9 HxCDD	< 0.5	< 0.6	< 0.3	< 0.7	< 0.5	0	< 0.3	< 0.7	< 0.5	-	
Non 2,3,7,8 HxCDD	5.68	< 0.6	2.76	< 3	< 2	2	< 0.6	5.68	2.76	-	
1,2,3,4,6,7,8 HpCDD	3.53	6.45	3.83	< 3	< 3	3	< 3	6.45	3.53	-	84
Non 2,3,7,8 HpCDD	5.01	6.68	5.80	< 5	< 6	3	< 5	6.68	5.80	-	
OCDD	42.9	32.6	45.3	< 30	< 50	3	< 30	45.3	42.9	-	70
2,3,7,8 TCDF	< 0.2	< 0.3	< 0.1	< 0.3	< 0.3	0	< 0.1	< 0.3	< 0.3	-	77
Non 2,3,7,8 TCDF	7.56	< 0.4	4.33	< 1	8.72	3	< 0.4	8.72	4.33	-	
1,2,3,7,8 PeCDF	< 0.1	< 0.2	< 0.1	< 0.5	< 0.4	0	< 0.1	< 0.5	< 0.2	-	79
2,3,4,7,8 PeCDF	< 0.2	< 0.2	< 0.1	< 0.5	< 0.4	0	< 0.1	< 0.5	< 0.2	-	77
Non 2,3,7,8 PeCDF	< 0.4	< 0.4	< 0.2	< 0.3	< 1	0	< 0.2	< 1	< 0.4	-	
1,2,3,4,7,8 HxCDF	< 0.2	< 0.9	< 0.3	< 0.6	< 0.4	0	< 0.2	< 0.9	< 0.4	-	78
1,2,3,6,7,8 HxCDF	< 0.2	< 0.4	< 0.1	< 0.5	< 0.4	0	< 0.1	< 0.5	< 0.4	-	78
2,3,4,6,7,8 HxCDF	< 0.2	< 0.9	< 0.1	< 0.6	< 0.4	0	< 0.1	< 0.9	< 0.4	-	80
1,2,3,7,8,9 HxCDF	< 0.3	< 0.6	< 0.2	< 0.8	< 0.6	0	< 0.2	< 0.8	< 0.6	-	78
Non 2,3,7,8 HxCDF	< 0.7	< 0.5	< 0.4	< 0.3	< 0.7	0	< 0.3	< 0.7	< 0.5	-	
1,2,3,4,6,7,8 HpCDF	< 0.9	2.94	< 0.9	< 0.9	< 0.9	1	< 0.9	2.94	< 0.9	-	85
1,2,3,4,7,8,9 HpCDF	< 0.4	< 0.7	< 0.2	< 0.6	< 0.7	0	< 0.2	< 0.7	< 0.6	-	86
Non 2,3,7,8 HpCDF	< 0.6	< 0.7	< 0.4	< 0.5	< 1	0	< 0.4	< 1	< 0.6	-	
OCDF	< 2	< 2	< 2	< 1	< 1	0	< 1	< 2	< 2	-	
Sum of PCDD/Fs (inc)[1]	99.2	55.5	67.0	26.9	101		26.9	101	67.0	69.9	
Sum of PCDD/Fs (exc)[2]	94.6	48.7	63.5	0	65.1		0	94.6	63.5	54.4	
Total I-TEQ (inc)[1]	0.48	0.85	0.35	0.80	0.72		0.35	0.85	0.72	0.64	
Total I-TEQ (exc)[2]	0.078	0.13	0.084	0	0		0	0.13	0.078	0.058	

1 = Including half LOD values
2 = Excluding LOD values
3 = Excludes any LOD value which is greater than a measured value
4 = Mean value reported only if a PCDD/F congener detected on more than 66% of occasions (minimum of 4 positive determinations)

Table D3 Concentrations of PCDDs and PCDFs in New Zealand hill country pasture soils (ng kg^{-1}, dry wt basis)

Congener	Northland	Waikato/Bay of Plenty	Hawke's Bay/East Coast	Taranaki/SW Waikato (n=2)[3]	Wellington/Wanganui	Marlborough/Canterbury	West Coast/Tasman	Otago/Southland	Number of positives	Minimum	Maximum[4]	Median	Mean[5]	Mean of ^{13}C surrogate standard recoveries, %, (n=9)
2,3,7,8 TCDD	8.08	< 0.3	< 0.4	< 0.3	< 0.6	< 0.2	< 0.2	< 0.3	1	< 0.2	8.08	< 0.3	-	88
Non 2,3,7,8 TCDD	18.3	8.05	< 3	< 4	< 2	6.18	10.5	2.18	5	< 2	18.3	4.09	-	
1,2,3,7,8 PeCDD	1.55	< 0.6	< 0.4	< 0.3	< 0.8	< 0.3	< 0.4	< 0.3	1	< 0.3	1.55	< 0.4	-	97
Non 2,3,7,8 PeCDD	20.1	4.64	< 0.9	< 1	< 1	< 0.5	< 4	< 0.3	2	< 0.3	20.1	< 1	-	
1,2,3,4,7,8 HxCDD	< 0.4	< 0.5	< 0.7	< 0.3	< 0.8	< 0.3	< 0.5	< 0.2	0	< 0.2	< 0.8	< 0.5	-	93
1,2,3,6,7,8 HxCDD	< 0.7	< 0.5	< 0.6	< 0.3	< 0.6	< 0.3	< 0.4	< 0.2	0	< 0.2	< 0.7	< 0.5	-	82
1,2,3,7,8,9 HxCDD	< 0.5	< 0.5	< 2	< 0.6	< 0.7	< 0.4	< 0.4	< 0.1	0	< 0.1	< 2	< 0.5	-	
Non 2,3,7,8 HxCDD	37.6	10.4	< 10	< 7	< 1	< 2	< 3	< 1	2	< 1	37.6	< 5	-	
1,2,3,4,6,7,8 HpCDD	< 3	7.87	< 6	< 2	< 2	< 2	< 2	< 1	1	< 1	7.87	< 2	-	87
Non 2,3,7,8 HpCDD	< 3	6.93	< 8	< 2	< 2	< 3	< 4	< 1	1	< 1	6.93	< 3	-	
OCDD	< 40	53.9	43.1	< 10	< 8	< 30	< 40	< 7	2	< 7	53.9	< 35	-	74
2,3,7,8 TCDF	< 0.5	< 0.3	< 0.2	< 0.2	< 0.4	< 0.1	< 0.2	< 0.2	0	< 0.1	< 0.5	< 0.2	-	89
Non 2,3,7,8 TCDF	7.31	6.19	< 2	< 0.9	< 2	8.43	7.14	3.46	5	< 0.9	8.43	4.83	-	
1,2,3,7,8 PeCDF	< 0.2	< 0.3	< 0.2	< 0.2	< 0.4	< 0.2	< 0.3	< 0.2	0	< 0.2	< 0.4	< 0.2	-	90
2,3,4,7,8 PeCDF	< 0.2	< 0.4	< 0.2	< 0.2	< 0.5	< 0.1	< 0.3	< 0.2	0	< 0.1	< 0.5	< 0.2	-	89
Non 2,3,7,8 PeCDF	1.69	< 0.6	< 0.3	< 0.3	< 0.7	< 0.3	< 3	< 0.2	1	< 0.2	1.69	< 0.5	-	
1,2,3,4,7,8 HxCDF	< 0.3	< 0.3	< 0.3	< 0.2	< 0.5	< 0.3	< 0.3	< 0.2	0	< 0.2	< 0.5	< 0.3	-	84
1,2,3,6,7,8 HxCDF	< 0.3	< 0.3	< 0.3	< 0.2	< 0.5	< 0.2	< 0.3	< 0.2	0	< 0.2	< 0.5	< 0.3	-	81
2,3,4,6,7,8 HxCDF	< 0.3	< 0.3	< 0.3	< 0.2	< 0.5	< 0.3	< 0.3	< 0.2	0	< 0.2	< 0.5	< 0.3	-	84
1,2,3,7,8,9 HxCDF	< 0.8	< 0.5	< 0.4	< 0.3	< 0.8	< 0.8	< 0.6	< 0.2	0	< 0.2	< 0.8	< 0.6	-	80
Non 2,3,7,8 HxCDF	< 0.3	< 0.9	< 0.5	< 0.3	< 0.9	< 0.3	< 0.7	< 0.2	0	< 0.2	< 0.9	< 0.4	-	
1,2,3,4,6,7,8 HpCDF	< 0.5	4.10	< 3	< 2	< 0.9	< 0.6	< 0.7	< 0.7	1	< 0.5	4.10	< 0.8	-	88
1,2,3,4,7,8,9 HpCDF	< 0.5	< 0.6	< 0.6	< 0.3	< 1	< 0.3	< 0.5	< 0.3	0	< 0.3	< 1	< 0.5	-	89
Non 2,3,7,8 HpCDF	< 0.3	2.63	< 0.6	< 0.5	< 1	< 0.5	< 0.4	< 0.4	1	< 0.3	2.63	< 0.5	-	
OCDF	< 0.9	5.92	< 2	< 0.8	< 1	< 1	< 1	< 0.4	1	< 0.4	5.92	< 1	-	
Sum of PCDD/Fs (inc)[1]	121	114	64.6	16.5	15.2	36.6	49.4	13.1		13.1	121	43.0	53.8	
Sum of PCDD/Fs (exc)[2]	94.6	111	43.1	0	0	14.6	17.6	5.64		0	111	16.1	35.8	
Total I-TEQ (inc)[1]	9.14	0.75	0.69	0.39	0.90	0.37	0.47	0.37		0.37	9.14	0.58	1.63	
Total I-TEQ (exc)[2]	8.86	0.18	0.043	0	0	0	0	0		0	8.86	0	1.14	

1 = Including half LOD values
2 = Excluding LOD values
3 = Mean of primary and blind duplicate samples (Table D8)
4 = Excludes any LOD value which is greater than a maximum measured value
5 = Mean value reported only if a PCDD/F congener detected on more than 66% of occasions (minimum of 6 positive determinations)

Table D4 Concentrations of PCDDs and PCDFs in New Zealand flat land pasture soils (ng kg^{-1}, dry wt basis)

Congener	Northland	Waikato/Bay of Plenty	Hawke's Bay/East Coast	Taranaki/SW Waikato	Wellington/Wanganui	Marlborough/Canterbury	West Coast/Tasman	Otago/Southland	Number of positives	Minimum	Maximum[3]	Median	Mean[4,5]	Mean of ^{13}C surrogate standard recoveries, %, (n=8)
2,3,7,8 TCDD	< 0.2	< 0.1	< 0.6	< 0.3	< 0.4	< 0.1	< 0.5	< 0.4	0	< 0.1	< 0.6	< 0.4	-	98
Non 2,3,7,8 TCDD	8.30	13.5	297	3.73	5.57	< 0.7	11.4	< 2	6	< 0.7	297	6.94	42.6	
1,2,3,7,8 PeCDD	< 0.5	< 0.2	< 0.4	< 0.5	< 0.6	< 0.1	< 0.6	< 0.4	0	< 0.1	< 0.6	< 0.5	-	100
Non 2,3,7,8 PeCDD	7.41	6.75	48.0	4.01	< 0.8	< 0.1	3.43	< 0.4	5	< 0.1	48.0	3.72	-	
1,2,3,4,7,8 HxCDD	< 0.4	< 0.5	< 0.4	< 0.4	< 0.6	< 0.1	< 1	< 0.4	0	< 0.1	< 1	< 0.4	-	99
1,2,3,6,7,8 HxCDD	< 0.5	< 0.3	< 0.3	< 0.4	< 0.5	< 0.1	< 0.5	< 0.3	0	< 0.1	< 0.5	< 0.4	-	89
1,2,3,7,8,9 HxCDD	< 0.4	< 1	< 0.3	< 0.8	< 0.9	< 0.1	< 0.6	< 0.3	0	< 0.1	< 1	< 0.5	-	
Non 2,3,7,8 HxCDD	7.31	11.7	< 3	5.70	4.55	< 0.7	< 6	< 0.4	4	< 0.4	11.7	5.13	-	
1,2,3,4,6,7,8 HpCDD	< 3	6.44	< 2	2.85	< 1	< 1	< 3	< 1	2	< 1	6.44	1.93	-	86
Non 2,3,7,8 HpCDD	< 2	7.17	< 2	3.17	< 1	< 1	< 3	< 1	2	< 1	7.17	< 2	-	
OCDD	25.2	61.4	< 10	28.7	< 7	9.88	31.9	15.5	6	< 7	61.4	20.4	22.6	79
2,3,7,8 TCDF	< 0.2	< 0.8	< 0.2	< 0.4	< 0.3	< 0.1	< 0.3	< 0.3	0	< 0.1	< 0.8	< 0.3	-	99
Non 2,3,7,8 TCDF	9.22	10.2	10.1	4.65	3.56	2.87	10.7	4.74	8	2.87	10.7	6.98	7.01	
1,2,3,7,8 PeCDF	< 0.2	< 0.1	< 0.2	< 0.3	< 0.3	< 0.1	< 0.3	< 0.2	0	< 0.1	< 0.3	< 0.2	-	96
2,3,4,7,8 PeCDF	< 0.3	< 0.1	< 0.2	< 0.3	< 0.3	< 0.1	< 0.3	< 0.2	0	< 0.1	< 0.3	< 0.3	-	98
Non 2,3,7,8 PeCDF	1.13	2.36	3.29	< 1	< 0.4	< 0.1	5.14	< 0.2	4	< 0.1	5.14	0.82	-	
1,2,3,4,7,8 HxCDF	< 0.3	< 0.2	< 0.2	< 0.3	< 0.4	< 0.1	< 0.4	< 0.2	0	< 0.1	< 0.4	< 0.3	-	88
1,2,3,6,7,8 HxCDF	< 0.3	< 0.2	< 0.2	< 0.3	< 0.4	< 0.1	< 0.3	< 0.2	0	< 0.1	< 0.4	< 0.3	-	89
2,3,4,6,7,8 HxCDF	< 0.3	< 0.2	< 0.2	< 0.3	< 0.4	< 0.1	< 0.4	< 0.3	0	< 0.1	< 0.4	< 0.3	-	89
1,2,3,7,8,9 HxCDF	< 0.5	< 0.1	< 0.3	< 0.4	< 0.6	< 0.2	< 0.6	< 0.4	0	< 0.1	< 0.6	< 0.4	-	77
Non 2,3,7,8 HxCDF	< 0.5	< 2	< 0.4	< 0.3	< 0.6	< 0.1	< 0.6	< 0.2	0	< 0.1	< 2	< 0.5	-	
1,2,3,4,6,7,8 HpCDF	< 0.7	< 1	< 1	2.37	< 1	< 0.3	< 1	< 1	1	< 0.3	2.37	< 1	-	85
1,2,3,4,7,8,9 HpCDF	< 0.4	< 0.2	< 0.3	< 0.5	< 0.8	< 0.1	< 0.6	< 0.4	0	< 0.1	< 0.8	< 0.4	-	93
Non 2,3,7,8 HpCDF	< 0.5	< 0.8	< 0.7	< 1	< 0.6	< 0.2	< 1	< 1	0	< 0.2	< 1	< 0.8	-	
OCDF	< 1	2.77	< 5	< 2	< 2	< 0.5	< 1	< 1	1	< 0.5	2.77	< 2	-	
Sum of PCDD/Fs (inc)[1]	64.7	126	372	59.9	24.1	15.8	73.6	26.3		15.8	372	62.3	95.3	
Sum of PCDD/Fs (exc)[2]	58.6	122	358	55.2	13.7	12.8	62.6	20.2		12.8	358	56.9	87.9	
Total I-TEQ (inc)[1]	0.50	0.43	0.58	0.61	0.66	0.17	0.74	0.50		0.17	0.74	0.54	0.52	
Total I-TEQ (exc)[2]	0.025	0.13	0	0.081	0	0.010	0.032	0.016		0	0.13	0.021	0.037	

1 = Including half LOD values
2 = Excluding LOD values
3 = Excludes any LOD value which is greater than a measured value
4 = Mean value reported only if a PCDD/F congener detected on more than 66% of occasions (minimum of 6 positive determinations)
5 = For any individual congener, calculation of the mean includes half LOD values

Table D5 Concentrations of PCDDs and PCDFs in New Zealand provincial centre soils (ng kg^{-1}, dry wt basis)

Congener	Whangarei Northland	Hamilton Waikato/Bay of Plenty (n=2)[3]	Napier Hawke's Bay/East Coast	New Plymouth[4] Taranaki/SW Waikato	New Plymouth[5] Taranaki/SW Waikato	Masterton Wellington/Wanganui	Timaru Marlborough/Canterbury (n=2)[3]	Greymouth West Coast/Tasman	Invercargill Otago/Southland	Number of positives	Minimum	Maximum[6]	Median	Mean (n=8)[7,8,9]	Mean of ^{13}C surrogate standard recoveries, %, (n=11)
2,3,7,8 TCDD	< 0.3	< 0.4	< 0.3	31.2	0.53	< 0.1	< 0.2	< 0.3	< 0.1	2	< 0.1	31.2	< 0.3	-	92
Non 2,3,7,8 TCDD	4.07	1.92	2.71	27.9	5.14	< 2	8.24	1.97	8.74	8	1.92	27.9	4.07	4.22	
1,2,3,7,8 PeCDD	< 0.8	< 0.6	< 0.8	2.30	< 0.3	< 0.5	< 0.4	< 0.7	< 0.3	1	< 0.3	2.30	< 0.6	-	94
Non 2,3,7,8 PeCDD	< 0.8	4.99	5.13	15.8	5.39	3.75	4.16	< 1	3.76	7	< 0.8	15.8	4.16	3.51	
1,2,3,4,7,8 HxCDD	< 0.7	< 0.5	< 0.7	0.59	< 0.4	< 0.4	< 0.4	< 1	< 0.3	1	< 0.3	0.59	< 0.5	-	95
1,2,3,6,7,8 HxCDD	< 0.6	< 1	< 1	1.01	1.83	< 0.8	< 0.6	3.80	< 0.6	3	< 0.6	3.80	< 1	-	85
1,2,3,7,8,9 HxCDD	< 1	< 2	< 1	0.52	< 0.7	< 0.8	< 1	3.13	< 2	2	0.52	3.13	< 1	-	
Non 2,3,7,8 HxCDD	5.58	18.3	10.8	10.5	13.0	12.6	3.63	14.2	9.21	9	3.63	18.3	10.8	10.9	
1,2,3,4,6,7,8 HpCDD	4.07	15.7	38.8	9.58	47.4	11.9	13.2	108	12.6	9	4.07	108	13.2	31.5	85
Non 2,3,7,8 HpCDD	3.71	15.5	41.1	8.38	33.4	10.4	11.7	67.8	10.5	9	3.71	67.8	11.7	24.3	
OCDD	38.2	124	459	111	478	156	119	693	116	9	38.2	693	124	273	75
2,3,7,8 TCDF	< 0.5	< 0.4	< 0.3	0.38	0.28	< 0.1	< 0.7	< 0.5	< 0.5	2	< 0.1	0.38	< 0.4	-	86
Non 2,3,7,8 TCDF	6.30	6.85	9.35	4.14	6.61	5.01	10.5	6.96	9.20	9	4.14	10.5	6.85	7.60	
1,2,3,7,8 PeCDF	< 0.4	< 0.4	< 0.3	< 0.2	< 0.2	< 0.3	< 0.3	< 0.4	< 0.2	0	< 0.2	< 0.4	< 0.3	-	88
2,3,4,7,8 PeCDF	< 0.5	< 0.4	< 0.5	< 0.2	< 0.2	< 0.3	< 0.3	< 0.4	< 0.2	0	< 0.2	< 0.5	< 0.3	-	85
Non 2,3,7,8 PeCDF	< 0.4	2.13	5.19	4.52	4.71	1.73	6.69	5.49	4.06	8	< 0.4	6.69	4.52	3.78	
1,2,3,4,7,8 HxCDF	< 0.5	< 0.6	< 0.7	< 0.4	< 0.5	< 0.6	< 0.5	< 0.8	< 0.4	0	< 0.4	< 0.8	< 0.5	-	85
1,2,3,6,7,8 HxCDF	< 0.5	< 0.6	< 0.5	< 0.2	< 0.5	< 0.3	< 0.5	< 0.7	< 0.2	0	< 0.2	< 0.7	< 0.5	-	82
2,3,4,6,7,8 HxCDF	< 0.5	< 0.5	< 0.5	< 0.3	< 0.5	< 0.3	< 0.4	< 0.6	< 0.2	0	< 0.2	< 0.6	< 0.5	-	84
1,2,3,7,8,9 HxCDF	< 0.7	< 0.7	< 0.3	< 0.1	< 0.2	< 0.4	< 0.3	< 0.6	< 0.1	0	< 0.1	< 0.7	< 0.3	-	77
Non 2,3,7,8 HxCDF	< 0.5	2.75	7.27	2.95	12.3	3.11	5.26	27.0	4.07	8	< 0.5	27.0	4.07	7.75	
1,2,3,4,6,7,8 HpCDF	2.07	3.77	11.1	4.17	21.5	6.29	5.64	47.0	6.46	9	2.07	47.0	6.29	13.0	82
1,2,3,4,7,8,9 HpCDF	< 0.4	< 0.6	< 0.8	< 0.2	< 1	< 0.5	< 0.4	< 1	< 0.2	0	< 0.2	< 1	< 0.5	-	85
Non 2,3,7,8 HpCDF	< 1	2.76	14.5	3.04	28.0	6.86	5.83	67.9	5.81	8	< 1	67.9	5.83	16.5	
OCDF	2.10	5.62	23.5	7.54	51.8	17.8	15.5	145	15.2	9	2.10	145	15.5	34.6	
Sum of PCDD/Fs (inc)[1]	71.2	208	632	246	712	239	212	1200	208		71.2	1200	239	435	
Sum of PCDD/Fs (exc)[2]	66.1	201	628	246	710	235	209	1190	206		66.1	1190	235	431	
Total I-TEQ (inc)[1]	0.84	1.05	1.81	33.0	2.23	0.80	0.81	3.73	0.72		0.72	33.0	1.05	1.50	
Total I-TEQ (exc)[2]	0.10	0.32	0.98	32.9	1.96	0.36	0.30	3.08	0.32		0.10	32.9	0.36	0.93	

1 = Including half LOD values
2 = Excluding LOD values
3 = Mean of primary and blind duplicate samples (Table D8)
4 = Sample collected from Mount Moturoa Domain, adjacent to chemical manufacturing plant
5 = Composite sample collected from Western Park, Marsland Hill and Brooklands Park
6 = Excludes any LOD value which is greater than a maximum measured value
7 = Mean value reported only if a PCDD/F congener detected on more than 66% of occasions (minimum of 6 positive determinations)
8 = For any individual congener, calculation of the mean includes half LOD values
9 = Calculation of the mean excludes the outlier collected from Mount Moturoa Domain, New Plymouth

Table D6 Concentrations of PCDDs and PCDFs in metropolitan Auckland soils (ng kg^{-1}, dry wt basis)

Congener	North Shore City (residential)	North Shore City (residential)	Western (residential)	Mt Eden/Mt Roskill (residential)	Tamaki/Maungakiekie (residential)	Western and Tamaki/Maungakiekie (commercial/light industrial)	Hobson/Eastern Bays (residential)	Hobson/Eastern Bays (commercial/light industrial) (n=2)[3]	Manukau City (residential)	Number of positives	Minimum	Maximum[4]	Median	Mean[5,6]	Mean of ^{13}C surrogate standard recoveries, %, (n=10)
2,3,7,8 TCDD	< 0.4	< 0.3	< 0.3	< 0.5	< 0.5	< 0.4	< 1	< 0.3	< 0.3	0	< 0.3	< 1	< 0.4	-	104
Non 2,3,7,8 TCDD	7.40	12.9	23.7	11.6	8.89	14.7	< 3	21.5	8.37	8	< 3	23.7	11.6	12.3	
1,2,3,7,8 PeCDD	< 0.6	< 0.4	< 1	< 1	< 0.8	< 0.8	< 3	< 0.9	< 0.7	0	< 0.4	< 3	< 0.8	-	108
Non 2,3,7,8 PeCDD	13.5	23.0	42.1	16.7	7.31	9.61	< 3	17.2	5.76	8	< 3	42.1	13.5	15.2	
1,2,3,4,7,8 HxCDD	< 0.6	< 1	< 1	< 1	< 1	< 1	< 4	< 1	< 0.7	0	< 0.6	< 4	< 1	-	106
1,2,3,6,7,8 HxCDD	< 0.7	< 1	< 2	5.35	< 2	< 1	< 3	< 2	< 0.6	1	< 0.6	5.35	< 2	-	89
1,2,3,7,8,9 HxCDD	< 1	< 2	< 3	< 3	< 2	< 2	< 3	< 2	< 1	0	< 1	< 3	< 2	-	
Non 2,3,7,8 HxCDD	15.4	30.2	45.3	40.9	15.1	21.7	12.0	19.9	11.4	9	11.4	45.3	19.9	23.5	
1,2,3,4,6,7,8 HpCDD	11.2	38.6	21.6	174	57.4	21.1	23.9	46.2	19.3	9	11.2	174	23.9	45.9	82
Non 2,3,7,8 HpCDD	12.7	34.9	23.7	148	63.7	22.2	26.9	46.2	20.1	9	12.7	148	26.9	44.3	
OCDD	94.4	545	141	2020	675	179	302	486	198	9	94.4	2020	302	516	67
2,3,7,8 TCDF	< 0.9	< 0.5	< 2	< 2	< 0.5	< 2	< 1	1.20	< 0.3	1	< 0.3	1.20	< 1	-	88
Non 2,3,7,8 TCDF	15.3	7.08	27.3	22.0	15.3	30.4	< 1	33.8	14.7	8	< 1	33.8	15.3	18.5	
1,2,3,7,8 PeCDF	< 0.5	< 0.4	< 1	< 1	< 0.5	< 1	< 1	< 1	< 0.4	0	< 0.4	< 1	< 1	-	85
2,3,4,7,8 PeCDF	< 0.5	< 0.4	< 1	< 2	< 0.5	< 1	< 1	< 1	< 0.4	0	< 0.4	< 2	< 1	-	97
Non 2,3,7,8 PeCDF	8.31	4.44	14.1	39.4	11.5	18.7	< 2	22.9	6.35	8	< 2	39.4	11.5	14.1	
1,2,3,4,7,8 HxCDF	< 0.7	< 0.5	< 2	< 2	< 1	< 2	< 2	< 2	< 0.5	0	< 0.5	< 2	< 2	-	93
1,2,3,6,7,8 HxCDF	< 0.4	< 0.6	< 1	< 1	< 1	< 1	< 2	< 1	< 0.4	0	< 0.4	< 2	< 1	-	85
2,3,4,6,7,8 HxCDF	< 0.5	< 0.5	< 1	< 2	< 1	< 1	< 2	< 1	< 0.5	0	< 0.5	< 2	< 1	-	91
1,2,3,7,8,9 HxCDF	< 0.6	< 0.4	< 1	< 1	< 1	< 1	< 3	< 0.7	< 0.7	0	< 0.4	< 3	< 1	-	83
Non 2,3,7,8 HxCDF	5.16	4.53	7.22	61.5	11.7	12.7	6.94	19.0	4.70	9	4.53	61.5	7.22	14.8	
1,2,3,4,6,7,8 HpCDF	5.55	6.08	6.30	57.4	15.1	12.9	9.03	15.7	5.52	9	5.52	57.4	9.03	14.8	99
1,2,3,4,7,8,9 HpCDF	< 0.5	< 1	< 1	2.62	< 1	< 1	< 3	< 0.9	< 0.5	1	< 0.5	2.62	< 1	-	86
Non 2,3,7,8 HpCDF	2.26	11.9	2.48	92.6	20.4	7.64	9.85	16.8	3.12	9	2.26	92.6	9.85	18.6	
OCDF	5.71	33.8	7.04	146	44.3	13.5	20.7	41.6	5.45	9	5.45	146	20.7	35.3	
Sum of PCDD/Fs (inc)[1]	201	757	370	2850	952	372	430	794	306		201	2850	430	781	
Sum of PCDD/Fs (exc)[2]	197	752	362	2840	946	364	411	788	303		197	2840	411	774	
Total I-TEQ (inc)[1]	1.03	1.72	1.76	6.67	2.51	1.76	3.19	2.34	1.12		1.03	6.67	1.76	2.46	
Total I-TEQ (exc)[2]	0.27	1.03	0.43	5.04	1.44	0.53	0.65	1.26	0.45		0.27	5.04	0.65	1.23	

1 = Including half LOD values
2 = Excluding LOD values
3 = Mean of primary and blind duplicate samples (Table D8)
4 = Excludes any LOD value which is greater than a measured value
5 = Mean value reported only if a PCDD/F congener detected on more than 66% of occasions (minimum of 6 positive determinations)
6 = For any individual congener, calculation of the mean includes half LOD values

Table D7 Concentrations of PCDDs and PCDFs in metropolitan Christchurch soils (ng kg^{-1}, dry wt basis)

Congener	Merivale/Shirley (residential)	City/Woolston (commercial/light industrial)	Spreydon/Halswell (residential)	Hornby/Birmingham Drive (commercial/light industrial) (n=2)[3]	Avonhead/Burnside (residential)	Port Hills	Number of positives	Minimum	Maximum	Median	Mean[4,5]	Mean of ^{13}C surrogate standard recoveries, %, (n=7)
2,3,7,8 TCDD	< 0.2	< 0.3	< 0.3	< 0.3	< 0.1	< 0.1	0	< 0.1	< 0.3	< 0.3	-	96
Non 2,3,7,8 TCDD	4.36	4.89	10.9	6.17	5.09	2.45	6	2.45	10.9	4.99	5.64	
1,2,3,7,8 PeCDD	< 0.4	< 0.6	< 0.4	< 0.7	< 0.2	< 0.1	0	< 0.1	< 0.7	< 0.4	-	98
Non 2,3,7,8 PeCDD	4.31	7.51	7.86	7.08	< 2	1.26	5	1.26	7.86	5.70	4.84	
1,2,3,4,7,8 HxCDD	< 0.2	< 1	< 0.4	< 0.8	< 0.2	< 0.1	0	< 0.1	< 1	< 0.3	-	109
1,2,3,6,7,8 HxCDD	< 0.9	< 1	< 0.5	< 1	< 0.5	< 0.3	0	< 0.3	< 1	< 0.7	-	92
1,2,3,7,8,9 HxCDD	< 0.7	< 1	< 0.4	< 1	< 0.6	< 0.3	0	< 0.3	< 1	< 0.7	-	
Non 2,3,7,8 HxCDD	10.5	9.98	9.23	13.6	4.89	2.17	6	2.17	13.6	9.61	8.39	
1,2,3,4,6,7,8 HpCDD	14.5	15.0	10.0	46.2	12.6	3.12	6	3.12	46.2	13.6	16.9	91
Non 2,3,7,8 HpCDD	13.4	13.2	9.26	46.8	9.34	2.72	6	2.72	46.8	11.3	15.8	
OCDD	100	121	96.3	594	91.1	24.5	6	24.5	594	98.2	171	78
2,3,7,8 TCDF	< 0.3	< 0.1	< 0.1	< 0.3	< 0.3	< 0.2	0	< 0.1	< 0.3	< 0.3	-	92
Non 2,3,7,8 TCDF	12.2	18.4	17.1	13.8	8.08	6.77	6	6.8	18.4	13.0	12.7	
1,2,3,7,8 PeCDF	< 0.3	< 0.5	< 0.4	< 0.3	< 0.1	< 0.1	0	< 0.1	< 0.5	< 0.3	-	90
2,3,4,7,8 PeCDF	< 0.2	< 0.5	< 0.4	< 0.2	< 0.1	< 0.1	0	< 0.1	< 0.5	< 0.2	-	90
Non 2,3,7,8 PeCDF	6.13	9.34	6.50	8.61	4.03	1.76	6	1.76	9.34	6.32	6.06	
1,2,3,4,7,8 HxCDF	< 0.3	< 1	< 1	< 0.7	< 0.3	< 0.2	0	< 0.2	< 1	< 0.5	-	92
1,2,3,6,7,8 HxCDF	< 0.3	< 1	< 0.4	< 0.6	< 0.3	< 0.1	0	< 0.1	< 1	< 0.4	-	87
2,3,4,6,7,8 HxCDF	< 0.3	< 1	< 0.3	< 0.6	< 0.2	< 0.1	0	< 0.1	< 1	< 0.3	-	94
1,2,3,7,8,9 HxCDF	< 0.2	< 1	< 0.7	< 0.3	< 0.2	< 0.2	0	< 0.2	< 1	< 0.3	-	85
Non 2,3,7,8 HxCDF	3.47	6.51	4.42	7.69	4.00	< 1	5	< 1.00	7.69	4.21	4.43	
1,2,3,4,6,7,8 HpCDF	3.84	8.32	6.15	10.9	5.03	2.30	6	2.30	10.9	5.59	6.08	84
1,2,3,4,7,8,9 HpCDF	< 0.2	< 1	< 0.5	< 1	< 0.3	< 0.1	0	< 0.1	< 1	< 0.4	-	97
Non 2,3,7,8 HpCDF	2.64	6.70	4.09	9.86	4.63	< 0.4	5	< 0.4	9.86	4.36	4.89	
OCDF	15.0	10.9	12.4	27.6	17.9	1.87	6	1.87	27.6	13.7	14.3	
Sum of PCDD/Fs (inc)[1]	193	237	197	796	169	50.6		50.6	796	195	274	
Sum of PCDD/Fs (exc)[2]	190	232	194	793	167	48.9		48.9	793	192	271	
Total I-TEQ (inc)[1]	0.75	1.16	0.82	1.84	0.54	0.26		0.54	1.84	0.79	0.90	
Total I-TEQ (exc)[2]	0.30	0.37	0.27	1.19	0.29	0.081		0.081	1.19	0.30	0.41	

1 = Including half LOD values

2 = Excluding LOD values

3 = Mean of primary and blind duplicate samples (Table D8)

4 = Mean value reported only if a PCDD/F congener detected on more than 66% of occasions (minimum of 4 positive determinations)

5 = For any individual congener, calculation of the mean includes half LOD values

Table D8 Comparative PCDD and PCDF concentrations in primary and blind duplicate samples (ng kg^{-1}, dry wt basis)

Congener	Catlins Forest (indigenous forest) Primary	Catlins Forest (indigenous forest) Blind duplicate	Taranaki/SW Waikato (hill country pasture) Primary	Taranaki/SW Waikato (hill country pasture) Blind duplicate	Hamilton (provincial centre) Primary	Hamilton (provincial centre) Blind duplicate	Timaru (provincial centre) Primary	Timaru (provincial centre) Blind duplicate	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) Blind duplicate	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) Blind duplicate
2,3,7,8 TCDD	< 0.3	< 0.4	< 0.2	< 0.3	< 0.4	< 0.3	< 0.3	< 0.1	< 0.3	< 0.3	< 0.4	< 0.2
Non 2,3,7,8 TCDD	4.59	7.46	< 4	< 3	3.44	< 0.8	7.67	8.80	21.9	21.1	5.82	6.52
1,2,3,7,8 PeCDD	< 0.3	< 0.5	< 0.3	< 0.3	< 0.5	< 0.7	< 0.5	< 0.3	< 0.9	< 0.8	< 0.8	< 0.5
Non 2,3,7,8 PeCDD	< 1	< 2	< 1	< 1	4.52	5.46	4.11	4.20	15.3	19.1	6.17	7.99
1,2,3,4,7,8 HxCDD	< 0.3	< 0.4	< 0.3	< 0.3	< 0.5	< 0.4	< 0.4	< 0.3	< 1	< 1	< 0.6	< 1
1,2,3,6,7,8 HxCDD	< 0.3	< 0.4	< 0.4	< 0.2	< 1	< 1	< 0.4	< 0.7	< 2	< 2	< 1	< 1
1,2,3,7,8,9 HxCDD	< 0.3	< 0.4	< 1	< 0.1	< 3	< 1	< 0.7	< 2	< 1	< 2	< 0.6	< 2
Non 2,3,7,8 HxCDD	4.91	7.58	< 7	< 6	17.3	19.2	3.94	3.31	22.6	17.2	15.0	12.1
1,2,3,4,6,7,8 HpCDD	< 2	2.95	< 2	< 2	14.8	16.6	11.2	15.2	46.1	46.3	56.5	35.8
Non 2,3,7,8 HpCDD	< 2	3.48	< 2	< 2	15.0	15.9	10.5	12.8	43.5	48.8	57.2	36.4
OCDD	18.1	31.9	< 10	< 10	117	130	103	134	431	540	811	376
2,3,7,8 TCDF	< 0.2	< 0.3	< 0.2	< 0.2	< 0.4	< 0.3	< 0.9	< 0.4	< 0.2	2.30	< 0.1	< 0.5
Non 2,3,7,8 TCDF	37.2	82.7	< 1	< 0.7	6.04	7.65	9.28	11.8	34.5	33.1	14.7	12.9
1,2,3,7,8 PeCDF	< 0.2	< 0.2	< 0.1	< 0.2	< 0.5	< 0.2	< 0.3	< 0.2	< 1	< 1	< 0.3	< 0.3
2,3,4,7,8 PeCDF	< 0.2	< 0.3	< 0.2	< 0.2	< 0.5	< 0.2	< 0.3	< 0.3	< 1	< 1	< 0.1	< 0.3
Non 2,3,7,8 PeCDF	2.74	2.86	< 0.2	< 0.3	3.14	1.12	5.86	7.52	26.6	19.1	7.02	10.2
1,2,3,4,7,8 HxCDF	< 0.2	< 0.3	< 0.2	< 0.2	< 0.7	< 0.5	< 0.6	< 0.4	< 2	< 1	< 0.8	< 0.5
1,2,3,6,7,8 HxCDF	< 0.2	< 0.3	< 0.2	< 0.2	< 0.6	< 0.5	< 0.5	< 0.4	< 1	< 1	< 0.5	< 0.7
2,3,4,6,7,8 HxCDF	< 0.2	< 0.3	< 0.2	< 0.2	< 0.7	< 0.3	< 0.3	< 0.4	< 1	< 1	< 0.5	< 0.6
1,2,3,7,8,9 HxCDF	< 0.3	< 0.4	< 0.2	< 0.3	< 1	< 0.4	< 0.4	< 0.1	< 1	< 0.3	< 0.4	< 0.2
Non 2,3,7,8 HxCDF	< 0.9	< 2	< 0.3	< 0.3	3.30	2.19	4.40	6.11	19.2	18.7	6.09	9.29
1,2,3,4,6,7,8 HpCDF	< 2	2.83	< 2	< 2	4.02	3.52	4.60	6.68	16.5	14.9	9.50	12.2
1,2,3,4,7,8,9 HpCDF	< 0.4	< 0.6	< 0.3	< 0.3	< 0.8	< 0.4	< 0.5	< 0.3	< 1	< 0.7	< 1	< 1
Non 2,3,7,8 HpCDF	< 0.5	< 0.8	< 0.4	< 0.5	2.78	2.73	5.41	6.24	16.3	17.3	8.32	11.4
OCDF	< 1	< 3	< 0.7	< 0.8	6.73	< 9	7.69	23.3	31.1	52.0	19.8	35.3
Sum of PCDD/Fs (inc)[1]	73.9	148	17.2	15.8	203	212	181	243	731	856	1020	571
Sum of PCDD/Fs (exc)[2]	67.5	142	0	0	198	204	178	240	725	850	1020	566
Total I-TEQ (inc)[1]	0.42	0.64	0.39	0.39	1.17	0.94	0.80	0.82	2.20	2.48	2.15	1.53
Total I-TEQ (exc)[2]	0.018	0.090	0	0	0.31	0.33	0.23	0.38	1.09	1.43	1.49	0.89

1 = Including half LOD values
2 = Excluding LOD values

Table D9 Comparative PCDD and PCDF concentrations in primary and split QC samples (ng kg^{-1}, dry wt basis)

Congenor	Mount Egmont National Park (indigenous grassland) Primary[3]	Mount Egmont National Park (indigenous grassland) Split QC[4,5]	Hawke's Bay/East Coast (hill country pasture) Primary	Hawke's Bay/East Coast (hill country pasture) Split QC	Marlborough/Canterbury (flat land pasture) Primary	Marlborough/Canterbury (flat land pasture) Split QC	Hamilton (provincial centre) Primary	Hamilton (provincial centre) Split QC	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) Split QC	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) Split QC
2,3,7,8 TCDD	< 0.4	< 0.3	< 0.4	< 0.2	< 0.1	< 0.1	< 0.4	< 0.2	< 0.3	< 0.2	< 0.4	< 0.3
Non 2,3,7,8 TCDD	< 0.6	< 0.3	< 3	< 1	< 0.7	0.94	3.44	1.6	21.9	9.5	5.82	2.3
1,2,3,7,8 PeCDD	< 0.8	< 0.3	< 0.4	< 0.3	< 0.1	< 0.2	< 0.5	< 0.4	< 0.9	0.65	< 0.8	< 0.6
Non 2,3,7,8 PeCDD	< 0.8	< 0.3	< 0.9	< 0.5	< 0.1	< 0.2	4.52	1.1	15.3	5.6	6.17	2.3
1,2,3,4,7,8 HxCDD	< 0.6	< 0.4	< 0.7	< 0.3	< 0.1	< 0.2	< 0.5	< 0.4	< 1	< 0.7	< 0.6	< 0.7
1,2,3,6,7,8 HxCDD	< 1	< 0.4	< 0.6	< 0.2	< 0.1	< 0.1	< 1	0.60	< 2	1.5	< 1	1.1
1,2,3,7,8,9 HxCDD	< 0.6	< 0.5	< 2	0.90	< 0.1	0.20	< 3	1.9	< 1	2.0	< 0.6	1.4
Non 2,3,7,8 HxCDD	< 0.6	2.7	< 10	3.4	< 0.7	< 1	17.3	7.5	22.6	15	15.0	7.5
1,2,3,4,6,7,8 HpCDD	6.45	4.1	< 6	2.2	< 1	< 1	14.8	8.8	46.1	31	56.5	37
Non 2,3,7,8 HpCDD	6.68	4.0	< 8	2.4	< 1	< 2	15.0	6.2	43.5	34	57.2	47
OCDD	32.6	18	43.1	13.0	9.88	8.60	117	59	431	260	811	630
2,3,7,8 TCDF	< 0.3	< 0.2	< 0.2	< 0.09	< 0.1	< 0.2	< 0.4	< 0.3	< 0.2	2.1	< 0.1	0.69
Non 2,3,7,8 TCDF	< 0.4	< 0.4	< 2	< 0.3	2.87	2.9	6.04	3.9	34.5	13	14.7	4.6
1,2,3,7,8 PeCDF	< 0.2	< 0.1	< 0.2	< 0.2	< 0.1	< 0.2	< 0.5	< 0.2	< 1	0.63	< 0.3	0.31
2,3,4,7,8 PeCDF	< 0.2	< 0.2	< 0.2	< 0.4	< 0.1	< 0.08	< 0.5	< 0.2	< 1	0.93	< 0.1	0.35
Non 2,3,7,8 PeCDF	< 0.4	< 0.5	< 0.3	< 0.3	< 0.1	< 0.7	3.14	1.6	26.6	12	7.02	3.5
1,2,3,4,7,8 HxCDF	< 0.9	< 0.5	< 0.3	< 0.1	< 0.1	< 0.1	< 0.7	< 0.3	< 2	1.6	< 0.8	0.63
1,2,3,6,7,8 HxCDF	< 0.4	< 0.4	< 0.3	< 0.2	< 0.1	< 0.2	< 0.6	< 0.3	< 1	0.91	< 0.5	< 0.5
2,3,4,6,7,8 HxCDF	< 0.9	< 0.3	< 0.3	< 0.2	< 0.1	< 0.2	< 0.7	< 0.2	< 1	< 0.9	< 0.5	< 0.5
1,2,3,7,8,9 HxCDF	< 0.6	< 0.6	< 0.4	< 0.8	< 0.2	< 0.6	< 1	< 0.7	< 1	< 0.8	< 0.4	< 0.6
Non 2,3,7,8 HxCDF	< 0.5	< 2	< 0.5	< 0.3	< 0.1	< 0.3	3.30	1.6	19.2	9.5	6.09	3.7
1,2,3,4,6,7,8 HpCDF	2.94	< 1	< 3	< 0.8	< 0.3	< 0.4	4.02	1.7	16.5	7.2	9.50	4.3
1,2,3,4,7,8,9 HpCDF	< 0.7	< 0.2	< 0.6	< 0.2	< 0.1	< 0.09	< 0.8	< 0.2	< 1	< 0.6	< 1	< 0.4
Non 2,3,7,8 HpCDF	< 0.7	< 0.3	< 0.6	< 0.2	< 0.2	< 0.4	2.78	1.8	16.3	10	8.32	5.0
OCDF	< 2	< 1	< 2	< 0.4	< 0.5	< 0.5	6.73	3.1	31.1	17	19.8	9.1
Sum of PCDD/Fs (inc)[1]	55.5	33.9	64.6	25.4	15.8	17.0	203	102	731	436	1020	763
Sum of PCDD/Fs (exc)[2]	48.7	28.8	43.1	21.9	12.8	12.6	198	100	725	434	1020	761
Total I-TEQ (inc)[1]	0.85	0.51	0.69	0.50	0.17	0.24	1.17	0.78	2.20	2.51	2.15	2.04
Total I-TEQ (exc)[2]	0.13	0.059	0.043	0.13	0.010	0.029	0.31	0.42	1.09	2.29	1.49	1.62

1 = Including half LOD values
2 = Excluding LOD values
3 = Analysed by primary laboratory
4 = Analysed by independent cross-check laboratory
5 = Split QC analyses (all samples) not congener-specific for 2,3,7,8 TCDF, 2,3,4,7,8 PeCDF, 1,2,3,4,7,8 HxCDF or 1,2,3,7,8,9 HxCDD

Table D10 Concentrations of PCDDs and PCDFs in soil field blanks and equipment rinsate blanks (ng kg^{-1}, dry weight basis for field blanks; ng L^{-1} for equipment rinsate blanks)

Congener	Waipoua Forest Northland (indigenous forest) Field blank	Otago Southland (hill country pasture) Field blank	Marlborough/Canterbury (flat land pasture) Field blank	Masterton (provincial centre) Field blank	Western (metropolitan Auckland) Field blank	City/Woolston (metropolitan Christchurch) Field blank	Napier (provincial centre) Rinsate blank	Greymouth (provincial centre) Rinsate blank	Mean of ^{13}C surrogate standard recoveries, %, (n=8)
2,3,7,8 TCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.006	< 0.006	98
Non 2,3,7,8 TCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.02	< 0.006	< 0.006	
1,2,3,7,8 PeCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.009	< 0.007	105
Non 2,3,7,8 PeCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.02	< 0.009	< 0.007	
1,2,3,4,7,8 HxCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.03	< 0.01	< 0.007	< 0.009	98
1,2,3,6,7,8 HxCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.006	< 0.008	90
1,2,3,7,8,9 HxCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.03	< 0.03	< 0.007	< 0.008	
Non 2,3,7,8 HxCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.03	< 0.02	< 0.007	< 0.009	
1,2,3,4,6,7,8 HpCDD	< 0.05	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	< 0.03	< 0.02	84
Non 2,3,7,8 HpCDD	< 0.03	< 0.01	< 0.01	< 0.01	< 0.05	< 0.02	< 0.05	< 0.02	
OCDD	< 0.4	< 0.1	< 0.07	< 0.08	< 0.2	< 0.04	< 0.6	< 0.09	60
2,3,7,8 TCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.004	< 0.004	90
Non 2,3,7,8 TCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.004	< 0.004	
1,2,3,7,8 PeCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.005	< 0.004	84
2,3,4,7,8 PeCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.005	< 0.004	86
Non 2,3,7,8 PeCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.005	< 0.004	
1,2,3,4,7,8 HxCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.005	< 0.005	89
1,2,3,6,7,8 HxCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.005	< 0.005	88
2,3,4,6,7,8 HxCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.005	< 0.007	87
1,2,3,7,8,9 HxCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.03	< 0.01	< 0.008	< 0.009	84
Non 2,3,7,8 HxCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.005	< 0.005	
1,2,3,4,6,7,8 HpCDF	< 0.04	< 0.01	< 0.01	< 0.01	< 0.03	< 0.02	< 0.009	< 0.01	89
1,2,3,4,7,8,9 HpCDF	< 0.02	< 0.01	< 0.01	< 0.01	< 0.03	< 0.01	< 0.009	< 0.02	86
Non 2,3,7,8 HpCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.03	< 0.02	< 0.009	< 0.01	
OCDF	< 0.05	< 0.02	< 0.03	< 0.02	< 0.08	< 0.04	< 0.02	< 0.06	
Sum of PCDD/Fs (inc)[1]	0.39	0.18	0.17	0.17	0.41	0.22	0.42	0.17	
Sum of PCDD/Fs (exc)[2]	0	0	0	0	0	0	0	0	
Total I-TEQ (inc)[1]	0.015	0.015	0.014	0.015	0.022	0.015	0.012	0.0089	
Total I-TEQ (exc)[2]	0	0	0	0	0	0	0	0	

1 = Including half LOD values
2 = Excluding LOD values

Appendix E Concentrations of PCBs in New Zealand soils

This appendix reports the levels of PCBs in all soil samples collected as part of the Organochlorines Programme. Results from field quality control samples are also provided.

Concentrations of 25 PCB congeners are reported. PCB TEQ levels were calculated, both excluding LOD values and including half LOD values, using the WHO TEFs (Ahlborg *et al*., 1994).

PCB data are reported in the following tables:

Table E1 Concentrations of PCBs in New Zealand indigenous forest soils (μg kg^{-1}, dry wt basis)[1]

Congener	Waipoua Forest Northland	Pirongia Forest Park Waikato/Bay of Plenty	Whirinaki Forest Waikato/Bay of Plenty	Rimutaka Forest Park Wellington/Wanganui	Arthur's Pass National Park Marlborough/Canterbury	Paparoa National Park West Coast/Tasman	Catlins Forest Otago/Southland (n=2)[4]	Number of positives	Minimum	Maximum[5]	Median	Mean[6]	Mean of ^{13}C surrogate standard recoveries, %, (n=8)
PCB #77	< 0.001	< 0.003	< 0.002	< 0.006	< 0.001	< 0.001	< 0.004	0	< 0.001	< 0.006	< 0.002	-	71
PCB #126	< 0.001	< 0.001	< 0.002	< 0.002	< 0.001	< 0.001	< 0.001	0	< 0.001	< 0.002	< 0.001	-	62
PCB #169	< 0.001	< 0.002	< 0.002	< 0.001	< 0.002	< 0.007	< 0.02	0	< 0.001	< 0.02	< 0.002	-	53
PCB #28 + PCB #31	< 0.06	< 0.1	< 0.06	< 0.2	< 0.1	< 0.07	< 0.2	0	< 0.06	< 0.2	< 0.1	-	85
PCB #52	< 0.02	< 0.03	< 0.02	< 0.07	< 0.02	< 0.02	< 0.05	0	< 0.02	< 0.07	< 0.02	-	97
PCB #101	< 0.02	0.037	0.032	0.11	< 0.01	< 0.01	< 0.04	3	< 0.01	0.11	0.032	-	84
PCB #99	< 0.01	< 0.02	< 0.02	0.035	< 0.01	< 0.01	< 0.02	1	< 0.01	0.035	< 0.02	-	
PCB #123	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #118	< 0.01	0.042	0.047	0.11	< 0.01	< 0.01	< 0.03	3	< 0.01	0.11	< 0.03	-	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #105	< 0.01	< 0.01	< 0.01	0.026	< 0.01	< 0.01	< 0.01	1	< 0.01	0.026	< 0.01	-	
PCB #153	< 0.01	0.079	0.10	0.17	< 0.01	< 0.01	< 0.02	3	< 0.01	0.17	< 0.02	-	81
PCB #138	< 0.02	0.11	0.14	0.25	< 0.02	< 0.01	< 0.03	3	< 0.01	0.25	< 0.03	-	
PCB #167	< 0.01	< 0.02	< 0.02	< 0.05	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.05	< 0.01	-	
PCB #156	< 0.01	< 0.04	< 0.01	0.021	< 0.01	< 0.01	< 0.01	1	< 0.01	0.021	< 0.01	-	
PCB #157	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #187	< 0.01	0.026	0.028	0.059	< 0.01	< 0.01	< 0.01	3	< 0.01	0.059	< 0.01	-	
PCB #183	< 0.01	< 0.01	< 0.01	0.022	< 0.01	< 0.01	< 0.01	1	< 0.01	0.022	< 0.01	-	
PCB #180	< 0.01	0.029	0.025	0.071	< 0.01	< 0.01	< 0.01	3	< 0.01	0.071	< 0.01	-	91
PCB #170	< 0.01	0.039	0.027	0.11	< 0.01	< 0.01	< 0.01	3	< 0.01	0.11	< 0.01	-	
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #202	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	92
PCB #194	< 0.01	< 0.01	< 0.01	0.023	< 0.01	< 0.01	< 0.01	1	< 0.01	0.023	< 0.01	-	
PCB #206	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Sum of PCBs (inc)[2]	0.15	0.51	0.50	1.20	0.17	0.14	0.24		0.14	1.20	0.24	0.42	
Sum of PCBs (exc)[3]	0	0.36	0.39	1.02	0	0	0		0	1.02	0	0.25	
Total PCB TEQ (inc)[1,2]	0.065	0.086	0.13	0.15	0.070	0.10	0.16		0.065	0.16	0.10	0.11	
Total PCB TEQ (exc)[1,3]	0	0.0084	0.0077	0.036	0	0	0		0	0.036	0	0.0074	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in μg kg^{-1} dry wt

2 = Including half LOD values

3 = Excluding LOD values

4 = Mean of primary and blind duplicate samples (Table E8)

5 = Mean value reported only if a PCB congener detected on more than 66% of occasions (minimum of 5 positive determinations)

6 = For any individual congener, calculation of the mean includes half LOD values

Table E2 Concentrations of PCBs in New Zealand indigenous grassland soils (µg kg^{-1}, dry wt basis)[1]

Congener	Ruahine Forest Park Hawke's Bay/East Coast	Mount Egmont National Park Taranaki/SW Waikato	Tararua Forest Park Wellington/Wanganui	Nelson Lakes National Park Marlborough/Canterbury	Blue Mountains Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[4]	Mean of ^{13}C surrogate standard recoveries, %, (n=5)
PCB #77	< 0.002	< 0.001	< 0.001	< 0.001	< 0.002	0	< 0.001	< 0.002	< 0.001	-	70
PCB #126	< 0.005	< 0.001	< 0.001	< 0.001	< 0.001	0	< 0.001	< 0.005	< 0.001	-	52
PCB #169	< 0.005	< 0.001	< 0.001	< 0.001	< 0.002	0	< 0.001	< 0.005	< 0.001	-	51
PCB #28 + PCB #31	< 0.2	< 0.05	< 0.2	< 0.07	< 0.08	0	< 0.05	< 0.2	< 0.08	-	73
PCB #52	< 0.04	< 0.02	< 0.03	< 0.01	< 0.02	0	< 0.01	< 0.04	< 0.02	-	71
PCB #101	< 0.03	< 0.01	< 0.02	< 0.01	< 0.02	0	< 0.01	< 0.03	< 0.02	-	65
PCB #99	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #123	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #118	< 0.02	< 0.01	< 0.02	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #105	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #153	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	66
PCB #138	< 0.03	< 0.02	< 0.02	< 0.01	< 0.02	0	< 0.01	< 0.03	< 0.02	-	
PCB #167	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #156	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #157	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #187	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #183	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #180	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	68
PCB #170	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #202	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	74
PCB #194	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #206	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
Sum of PCBs (inc)[2]	0.25	0.14	0.23	0.13	0.16		0.13	0.25	0.16	0.18	
Sum of PCBs (exc)[3]	0	0	0	0	0		0	0	0	0	
Total PCB TEQ (inc)[1,2]	0.29	0.065	0.066	0.065	0.071		0.065	0.29	0.066	0.11	
Total PCB TEQ (exc)[1,3]	0	0	0	0	0		0	0	0	0	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in µg kg^{-1} dry wt

2 = Including half LOD values

3 = Excluding LOD values

4 = Mean value reported only if a PCB congener detected on more than 66% of occasions (minimum of 4 positive determinations)

Table E3 Concentrations of PCBs in New Zealand hill country pasture soils (µg kg^{-1}, dry wt basis)[1]

Congener	Northland	Waikato/Bay of Plenty	Hawke's Bay/East Coast	Taranaki/SW Waikato (n=2)[4]	Wellington/Wanganui	Marlborough/Canterbury	West Coast/Tasman	Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[5]	Mean of ^{13}C surrogate standard recoveries, %, (n=9)
PCB #77	< 0.001	< 0.001	< 0.001	< 0.002	< 0.002	< 0.001	< 0.001	< 0.003	0	< 0.001	< 0.003	< 0.001	-	74
PCB #126	< 0.001	< 0.001	< 0.001	< 0.002	< 0.002	< 0.001	< 0.001	< 0.001	0	< 0.001	< 0.002	< 0.001	-	75
PCB #169	< 0.001	< 0.002	< 0.002	< 0.003	< 0.001	< 0.001	< 0.001	< 0.001	0	< 0.001	< 0.003	< 0.001	-	68
PCB #28 + PCB #31	< 0.04	< 0.06	< 0.03	< 0.07	< 0.1	< 0.03	< 0.06	< 0.1	0	< 0.03	< 0.1	< 0.06	-	87
PCB #52	< 0.01	< 0.02	< 0.01	< 0.02	< 0.02	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	77
PCB #101	< 0.01	< 0.02	< 0.01	< 0.03	< 0.02	< 0.01	< 0.01	< 0.02	0	< 0.01	< 0.03	< 0.02	-	72
PCB #99	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #123	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #118	< 0.01	< 0.02	< 0.01	< 0.02	< 0.02	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #105	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #153	< 0.01	< 0.02	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	86
PCB #138	< 0.02	< 0.03	< 0.02	< 0.03	< 0.02	< 0.01	< 0.01	< 0.02	0	< 0.01	< 0.03	< 0.02	-	
PCB #167	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #156	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #157	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #187	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #183	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #180	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	77
PCB #170	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #202	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	70
PCB #194	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #206	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Sum of PCBs (inc)[2]	0.13	0.16	0.12	0.17	0.18	0.12	0.13	0.16		0.12	0.18	0.15	0.15	
Sum of PCBs (exc)[3]	0	0	0	0	0	0	0	0		0	0	0	0	
Total PCB TEQ (inc)[1,2]	0.065	0.071	0.070	0.10	0.12	0.065	0.065	0.066		0.065	0.12	0.068	0.078	
Total PCB TEQ (exc)[1,3]	0	0	0	0	0	0	0	0		0	0	0	0	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in µg kg^{-1} dry wt

2 = Including half LOD values

3 = Excluding LOD values

4 = Mean of primary and blind duplicate samples (Table E8)

5 = Mean value reported only if a PCB congener detected on more than 66% of occasions (minimum of 6 positive determinations).

Table E4 Concentrations of PCBs in New Zealand flat land pasture soils (µg kg^{-1}, dry wt basis)[1]

Congener	Northland	Waikato/Bay of Plenty	Hawke's Bay/East Coast	Taranaki/SW Waikato	Wellington/Wanganui	Marlborough/Canterbury	West Coast/Tasman	Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[4]	Mean of ^{13}C surrogate standard recoveries, %, (n=8)
PCB #77	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	0	< 0.001	< 0.002	< 0.001	-	88
PCB #126	< 0.002	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	< 0.002	0	< 0.001	< 0.002	< 0.001	-	79
PCB #169	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.004	< 0.003	0	< 0.001	< 0.004	< 0.001	-	77
PCB #28 + PCB #31	< 0.2	< 0.1	< 0.03	< 0.06	< 0.3	< 0.03	< 0.06	< 0.07	0	< 0.03	< 0.3	< 0.07	-	85
PCB #52	< 0.05	< 0.02	< 0.01	< 0.02	< 0.04	< 0.01	< 0.02	< 0.01	0	< 0.01	< 0.05	< 0.02	-	84
PCB #101	< 0.04	< 0.02	< 0.01	< 0.02	< 0.05	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.05	< 0.02	-	75
PCB #99	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
PCB #123	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #118	< 0.02	< 0.02	< 0.01	< 0.02	< 0.05	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.05	< 0.02	-	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #105	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #153	< 0.02	0.041	< 0.02	0.070	< 0.02	< 0.01	< 0.01	< 0.01	2	< 0.01	0.070	< 0.02	-	81
PCB #138	< 0.02	0.065	< 0.03	0.095	< 0.04	< 0.02	< 0.02	< 0.01	2	< 0.01	0.095	< 0.03	-	
PCB #167	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #156	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #157	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #187	< 0.01	< 0.02	< 0.01	0.031	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	0.031	< 0.01	-	
PCB #183	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #180	< 0.01	< 0.02	< 0.01	0.026	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	0.026	< 0.01	-	84
PCB #170	< 0.01	< 0.02	< 0.01	0.031	< 0.02	< 0.01	< 0.01	< 0.01	1	< 0.01	0.031	< 0.01	-	
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
PCB #202	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	82
PCB #194	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #206	< 0.01	< 0.01	< 0.01	< 0.01	< 0.03	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.03	< 0.01	-	
Sum of PCBs (inc)[2]	0.25	0.27	0.13	0.37	0.36	0.12	0.14	0.14		0.12	0.37	0.20	0.22	
Sum of PCBs (exc)[3]	0	0.11	0	0.25	0	0	0	0		0	0.25	0	0.045	
Total PCB TEQ (inc)[1,2]	0.12	0.066	0.065	0.069	0.12	0.065	0.080	0.13		0.065	0.13	0.075	0.089	
Total PCB TEQ (exc)[1,3]	0	0	0	0.0034	0	0	0	0		0	0.0034	0	0.00043	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in µg kg^{-1} dry wt

2 = Including half LOD values

3 = Excluding LOD values

4 = Mean value reported only if a PCB congener detected on more than 66% of occasions (minimum of 6 positive determinations)

Table E5 Concentrations of PCBs in New Zealand provincial centre soils (µg kg^{-1}, dry wt basis)[1]

Congener	Whangarei Northland	Hamilton Waikato/Bay of Plenty (n=2)[4]	Napier Hawke's Bay/East Coast	New Plymouth Taranaki/SW Waikato	Masterton Wellington/Wanganui	Timaru Marlborough/Canterbury (n=2)[4]	Greymouth West Coast/Tasman	Invercargill Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[5,6]	Mean of ^{13}C surrogate standard recoveries, %, (n=10)
PCB #77	< 0.001	< 0.004	< 0.003	< 0.01	< 0.004	< 0.005	< 0.004	< 0.006	0	< 0.001	< 0.01	< 0.004	-	79
PCB #126	< 0.001	< 0.003	< 0.002	< 0.001	< 0.004	< 0.002	< 0.002	< 0.002	0	< 0.001	< 0.004	< 0.002	-	65
PCB #169	< 0.001	< 0.002	< 0.001	< 0.003	< 0.001	< 0.001	< 0.001	< 0.003	0	< 0.001	< 0.003	< 0.001	-	73
PCB #28 + PCB #31	< 0.03	< 0.06	< 0.04	< 0.2	< 0.1	< 0.04	< 0.05	< 0.06	0	< 0.03	< 0.2	< 0.06	-	83
PCB #52	< 0.01	< 0.02	< 0.02	< 0.04	< 0.02	< 0.03	< 0.03	< 0.05	0	< 0.01	< 0.05	< 0.03	-	81
PCB #101	< 0.02	0.11	0.11	0.19	0.076	0.22	0.21	0.39	7	< 0.02	0.39	0.15	0.16	79
PCB #99	< 0.01	0.022	0.028	0.064	< 0.02	0.017	0.032	0.050	6	< 0.01	0.064	0.025	0.029	
PCB #123	< 0.01	< 0.01	< 0.01	< 0.02	< 0.02	< 0.01	< 0.02	< 0.03	0	< 0.01	< 0.03	< 0.02	-	
PCB #118	< 0.03	0.077	0.11	0.13	< 0.07	0.11	0.13	0.20	6	< 0.03	0.20	0.11	0.10	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #105	< 0.01	< 0.02	0.028	0.042	< 0.02	0.022	0.028	0.039	5	< 0.01	0.042	0.025	-	
PCB #153	0.065	0.36	0.30	0.38	0.13	0.49	0.52	0.58	8	0.065	0.58	0.37	0.35	84
PCB #138	0.10	0.53	0.49	0.56	0.18	0.72	0.87	0.88	8	0.10	0.88	0.55	0.54	
PCB #167	< 0.01	0.057	0.060	0.074	< 0.02	0.060	0.10	0.11	6	< 0.01	0.11	0.060	0.060	
PCB #156	< 0.01	0.022	0.022	0.034	< 0.02	0.028	0.036	0.058	6	< 0.01	0.058	0.025	0.027	
PCB #157	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #187	< 0.02	0.15	0.12	0.15	0.034	0.21	0.24	0.24	7	< 0.02	0.24	0.15	0.14	
PCB #183	< 0.01	0.047	0.029	0.036	< 0.01	0.079	0.084	0.090	6	< 0.01	0.090	0.042	0.047	
PCB #180	< 0.02	0.14	0.10	0.12	0.033	0.21	0.22	0.24	7	< 0.02	0.24	0.13	0.13	79
PCB #170	< 0.02	0.15	0.15	0.15	0.028	0.24	0.25	0.35	7	< 0.02	0.35	0.15	0.17	
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #202	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	78
PCB #194	< 0.01	0.029	0.025	0.037	< 0.01	0.043	0.059	0.055	6	< 0.01	0.059	0.033	0.032	
PCB #206	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Sum of PCBs (inc)[2]	0.30	1.76	1.63	2.12	0.67	2.51	2.86	3.38		0.30	3.38	1.94	1.90	
Sum of PCBs (exc)[3]	0.17	1.67	1.57	1.96	0.48	2.43	2.78	3.28		0.17	3.28	1.82	1.79	
Total PCB TEQ (inc)[1,2]	0.067	0.18	0.15	0.13	0.23	0.14	0.17	0.21		0.067	0.23	0.16	0.16	
Total PCB TEQ (exc)[1,3]	0	0.036	0.041	0.051	0.0031	0.053	0.062	0.091		0	0.091	0.046	0.042	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in µg kg^{-1} dry wt

2 = Including half LOD values

3 = Excluding LOD values

4 = Mean of primary and blind duplicate samples

5 = Mean value reported only if a PCB congener detected on more than 66% of occasions (minimum of 6 positive determinations)

6 = For any individual congener, calculation of the mean includes half LOD values

Table E6 Concentrations of PCBs in metropolitan Auckland soils (µg kg^{-1}, dry wt basis)[1]

Congener	North Shore City (residential)	North Shore City (residential)	Western (residential)	Mt Eden/Mt Roskill (residential)	Tamaki/Maungakiekie (residential)	Western and Tamaki/Maungakiekie (commercial/light industrial)	Hobson/Eastern Bays (residential)	Hobson/Eastern Bays (commercial/light industrial) (n=2)[4]	Manukau City (residential)	Number of positives	Minimum	Maximum	Median	Mean[5,6]	Mean of ^{13}C surrogate standard recoveries, %, (n=10)
PCB #77	< 0.004	< 0.004	< 0.008	< 0.008	< 0.008	< 0.008	< 0.006	0.028	< 0.008	1	< 0.004	0.028	< 0.008	-	78
PCB #126	< 0.003	< 0.001	< 0.007	< 0.004	< 0.004	< 0.003	< 0.003	0.011	< 0.004	1	< 0.001	0.011	< 0.004	-	65
PCB #169	< 0.001	< 0.001	< 0.002	< 0.002	< 0.001	< 0.002	< 0.001	< 0.002	< 0.002	0	< 0.001	< 0.002	< 0.002	-	74
PCB #28 + PCB #31	< 0.04	< 0.04	< 0.08	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.09	0	< 0.04	< 0.2	< 0.1	-	82
PCB #52	< 0.02	< 0.02	< 0.05	< 0.05	< 0.05	< 0.04	< 0.03	0.10	< 0.04	1	< 0.02	0.10	< 0.04	-	90
PCB #101	0.054	0.088	0.26	0.17	0.19	0.11	0.072	0.66	0.13	9	0.054	0.66	0.13	0.19	87
PCB #99	0.022	0.033	0.072	0.055	0.055	0.041	0.026	0.30	0.040	9	0.022	0.30	0.041	0.072	
PCB #123	< 0.01	< 0.01	< 0.02	< 0.02	< 0.02	< 0.01	< 0.01	< 0.03	< 0.01	0	< 0.01	< 0.03	< 0.01	-	
PCB #118	0.085	0.098	0.27	0.16	0.19	0.14	0.11	0.83	0.14	9	0.085	0.83	0.14	0.22	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #105	0.024	0.026	0.070	0.050	0.063	0.043	0.032	0.26	0.043	9	0.024	0.26	0.043	0.068	
PCB #153	0.18	0.20	0.66	0.44	0.53	0.33	0.31	1.19	0.30	9	0.18	1.19	0.33	0.46	85
PCB #138	0.29	0.34	1.02	0.75	0.86	0.50	0.48	2.29	0.51	9	0.29	2.29	0.51	0.78	
PCB #167	0.048	0.031	0.17	0.12	0.14	0.077	0.069	0.43	0.083	9	0.031	0.43	0.083	0.13	
PCB #156	< 0.02	< 0.02	0.062	0.038	0.046	0.028	0.022	0.14	0.026	7	< 0.02	0.14	0.028	0.042	
PCB #157	< 0.01	< 0.01	< 0.02	< 0.02	< 0.02	< 0.01	< 0.01	0.061	< 0.01	1	< 0.01	0.061	< 0.01	-	
PCB #187	0.063	0.074	0.24	0.28	0.19	0.13	0.12	0.33	0.10	9	0.063	0.33	0.13	0.17	
PCB #183	< 0.02	0.022	0.086	0.085	0.054	0.034	0.028	0.11	0.034	8	< 0.02	0.11	0.034	0.051	
PCB #180	0.057	0.063	0.24	0.23	0.17	0.11	0.094	0.32	0.11	9	0.057	0.32	0.11	0.15	85
PCB #170	0.063	0.068	0.30	0.23	0.21	0.12	0.11	0.39	0.12	9	0.063	0.39	0.12	0.18	
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #202	< 0.01	< 0.01	< 0.01	0.024	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	1	< 0.01	0.024	< 0.01	-	82
PCB #194	< 0.02	< 0.02	0.057	0.090	0.048	0.035	0.022	0.099	0.024	7	< 0.02	0.099	0.035	0.044	
PCB #206	< 0.01	< 0.01	< 0.02	0.10	0.023	0.027	< 0.01	0.071	< 0.01	4	< 0.01	0.10	< 0.02	-	
Sum of PCBs (inc)[2]	0.98	1.12	3.63	2.93	2.88	1.83	1.60	7.71	1.77		0.98	7.71	1.83	2.72	
Sum of PCBs (exc)[3]	0.89	1.04	3.51	2.82	2.77	1.72	1.50	7.58	1.67		0.89	7.58	1.72	2.61	
Total PCB TEQ (inc)[1,2]	0.19	0.087	0.47	0.29	0.29	0.21	0.20	1.33	0.26		0.087	1.33	0.26	0.37	
Total PCB TEQ (exc)[1,3]	0.018	0.020	0.10	0.067	0.072	0.046	0.038	1.32	0.045		0.018	1.32	0.046	0.19	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in µg kg^{-1} dry wt

2 = Including half LOD values

3 = Excluding LOD values

4 = Mean of primary and blind duplicate samples (Table E8)

5 = Mean value reported only if a PCB congener detected on more than 66% of occasions (minimum of 6 positive determinations)

6 = For any individual congener, calculation of the mean includes half LOD values

Table E7 Concentrations of PCBs in metropolitan Christchurch soils (µg kg^{-1}, dry wt basis)[1]

Congener	Merivale/Shirley (residential)	City/Woolston (commercial/light industrial)	Spreydon/Halswell (residential)	Hornby/Birmingham Drive (commercial/light industrial) (n=2)[4]	Avonhead/Burnside (residential)	Port Hills	Number of positives	Minimum	Maximum	Median[5]	Mean[6,7]	Mean of ^{13}C surrogate standard recoveries, %, (n=7)
PCB #77	< 0.006	0.018	< 0.008	< 0.007	< 0.004	< 0.001	1	< 0.001	0.018	< 0.007	-	80
PCB #126	< 0.002	< 0.008	< 0.002	< 0.003	< 0.002	< 0.005	0	< 0.002	< 0.008	< 0.003	-	71
PCB #169	< 0.004	< 0.002	< 0.001	< 0.002	< 0.003	< 0.003	0	< 0.001	< 0.004	< 0.003	-	76
PCB #28 + PCB #31	< 0.02	< 0.1	< 0.1	< 0.07	< 0.03	< 0.02	0	< 0.02	< 0.1	< 0.05	-	88
PCB #52	< 0.02	0.13	< 0.05	< 0.03	< 0.01	< 0.01	1	< 0.01	0.13	< 0.03	-	87
PCB #101	0.14	1.09	0.18	0.15	0.061	< 0.02	5	< 0.02	1.09	0.15	0.27	85
PCB #99	0.027	0.17	0.041	0.029	< 0.01	< 0.01	4	< 0.01	0.17	0.028	0.046	
PCB #123	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
PCB #118	0.087	0.52	0.11	0.11	0.048	< 0.02	5	< 0.02	0.52	0.099	0.15	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
PCB #105	< 0.02	0.14	0.028	0.032	< 0.01	< 0.01	3	< 0.01	0.14	0.019	-	
PCB #153	0.25	1.62	0.27	0.28	0.13	0.040	6	0.040	1.62	0.26	0.43	83
PCB #138	0.44	2.68	0.43	0.46	0.21	0.067	6	0.067	2.68	0.44	0.71	
PCB #167	0.029	0.37	0.059	0.061	< 0.02	< 0.01	4	< 0.01	0.37	0.044	0.089	
PCB #156	< 0.02	0.13	< 0.02	0.024	< 0.01	< 0.01	2	< 0.01	0.13	< 0.02	-	
PCB #157	< 0.01	0.038	< 0.01	< 0.01	< 0.01	< 0.01	1	< 0.01	0.038	< 0.01	-	
PCB #187	0.091	0.69	0.11	0.11	0.043	< 0.02	5	< 0.02	0.69	0.10	0.18	
PCB #183	0.041	0.29	0.039	0.035	< 0.02	< 0.01	4	< 0.01	0.29	0.037	0.070	
PCB #180	0.084	0.71	0.091	0.10	0.054	< 0.02	5	< 0.02	0.71	0.088	0.17	87
PCB #170	0.094	0.83	0.10	0.12	0.054	< 0.01	5	< 0.01	0.83	0.097	0.20	
PCB #189	< 0.02	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
PCB #202	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	91
PCB #194	< 0.01	0.20	< 0.02	< 0.03	< 0.01	< 0.01	1	< 0.01	0.20	< 0.02	-	
PCB #206	< 0.03	< 0.06	< 0.02	< 0.01	< 0.03	< 0.01	0	< 0.01	< 0.06	< 0.03	-	
Sum of PCBs (inc)[2]	1.38	9.74	1.59	1.61	0.70	0.23		0.23	9.74	1.49	2.54	
Sum of PCBs (exc)[3]	1.28	9.62	1.46	1.50	0.60	0.11		0.11	9.62	1.37	2.43	
Total PCB TEQ (inc)[1,2]	0.15	0.67	0.14	0.18	0.14	0.28		0.14	0.67	0.17	0.26	
Total PCB TEQ (exc)[1,3]	0.019	0.25	0.025	0.040	0.011	0		0	0.25	0.022	0.058	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in µg kg^{-1} dry wt
2 = Including half LOD values
3 = Excluding LOD values
4 = Mean of primary and blind duplicate samples (Table E8)
5 = For any individual congener, calculation of the median includes half LOD values
6 = Mean value reported only if a PCB congener detected on more than 66% of occasions (minimum of 4 positive determinations)
7 = For any individual congener, calculation of the mean includes half LOD values

Table E8 Comparative PCB concentrations in primary and blind duplicate samples (µg kg^{-1}, dry wt basis)[1]

Congener	Catlins Forest (indigenous forest) Primary	Catlins Forest (indigenous forest) Blind duplicate	Taranaki/SW Waikato (hill country pasture) Primary	Taranaki/SW Waikato (hill country pasture) Blind duplicate	Hamilton (provincial centre) Primary	Hamilton (provincial centre) Blind duplicate	Timaru (provincial centre) Primary	Timaru (provincial centre) Blind duplicate	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) Blind duplicate	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) Blind duplicate
PCB #77	< 0.006	< 0.001	< 0.001	< 0.002	< 0.004	< 0.004	< 0.003	< 0.006	0.026	0.030	< 0.008	< 0.006
PCB #126	< 0.001	< 0.001	< 0.002	< 0.001	< 0.003	< 0.002	< 0.002	< 0.001	0.011	0.010	< 0.002	< 0.003
PCB #169	< 0.02	< 0.02	< 0.003	< 0.003	< 0.002	< 0.001	< 0.001	< 0.001	< 0.002	< 0.002	< 0.001	< 0.003
PCB #28 + PCB #31	< 0.2	< 0.1	< 0.1	< 0.04	< 0.08	< 0.04	< 0.04	< 0.04	< 0.2	< 0.2	< 0.1	< 0.04
PCB #52	< 0.06	< 0.04	< 0.02	< 0.01	< 0.03	< 0.01	< 0.02	< 0.03	0.11	0.97	< 0.04	< 0.02
PCB #101	< 0.05	< 0.03	< 0.03	< 0.02	0.12	0.090	0.21	0.23	0.74	0.58	0.17	0.12
PCB #99	< 0.02	< 0.01	< 0.01	< 0.01	0.022	0.021	< 0.02	0.024	0.33	0.26	0.042	< 0.03
PCB #123	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.04	< 0.01	< 0.01	< 0.01
PCB #118	< 0.03	< 0.03	< 0.02	< 0.01	0.083	0.070	0.10	0.11	0.91	0.74	0.11	0.11
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
PCB #105	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.02	< 0.02	< 0.03	0.29	0.23	0.033	0.030
PCB #153	< 0.02	< 0.02	< 0.02	< 0.02	0.37	0.35	0.51	0.46	1.22	1.15	0.28	0.28
PCB #138	< 0.03	< 0.03	< 0.03	< 0.02	0.56	0.49	0.82	0.62	2.26	2.31	0.46	0.46
PCB #167	< 0.01	< 0.01	< 0.01	< 0.01	0.072	0.041	0.081	0.038	0.45	0.40	0.065	0.057
PCB #156	< 0.01	< 0.01	< 0.01	< 0.01	0.024	0.020	0.030	0.026	0.15	0.13	0.022	0.026
PCB #157	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.070	0.052	< 0.01	< 0.01
PCB #187	< 0.01	< 0.01	< 0.01	< 0.01	0.15	0.14	0.24	0.18	0.32	0.33	0.11	0.11
PCB #183	< 0.01	< 0.01	< 0.01	< 0.01	0.047	0.046	0.082	0.076	0.11	0.10	0.036	0.034
PCB #180	< 0.01	< 0.01	< 0.01	< 0.01	0.13	0.14	0.23	0.19	0.32	0.31	0.10	0.10
PCB #170	< 0.01	< 0.01	< 0.01	< 0.01	0.15	0.15	0.28	0.20	0.39	0.38	0.11	0.13
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
PCB #202	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.02	< 0.01	< 0.01
PCB #194	< 0.01	< 0.01	< 0.01	< 0.01	0.025	0.032	0.053	0.033	0.12	0.077	< 0.03	< 0.03
PCB #206	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	0.076	0.066	< 0.01	< 0.01
Sum of PCBs (inc)[2]	0.27	0.21	0.19	0.14	1.85	1.66	2.72	2.29	8.04	7.37	1.66	1.55
Sum of PCBs (exc)[3]	0	0	0	0	1.75	1.59	2.64	2.22	7.90	7.25	1.54	1.46
Total PCB TEQ (inc)[1,2]	0.16	0.16	0.13	0.076	0.21	0.15	0.17	0.11	1.40	1.26	0.15	0.21
Total PCB TEQ (exc)[1,3]	0	0	0	0	0.037	0.034	0.056	0.049	1.39	1.25	0.038	0.042

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt. All other results in µg kg^{-1} dry wt

2 = Including half LOD values

3 = Excluding LOD values

Table E9 Comparative PCB concentrations in primary and split QC samples (µg kg^{-1}, dry wt basis)[1]

Congener	Mount Egmont National Park (indigenous grassland) Primary[1]	Mount Egmont National Park (indigenous crassland) Split QC[2]	Hawke's Bay/East Coast (hill country pasture) Primary	Hawke's Bay/East Coast (hill country pasture) Split QC	Marlborough/Canterbury (flat land pasture) Primary	Marlborough/Canterbury (flat land pasture) Split QC	Hamilton (provincial centre) Primary	Hamilton (provincial centre) Split QC	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) Split QC	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) Split QC
PCB #77	< 0.001	< 0.001	< 0.001	< 0.0008	< 0.001	< 0.001	< 0.004	< 0.008	0.026	0.059	< 0.008	0.010
PCB #126	< 0.001	< 0.0003	< 0.001	< 0.0003	< 0.001	< 0.0003	< 0.003	< 0.005	0.011	0.014	< 0.002	0.0033
PCB #169	< 0.001	< 0.0003	< 0.002	< 0.0005	< 0.001	< 0.0003	< 0.002	< 0.001	< 0.002	0.0014	< 0.001	< 0.001
PCB #118	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	0.023	0.083	0.082	0.91	0.91	0.11	0.11
PCB #105	< 0.01	< 0.01	< 0.01	< 0.005	< 0.01	0.011	< 0.02	0.030	0.29	0.46	0.033	0.048

1 = Analysed by primary laboratory
2 = Analysed by independent cross-check laboratory

Table E10 Concentrations of PCBs in soil field blanks and equipment rinsate blanks (µg kg^{-1}, dry wt basis for field blanks; µg L^{-1} for equipment rinsate blanks)[1]

Congener	Waipoua Forest Northland (indigenous forest)	Otago Southland (hill country pasture)	Marlborough/Canterbury (flat land pasture)	Masterton (provincial centre)	Western (metropolitan Auckland)	City/Woolston (metropolitan Christchurch)	Napier (provincial centre)	Greymouth (provincial centre)	Mean of ^{13}C surrogate standard recoveries, %, (n=8)
	Field blank	Field blank	Field blank	Field blank	Field blank	Field blank	Rinsate blank	Rinsate blank	
PCB #77	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	80
PCB #126	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	60
PCB #169	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	83
PCB #28 + PCB #31	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	82
PCB #52	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	80
PCB #101	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	83
PCB #99	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #123	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #118	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #114	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #105	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #153	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	97
PCB #138	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #167	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #156	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #157	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #187	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #183	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #180	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	86
PCB #170	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #189	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #202	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	77
PCB #194	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
PCB #206	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Sum of PCBs (inc)[2]	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	
Sum of PCBs (exc)[3]	0	0	0	0	0	0	0	0	
Total PCB TEQ (inc)[1,2]	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	
Total PCB TEQ (exc)[1,3]	0	0	0	0	0	0	0	0	

1 = Total PCB TEQ data reported in ng kg^{-1} dry wt (field blanks) or ng L^{-1} (rinsate blanks). All other results in µg kg^{-1} dry wt (field blanks) or µg L^{-1} (rinsate blanks)

2 = Including half LOD values

3 = Excluding LOD values

Appendix F Concentrations of organochlorine pesticides in New Zealand soils

This appendix reports the levels of organochlorine pesticides and pesticide degradation products in soil samples collected as part of the Organochlorines Programme. Results from field quality control samples are also provided.

Organochlorine pesticide data are reported in the following tables:

Table F1 Concentrations of organochlorine pesticides in New Zealand indigenous forest soils (µg kg^{-1}, dry wt basis)

Pesticide	Waipoua Forest Northland	Pirongia Forest Park Waikato/Bay of Plenty	Whirinaki Forest Waikato/Bay of Plenty	Rimutaka Forest Park Wellington/Wanganui	Arthur's Pass National Park Marlborough/Canterbury	Paparoa National Park West Coast/Tasman	Catlins Forest Otago/Southland (n=2)[1]	Number of positives	Minimum	Maximum	Median	Mean[2]	Mean of 13C surrogate standard recoveries, %, (n=8)
Alpha-HCH	< 0.01	< 0.03	< 0.02	< 0.01	< 0.02	< 0.01	< 0.03	0	< 0.01	< 0.03	< 0.02	-	
Beta-HCH	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	0	< 0.01	< 0.02	< 0.01	-	
Gamma-HCH	< 0.02	< 0.04	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0	< 0.02	< 0.04	< 0.02	-	77
HCB	0.11	0.17	0.28	0.15	0.15	0.085	0.16	7	0.085	0.28	0.15	0.16	89
Aldrin	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Dieldrin	< 0.03	0.54	0.50	0.83	< 0.07	< 0.05	0.24	4	< 0.03	0.83	0.24	-	63
Heptachlor	< 0.01	< 0.04	< 0.04	< 0.03	< 0.02	< 0.02	< 0.04	0	< 0.01	< 0.04	< 0.03	-	
Heptachlor epoxide	< 0.06	< 0.01	< 0.03	< 0.03	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.06	< 0.01	-	
Alpha-chlordane	< 0.04	< 0.06	< 0.02	< 0.04	< 0.03	< 0.02	< 0.02	0	< 0.02	< 0.06	< 0.03	-	
Gamma-chlordane	< 0.04	< 0.06	< 0.02	< 0.03	< 0.02	< 0.02	< 0.02	0	< 0.02	< 0.06	< 0.02	-	
pp-DDE	0.098	1.20	2.69	2.00	0.18	0.048	1.73	7	0.048	2.69	1.20	1.14	79
pp-TDE	< 0.02	0.13	0.093	0.087	< 0.01	< 0.01	0.12	4	< 0.01	0.13	0.087	-	
op-DDT	< 0.02	0.11	0.28	0.20	0.026	< 0.01	0.37	5	< 0.01	0.37	0.11	0.14	
pp-DDT	0.099	0.83	2.27	2.19	0.13	0.034	2.70	7	0.034	2.70	0.83	1.18	67

1 = Mean of primary and blind duplicate samples (Table F6)

2 = Mean value reported only if a pesticide detected on more than 66% of occasions (minimum of 5 positive determinations)

Table F2 Concentrations of organochlorine pesticides in New Zealand indigenous grassland soils (µg kg^{-1}, dry wt basis)

Pesticide	Ruahine Forest Park Hawke's Bay/East Coast	Mount Egmont National Park Taranaki/SW Waikato	Tararua Forest Park Wellington/Wanganui	Nelson Lakes National Park Marlborough/Canterbury	Blue Mountains Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[1]	Mean of 13C surrogate standard recoveries, %, (n=5)
Alpha-HCH	< 0.02	< 0.01	< 0.01	< 0.01	< 0.02	0	< 0.01	< 0.02	< 0.01	-	
Beta-HCH	< 0.02	< 0.01	< 0.01	< 0.01	< 0.03	0	< 0.01	< 0.03	< 0.01	-	
Gamma-HCH	< 0.05	< 0.01	< 0.04	< 0.02	< 0.02	0	< 0.01	< 0.05	< 0.02	-	61
HCB	0.20	0.070	0.12	0.065	0.074	5	0.065	0.20	0.074	0.11	78
Aldrin	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	0	< 0.01	< 0.02	< 0.01	-	
Dieldrin	0.57	0.23	0.20	0.12	0.24	5	0.12	0.57	0.23	0.27	54
Heptachlor	< 0.03	< 0.01	< 0.01	< 0.01	< 0.02	0	< 0.01	< 0.03	< 0.01	-	
Heptachlor epoxide	< 0.02	< 0.01	< 0.02	< 0.02	< 0.02	0	< 0.01	< 0.02	< 0.02	-	
Alpha-chlordane	< 0.06	< 0.04	< 0.03	< 0.03	< 0.04	0	< 0.03	< 0.06	< 0.04	-	
Gamma-chlordane	< 0.05	< 0.04	< 0.03	< 0.03	< 0.03	0	< 0.03	< 0.05	< 0.03	-	
pp-DDE	1.57	0.69	0.28	0.67	0.64	5	0.28	1.57	0.67	0.77	65
pp-TDE	0.27	0.21	0.079	0.052	0.13	5	0.052	0.27	0.13	0.15	
op-DDT	0.18	0.084	0.033	0.10	0.12	5	0.033	0.18	0.10	0.10	
pp-DDT	1.76	0.76	0.28	0.60	1.25	5	0.28	1.76	0.76	0.93	53

1 = Mean value reported only if a pesticide detected on more than 66% of occasions (minimum of 4 positive determinations)

Table F3 Concentrations of organochlorine pesticides in New Zealand provincial centre soils (µg kg^{-1}, dry wt basis)

Pesticide	Whangarei Northland	Hamilton Waikato/Bay of Plenty (n=2)[1]	Napier Hawke's Bay/East Coast	New Plymouth Taranaki/SW Waikato	Masterton Wellington/Wanganui	Timaru Marlborough/Canterbury (n=2)[1]	Greymouth West Coast/Tasman	Invercargill Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[2]	Mean of ^{13}C surrogate standard recoveries, %, (n=10)
Alpha-HCH	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
Beta-HCH	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.01	< 0.01	-	
Gamma-HCH	< 0.02	< 0.02	< 0.02	0.11	< 0.02	< 0.03	< 0.02	< 0.02	1	< 0.02	0.11	< 0.02	-	56
HCB	< 0.04	< 0.04	1.00	1.16	< 0.04	< 0.04	< 0.04	0.079	3	< 0.04	1.16	< 0.04	-	72
Aldrin	< 0.02	< 0.02	< 0.03	< 0.04	< 0.01	< 0.02	< 0.01	< 0.02	0	< 0.01	< 0.04	< 0.02	-	
Dieldrin	0.43	0.64	0.15	0.64	0.20	0.39	0.24	2.17	8	0.15	2.17	0.41	0.61	49
Heptachlor	< 0.02	< 0.01	< 0.01	< 0.01	< 0.02	< 0.02	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Heptachlor epoxide	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.03	< 0.01	< 0.01	0	< 0.01	< 0.03	< 0.01	-	
Alpha-chlordane	< 0.02	< 0.03	< 0.02	< 0.02	0.14	< 0.04	< 0.02	< 0.06	1	< 0.02	0.14	< 0.03	-	
Gamma-chlordane	< 0.02	< 0.03	< 0.02	< 0.02	0.15	< 0.04	< 0.01	< 0.04	1	< 0.01	0.15	< 0.03	-	
pp-DDE	6.54	0.58	10.9	7.73	51.2	2.47	16.9	86.9	8	0.58	86.9	9.32	22.9	81
pp-TDE	3.12	0.033	0.58	1.58	1.70	0.69	1.45	28.5	8	0.033	28.5	1.52	4.71	
op-DDT	0.52	0.085	0.33	0.99	2.05	0.38	1.69	8.12	8	0.085	8.12	0.76	1.77	
pp-DDT	14.4	0.80	11.2	9.85	14.4	4.23	12.8	121	8	0.80	121	12.0	23.6	69

1 = Mean of primary and blind duplicate samples (Table F6)

2 = Mean value reported only if a pesticide detected on more than 66% of occasions (minimum of 6 positive determinations)

Table F4 Concentrations of organochlorine pesticides in metropolitan Auckland soils (µg kg^{-1}, dry wt basis)

Pesticide	North Shore City (residential)	North Shore City (residential)	Western (residential)	Mt Eden/Mt Roskill (residential)	Tamaki/Maungakiekie (residential)	Western and Tamaki/Maungakiekie (commercial/light industrial)	Hobson/Eastern Bays (residential)	Hobson/Eastern Bays (commercial/light industrial) (n=2)[1]	Manukau City (residential)	Number of positives	Minimum	Maximum	Median	Mean[2]	Mean of ^{13}C surrogate standard recoveries, %, (n=10)
Alpha-HCH	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Beta-HCH	< 0.01	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Gamma-HCH	< 0.02	< 0.02	< 0.02	0.045	0.057	0.059	< 0.03	< 0.04	< 0.04	3	< 0.02	0.059	< 0.04	-	57
HCB	0.12	0.050	0.053	1.22	0.10	0.11	0.11	0.091	0.076	9	0.050	1.22	0.10	0.21	92
Aldrin	< 0.01	< 0.02	< 0.02	0.085	< 0.06	< 0.02	< 0.02	< 0.02	< 0.02	1	< 0.01	0.085	< 0.02	-	
Dieldrin	2.78	1.60	0.53	42.1	1.55	0.69	0.31	0.35	0.23	9	0.23	42.1	0.69	5.57	46
Heptachlor	< 0.01	< 0.02	< 0.01	< 0.02	< 0.03	< 0.01	< 0.03	< 0.03	< 0.01	0	< 0.01	< 0.03	< 0.02	-	
Heptachlor epoxide	< 0.02	< 0.01	< 0.03	0.12	< 0.02	< 0.04	0.071	< 0.03	< 0.02	2	< 0.01	0.12	< 0.03	-	
Alpha-chlordane	< 0.05	< 0.04	0.080	0.20	0.086	< 0.06	0.33	0.12	< 0.04	5	< 0.04	0.33	0.080	-	
Gamma-chlordane	< 0.03	< 0.03	0.055	0.095	0.050	< 0.05	0.13	0.078	< 0.03	5	< 0.03	0.13	0.050	-	
pp-DDE	19.8	1.05	2.47	27.3	38.4	16.1	0.96	4.09	2.73	9	0.96	38.4	4.09	12.5	63
pp-TDE	0.48	0.19	0.37	3.81	0.77	2.09	0.077	0.55	0.22	9	0.077	3.81	0.48	0.95	
op-DDT	0.95	0.085	0.084	2.72	2.08	1.08	0.073	1.78	0.29	9	0.073	2.72	0.95	1.02	
pp-DDT	9.97	0.53	1.60	30.1	29.1	13.3	1.05	8.54	3.71	9	0.53	30.1	8.54	10.9	65

1 = Mean of primary and blind duplicate samples (Table F6)

2 = Mean value reported only if a pesticide detected on more than 66% of occasions (minimum of 6 positive determinations)

Table F5 Concentrations of organochlorine pesticides in metropolitan Christchurch soils (µg kg^{-1}, dry wt basis)

Pesticide	Merivale/Shirley (residential)	City/Woolston (commercial/light industrial)	Spreydon/Halswell (residential)	Hornby/Birmingham Drive (commercial/light industrial) (n=2)[1]	Avonhead/Burnside (residential)	Port Hills	Number of positives	Minimum	Maximum	Median	Mean[2]	Mean of 13C surrogate standard recoveries, %, (n=7)
Alpha-HCH	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.01	0	< 0.01	< 0.02	< 0.01	-	
Beta-HCH	< 0.03	< 0.01	< 0.01	< 0.02	0.068	< 0.04	1	< 0.01	0.068	< 0.03	-	
Gamma-HCH	< 0.04	< 0.03	< 0.03	< 0.04	0.067	< 0.02	1	< 0.02	0.067	< 0.04	-	67
HCB	0.077	0.11	0.091	0.056	0.12	0.056	6	0.056	0.12	0.084	0.085	72
Aldrin	< 0.01	< 0.03	< 0.02	< 0.02	< 0.01	< 0.01	0	< 0.01	< 0.03	< 0.02	-	
Dieldrin	1.19	1.75	1.85	1.31	1.57	0.21	6	0.21	1.85	1.44	1.31	60
Heptachlor	< 0.01	< 0.01	0.061	< 0.01	< 0.01	< 0.01	1	< 0.01	0.061	< 0.01	-	
Heptachlor epoxide	< 0.01	< 0.01	12.1	< 0.01	< 0.01	< 0.01	1	< 0.01	12.1	< 0.01	-	
Alpha-chlordane	< 0.04	< 0.04	1.11	< 0.03	< 0.03	< 0.02	1	< 0.02	1.11	< 0.04	-	
Gamma-chlordane	< 0.03	< 0.03	1.72	< 0.03	< 0.02	< 0.02	1	< 0.02	1.72	< 0.03	-	
pp-DDE	171	208	273	119	469	139	6	119	469	190	230	87
pp-TDE	10.4	4.14	6.06	2.85	4.62	3.74	6	2.85	10.4	4.38	5.30	
op-DDT	17.1	24.0	37.7	10.3	39.7	11.9	6	10.3	39.7	20.6	23.5	
pp-DDT	106	154	248	107	340	78.8	6	78.8	340	131	172	78

1 = Mean of primary and blind duplicate samples (Table F6)

2 = Mean value reported only if a pesticide detected on more than 66% of occasions (minimum of 5 positive determinations)

Table F6 Comparative organochlorine pesticide concentrations in primary and blind duplicate samples (µg kg^{-1}, dry wt basis)

Pesticide	Catlins Forest (indigenous forest) Primary	Catlins Forest (indigenous forest) Blind duplicate	Hamilton (provincial centre) Primary	Hamilton (provincial centre) Blind duplicate	Timaru (provincial centre) Primary	Timaru (provincial centre) Blind duplicate	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) Blind duplicate	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) Blind duplicate
Alpha-HCH	< 0.03	< 0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01
Beta-HCH	< 0.02	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01
Gamma-HCH	< 0.01	< 0.03	< 0.02	< 0.02	< 0.02	< 0.04	< 0.04	< 0.04	< 0.05	< 0.03
HCB	0.16	0.16	< 0.04	< 0.04	< 0.04	< 0.04	0.072	0.11	0.067	0.045
Aldrin	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dieldrin	0.23	0.24	0.63	0.64	0.36	0.42	0.36	0.34	1.07	1.55
Heptachlor	< 0.04	< 0.04	< 0.01	< 0.01	< 0.01	< 0.02	< 0.04	< 0.02	< 0.01	< 0.01
Heptachlor epoxide	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	< 0.02	< 0.03	< 0.01	< 0.01
Alpha-chlordane	< 0.02	< 0.02	< 0.03	< 0.02	< 0.04	< 0.04	0.11	0.12	< 0.04	< 0.02
Gamma-chlordane	< 0.02	< 0.02	< 0.03	< 0.02	< 0.03	< 0.04	0.056	0.10	< 0.03	< 0.02
pp-DDE	1.56	1.89	0.66	0.49	2.63	2.30	4.65	3.53	142	95.8
pp-TDE	0.13	0.11	0.066	< 0.03	0.19	1.18	0.47	0.63	2.82	2.87
op-DDT	0.32	0.42	0.077	0.093	0.41	0.35	2.55	1.00	12.2	8.35
pp-DDT	2.38	3.02	0.72	0.87	4.39	4.06	10.4	6.68	111	102

Table F7 Comparative organochlorine pesticide concentrations in primary and split QC samples (µg kg^{-1}, dry wt basis)

Pesticide	Mount Egmont National Park (indigenous grassland) Primary[1]	Mount Egmont National Park (indigenous grassland) Split QC[2]	Hamilton (provincial centre) Primary	Hamilton (provincial centre) Split QC	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) (n=2)[3] Split QC	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) (n=2)[3] Split QC
Alpha-HCH	< 0.01	< 0.05	< 0.01	< 0.05	< 0.01	< 0.05	< 0.02	< 0.05
Beta-HCH	< 0.01	< 0.05	< 0.01	< 0.05	< 0.01	< 0.05	< 0.02	< 0.05
Gamma-HCH	< 0.01	< 0.05	< 0.02	< 0.05	< 0.04	< 0.05	< 0.05	< 0.05
HCB	0.070	< 0.05	< 0.04	0.060	0.072	< 0.05	0.067	< 0.05
Aldrin	< 0.01	< 0.05	< 0.01	< 0.05	< 0.02	< 0.05	< 0.02	< 0.05
Dieldrin	0.23	0.31	0.63	0.79	0.36	1.07	1.07	1.24
Heptachlor	< 0.01	< 0.05	< 0.01	< 0.05	< 0.04	< 0.05	< 0.01	< 0.05
Heptachlor epoxide	< 0.01	< 0.05	< 0.01	< 0.05	< 0.02	< 0.05	< 0.01	< 0.05
Alpha-chlordane	< 0.04	< 0.05	< 0.03	< 0.05	0.11	< 0.05	< 0.04	< 0.05
Gamma-chlordane	< 0.04	< 0.05	< 0.03	< 0.05	0.056	< 0.05	< 0.03	< 0.05
pp-DDE	0.69	0.58	0.66	1.10	4.65	3.65	142	118
pp-TDE	0.21	< 0.05	0.066	< 0.05	0.47	< 0.05	2.82	< 0.05
op-DDT	0.084	0.050	0.077	< 0.05	2.55	2.47	12.2	10.5
pp-DDT	0.76	0.36	0.72	0.62	10.4	8.27	111	58.0

1 = Analysed by primary laboratory
2 = Analysed by independent cross-check laboratory
3 = Mean of laboratory duplicate analyses

Table F8 Concentrations of organochlorine pesticides in soil field blanks and equipment rinsate blanks (µg kg^{-1}, dry wt basis for field blanks; µg L^{-1} for equipment rinsate blanks)

Chlorophenol	Waipoua Forest Northland (indigenous forest) Field blank	Masterton (provincial centre) Field blank	Western (metropolitan Auckland) Field blank	City/Woolston (metropolitan Christchurch) Field blank	Napier (provincial centre) Rinsate blank	Greymouth (provincial centre) Rinsate blank	Mean of ^{13}C surrogate standard recoveries, %, (n=6)
Alpha-HCH	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Beta-HCH	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Gamma-HCH	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	58
HCB	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	57
Aldrin	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Dieldrin	< 0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	61
Heptachlor	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Heptachlor epoxide	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Alpha-chlordane	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Gamma-chlordane	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
pp-DDE	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	72
pp-TDE	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
op-DDT	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
pp-DDT	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	62

Appendix G Concentrations of chlorophenols in New Zealand soils

This appendix reports the levels of chlorophenols in all soil samples collected as part of the Organochlorines Programme. Results from field quality control samples are also provided.

Chlorophenol data is reported in the following tables:

Table G1 Concentrations of chlorophenols in New Zealand indigenous forest soils (µg kg^{-1}, dry wt basis)

Chlorophenol	Waipoua Forest Northland	Pirongia Forest Park Waikato/Bay of Plenty	Whirinaki Forest Waikato/Bay of Plenty	Rimutaka Forest Park Wellington/Wanganui	Arthur's Pass National Park Marlborough/Canterbury	Paparoa National Park West Coast/Tasman	Catlins Forest Otago/Southland (n=2)[1]	Number of positives	Minimum	Maximum	Median	Mean[2]
2,4,6 Trichlorophenol	6.8	7.9	< 5	8.2	< 4	< 4	< 4	3	< 4	8.2	< 5	-
2,3,5 Trichlorophenol	< 4	< 5	< 5	< 4	< 4	< 4	< 4	0	< 4	< 5	< 4	-
2,4,5 Trichlorophenol	< 4	< 5	< 5	< 4	< 4	< 4	< 4	0	< 4	< 5	< 4	-
2,3,6 Trichlorophenol	< 4	< 5	< 5	< 4	< 4	< 4	< 4	0	< 4	< 5	< 4	-
2,3,4 Trichlorophenol	< 4	< 5	< 5	< 4	< 4	< 4	< 4	0	< 4	< 5	< 4	-
2,3,5,6 Tetrachlorophenol	< 2	< 3	< 3	< 2	< 2	< 2	< 2	0	< 2	< 3	< 2	-
2,3,4,6 Tetrachlorophenol	< 2	< 3	< 3	< 2	< 2	< 2	< 2	0	< 2	< 3	< 2	-
2,3,4,5 Tetrachlorophenol	< 2	< 3	< 3	< 2	< 2	< 2	< 2	0	< 2	< 3	< 2	-
Pentachlorophenol	< 1	< 2	< 1	< 1	< 1	< 1	< 1	0	< 1	< 2	< 1	-

1 = Mean of primary and blind duplicate samples (Table G8)

2 = Mean value reported only if a pesticide detected on more than 66% of occasions (minimum of 5 positive determinations)

Table G2 Concentrations of chlorophenols in New Zealand indigenous grassland soils (µg kg^{-1}, dry wt basis)

Chlorophenol	Ruahine Forest Park Hawke's Bay/East Coast	Mount Egmont National Park Taranaki/SW Waikato	Tararua Forest Park Wellington/Wanganui	Nelson Lakes National Park Marlborough/Canterbury	Blue Mountains Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[1]
2,4,6 Trichlorophenol	< 7	< 4	< 6	< 4	< 5	0	< 4	< 7	< 5	-
2,3,5 Trichlorophenol	< 7	< 4	< 6	< 4	< 5	0	< 4	< 7	< 5	-
2,4,5 Trichlorophenol	< 7	< 4	< 6	< 4	< 5	0	< 4	< 7	< 5	-
2,3,6 Trichlorophenol	< 7	< 4	< 6	< 4	< 5	0	< 4	< 7	< 5	-
2,3,4 Trichlorophenol	< 7	< 4	< 6	< 4	< 5	0	< 4	< 7	< 5	-
2,3,5,6 Tetrachlorophenol	< 4	< 2	< 3	< 2	< 3	0	< 2	< 4	< 3	-
2,3,4,6 Tetrachlorophenol	< 4	< 2	< 3	< 2	< 3	0	< 2	< 4	< 3	-
2,3,4,5 Tetrachlorophenol	< 4	< 2	< 3	< 2	< 3	0	< 2	< 4	< 3	-
Pentachlorophenol	< 2	< 0.8	< 2	< 1	< 2	0	< 0.8	< 2	< 2	-

1 = Mean value reported only if a chlorophenol detected on more than 66% of occasions (minimum of 4 positive determinations)

Table G3 Concentrations of chlorophenols in New Zealand hill country pasture soils (µg kg^{-1}, dry wt basis)

Chlorophenol	Northland (n=2)[1]	Waikato/Bay of Plenty	Hawke's Bay/East Coast	Taranaki/SW Waikato (n=2)[2]	Wellington/Wanganui	Marlborough/Canterbury	West Coast/Tasman	Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[3]
2,4,6 Trichlorophenol	< 4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 4	< 3	-
2,3,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,4,5 Trichlorophenol	10.1	< 3	< 3	< 3	< 3	< 3	< 3	< 3	1	< 3	10.1	< 3	-
2,3,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,4 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,5,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,5 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
Pentachlorophenol	< 1	< 0.7	< 0.7	< 1	< 0.6	< 0.7	< 0.7	< 0.6	0	< 0.6	< 1	< 0.7	-

1 = Mean of laboratory duplicate analyses
2 = Mean of primary and blind duplicate samples (Table G8)
3 = Mean value reported only if a chlorophenol detected on more than 66% of occasions (minimum of 6 positive determinations)

Table G4 Concentrations of chlorophenols in New Zealand flat land pasture soils (µg kg^{-1}, dry wt basis)

Chlorophenol	Northland	Waikato/Bay of Plenty	Hawke's Bay/East Coast	Taranaki/SW Waikato	Wellington/Wanganui (n=2)[1]	Marlborough/Canterbury	West Coast/Tasman	Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[2]
2,4,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	0	< 3	< 4	< 3	-
2,3,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	0	< 3	< 4	< 3	-
2,4,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	0	< 3	< 4	< 3	-
2,3,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	0	< 3	< 4	< 3	-
2,3,4 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	0	< 3	< 4	< 3	-
2,3,5,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,5 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
Pentachlorophenol	< 0.7	< 0.7	< 0.6	< 0.7	< 0.8	< 0.6	< 0.8	< 0.6	0	< 0.6	< 0.8	< 0.7	-

1 = Mean of laboratory duplicate analyses (Table G8)

2 = Mean value reported only if a chlorophenol detected on more than 66% of occasions (minimum of 6 positive determinations)

Table G5 Concentrations of chlorophenols in New Zealand provincial centre soils (µg kg^{-1}, dry wt basis)

Chlorophenol	Whangarei Northland	Hamilton Waikato/Bay of Plenty (n=2)[1]	Napier Hawkes Bay/East Coast (n=2)[2]	New Plymouth Taranaki/SW Waikato (n=2)[2]	Masterton Wellington/Wanganui	Timaru Marlborough/Canterbury (n=2)[1]	Greymouth West Coast/Tasman	Invercargill Otago/Southland	Number of positives	Minimum	Maximum	Median	Mean[3]
2,4,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,4,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,4 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,5,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,5 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
Pentachlorophenol	< 1	< 0.7	< 1	< 1	< 0.6	< 0.6	2.1	< 1	1	< 0.6	2.1	< 1	-

1 = Mean of primary and blind duplicate samples (Table G8)
2 = Mean of laboratory duplicate analyses
3 = Mean value reported only if a chlorophenol detected on more than 66% of occasions (minimum of 6 positive determinations)

Table G6 Concentrations of chlorophenols in metropolitan Auckland soils (µg kg^{-1}, dry wt basis)

Chlorophenol	North Shore City (residential)	North Shore City (residential)	Western (residential)	Mt Eden/Mt Roskill (residential)	Tamaki/Maungakiekie (residential)	Western and Tamaki/Maungakiekie (commercial/light industrial)	Hobson/Eastern Bays (residential)	Hobson/Eastern Bays (commercial/light industrial) (n=2)[1]	Manukau City (residential)	Number of positives	Minimum	Maximum	Median	Mean[2]
2,4,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	< 3	0	< 3	< 4	< 3	-
2,3,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	< 3	0	< 3	< 4	< 3	-
2,4,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	< 3	0	< 3	< 4	< 3	-
2,3,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	< 3	0	< 3	< 4	< 3	-
2,3,4 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	< 4	< 3	< 3	0	< 3	< 4	< 3	-
2,3,5,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,5 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
Pentachlorophenol	< 0.7	< 0.7	< 0.7	< 0.7	< 0.8	< 0.7	< 0.8	< 0.7	< 0.7	0	< 0.7	< 0.8	< 0.7	-

1 = Mean of primary and blind duplicate samples (Table G8)
2 = Mean value reported only if a chlorophenol detected on more than 66% of occasions (minimum of 6 positive determinations)

Table G7 Concentrations of chlorophenols in metropolitan Christchurch soils (µg kg^{-1}, dry wt basis)

Chlorophenol	Merivale/Shirley (residential)	City/Woolston (commercial/light industrial)	Spreydon/Halswell (residential)	Hornby/Birmingham Drive (commercial/light industrial) (n=2)[1]	Avonhead/Burnside (residential)	Port Hills	Number of positives	Minimum	Maximum	Median	Mean[2]
2,4,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,4,5 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,6 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,4 Trichlorophenol	< 3	< 3	< 3	< 3	< 3	< 3	0	< 3	< 3	< 3	-
2,3,5,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
2,3,4,5 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	0	< 2	< 2	< 2	-
Pentachlorophenol	< 0.6	< 0.6	< 0.6	0.95	< 0.5	< 0.6	1	< 0.5	0.95	< 0.6	-

1 = Mean of primary and blind duplicate samples (Table G8)
2 = Mean value reported only if a chlorophenol detected on more than 66% of occasions (minimum of 4 positive determinations)

Table G8 Comparative chlorophenol concentrations in primary and blind duplicate sample analyses (µg kg^{-1}, dry wt basis)

Chlorophenol	Catlins Forest (indigenous forest) Primary	Catlins Forest (indigenous forest) Blind duplicate	Taranaki/SW Waikato (hill country pasture) Primary	Taranaki/SW Waikato (hill country pasture) Blind duplicate	Hamilton (provincial centre) Primary	Hamilton (provincial centre) (n=2)[1] Blind duplicate	Timaru (provincial centre) Primary	Timaru (provincial centre) Blind duplicate	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) Blind duplicate	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) Blind duplicate
2,4,6 Trichlorophenol	< 4	< 4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
2,3,5 Trichlorophenol	< 4	< 4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
2,4,5 Trichlorophenol	< 4	< 4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
2,3,6 Trichlorophenol	< 4	< 4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
2,3,4 Trichlorophenol	< 4	< 4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
2,3,5,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
2,3,4,6 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
2,3,4,5 Tetrachlorophenol	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pentachlorophenol	< 1	< 1	< 1	< 1	< 0.7	< 0.7	< 0.6	< 0.6	< 0.7	< 0.7	1.0	0.9

1 = Mean of laboratory duplicate analyses

Table G9 Comparative chlorophenol concentrations in primary and split QC sample analyses (µg kg^{-1}, dry wt basis)

Chlorophenol	Mount Egmont National Park (indigenous grassland) Primary[1]	Mount Egmont National Park (indigenous grassland) Split QC[2]	Hawke's Bay/East Coast (hill country pasture) Primary	Hawke's Bay/East Coast (hill country pasture) Split QC	Marlborough/Canterbury (flat land pasture) Primary	Marlborough/Canterbury (flat land pasture) Split QC	Hamilton[3] (provincial centre) Primary	Hamilton (provincial centre) Split QC	Hobson/Eastern Bays (metropolitan Auckland) Primary	Hobson/Eastern Bays (metropolitan Auckland) Split QC	Hornby/Birmingham Drive (metropolitan Christchurch) Primary	Hornby/Birmingham Drive (metropolitan Christchurch) Split QC
2,4,6 Trichlorophenol	< 4	< 2	< 3	7.68	< 3	< 2	< 3	6.67	< 3	4.09	< 3	3.68
2,3,5 Trichlorophenol	< 4	< 0.1	< 3	< 0.1	< 3	< 0.1	< 3	< 0.1	< 3	< 0.1	< 3	< 0.1
2,4,5 Trichlorophenol	< 4	< 0.2	< 3	< 0.3	< 3	< 0.2	< 3	< 0.2	< 3	< 0.2	< 3	0.65
2,3,4 Trichlorophenol	< 4	< 0.1	< 3	< 0.1	< 3	< 0.3	< 3	< 0.4	< 3	< 0.4	< 3	< 0.3
2,3,5,6 Tetrachlorophenol	< 2	< 0.1	< 2	< 0.1	< 2	< 0.1	< 2	< 0.1	< 2	< 0.1	< 2	< 0.1
2,3,4,6 Tetrachlorophenol	< 2	< 2	< 2	< 0.1	< 2	< 0.5	< 2	< 2	< 2	< 2	< 2	< 0.2
2,3,4,5 Tetrachlorophenol	< 2	< 0.1	< 2	< 0.4	< 2	< 0.1	< 2	< 0.4	< 2	< 0.4	< 2	< 0.1
Pentachlorophenol	< 0.8	< 2	< 0.7	< 0.5	< 0.6	< 2	< 0.7	< 4	< 0.7	< 4	1.0	< 3

1 = Analysed by primary laboratory
2 = Analysed by independent cross-check laboratory
3 = Mean of laboratory duplicate analyses

Table G10 **Concentrations of chlorophenols in soil field blanks and equipment rinsate blanks (µg kg^{-1}, dry wt basis for field blanks; µg L^{-1} for equipment rinsate blanks)**

Chlorophenol	Waipoua Forest Northland (indigenous forest) Field blank	Otago Southland (hill country pasture) Field blank	Marlborough/Canterbury (flat land pasture) Field blank	Masterton (provincial centre) Field blank	Western (metropolitan Auckland) Field blank	City/Woolston (metropolitan Christchurch) Field blank	Napier (provincial centre) Rinsate blank	Greymouth (provincial centre) Rinsate blank
2,4,6 Trichlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
2,3,5 Trichlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
2,4,5 Trichlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
2,3,6 Trichlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
2,3,4 Trichlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
2,3,5,6 Tetrachlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
2,3,4,6 Tetrachlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
2,3,4,5 Tetrachlorophenol	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.02	< 0.02
Pentachlorophenol	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.01	< 0.01

Appendix H Overseas PCDD and PCDF soil data

This appendix provides a summary of the New Zealand Organochlorines Programme PCDD and PCDF contaminant level data (as reported in full in Appendix D), and details comparative data for PCDD and PCDF concentrations in soils overseas as reported in the published literature.

Table H1 Concentrations of PCDDs and PCDFs in New Zealand and overseas soils

Table H1 Concentrations of PCDDs and PCDFs in New Zealand and overseas soils

Country	Location type	Date sampled	Number of sites[1]	Conc. (ng TEQ kg^{-1} DW)[2,3] Min.	Max.	Analysis	Reference
Reference/pristine							
New Zealand	Indigenous forest	1996	8	0.17	1.99	I-TEQ, ½ LOD	This study
New Zealand	Indigenous grassland	1996	5	0.35	0.85	I-TEQ, ½ LOD	This study
Australia	Conservation areas (burnt/un-burnt)	1994	6	2.2	38.5	I-TEQ, ½ LOD	Buckland *et al*., 1994
Austria, Salzburg	Alpine, meadow	1990-91	1	1.3		I-TEQ, ½ LOD	Boos *et al*., 1992
Brazil, Amazon basin	Forest		5	0.02	0.4	I-TEQ	Krauβ *et al*., 1995
Czechoslovakia	High mountain forest		6	16.8	26.6	I-TEQ	Holoubek *et al*., 1994
Germany	Forest		14	5.9	112	I-TEQ	Rotard *et al*., 1994
Switzerland, Rheinfelden	Forest		4	2.9	11.2	BGA[4]	Gälli *et al*., 1992
Switzerland, Rheinfelden	Remote soils		3	0.7	1.3	BGA	Gälli *et al*., 1992
Rural/agricultural							
New Zealand	Hill country pasture	1996	8	0.37	0.90 (9.14)[5]	I-TEQ, ½ LOD	This study
New Zealand	Flat land pasture	1996	8	0.17	0.74	I-TEQ, ½ LOD	This study
Austria, Salzburg	Rural meadows	1990-91	5	1.6	3.8	I-TEQ, ½ LOD	Boos *et al*., 1992
Canada, BC	Various background sites	1990-92	53	0	57.0	I-TEQ, LOD=0	Van Oostdam and Ward, 1995
Canada, ON & US Midwest	Rural		30	0.16	2.2	I-TEQ, ½ LOD	Birmingham, 1990
Germany	Rural area		69	0.6	11.1	I-TEQ	NRW, 1991
Germany, Baden-Württemberg	Rural/suburban grassland		25	0.02	7.6	I-TEQ	Nobel *et al*., 1993
Germany	Grassland		7	0.4	4.8 (29.5)[5]	I-TEQ	Rotard *et al*., 1994
Germany	Plowland		10	0.3	3.7	I-TEQ	Rotard *et al*., 1994
Germany, Saxony-Anhalt	Farmland/grassland/gardens	1993-94	6	0.6	9.5		Feist *et al*., 1995
Japan	Paddy field	1993-94	1	2.53		I-TEQ, LOD=0	Sakurai *et al*., 1996
Netherlands	Grassland sites	1991	32	1.8	16.4	I-TEQ	Van den Berg *et al*., 1994
Sweden, Stockholm	Arable land, close to major roads	1989	4	13	49	Nordic TEQ, LOD=0[6]	Broman *et al*., 1990
Sweden, Stockholm	Arable land, no major roads	1989	4	9	32	Nordic TEQ, LOD=0[6]	Broman *et al*., 1990
Switzerland, Rheinfelden	Rural fields		4	0.5	2.5	BGA	Gälli *et al*., 1992
UK	Rural sites	1986-86	11	0.78	17.5	I-TEQ, LOD=limit	HMIP, 1995
UK, Hampshire	Rural soils	1995	3	1.72	3.52	I-TEQ, LOD=limit	Environment Agency, 1997
US, Ohio, Columbus	Rural background	1995	3	0.99	1.95	I-TEQ, ½ LOD	Lorber *et al*., 1996
US, Mississippi	Various rural sites	1994	36	0.08	22.9	I-TEQ	Fiedler *et al*., 1995

Table H1 Concentrations of PCDDs and PCDFs in New Zealand and overseas soils (Cont.)

Country	Location type	Date sampled	Number of sites[1]	Conc. (ng TEQ kg^{-1} DW)[2,3] Min.	Max.	Analysis	Reference
Urban/industrial							
New Zealand	Provincial centre	1996	9	0.72	3.73 (33.0)[5]	I-TEQ, ½ LOD	This study
New Zealand	Metropolitan centre	1996	15	0.26	6.67	I-TEQ, ½ LOD	This study
Australia, Melbourne	Urban parks and gardens	1990	3	1.8	8.2	I-TEQ	Sund *et al.*, 1993
Australia, Melbourne	Industrial sites	1990	4	0.09	2.1	I-TEQ	Sund *et al.*, 1993
Australia, Sydney	Traffic impacted urban area	1994	1	42.6		I-TEQ, ½ LOD	Buckland *et al.*, 1994
Austria, Linz	Industrial/urban		13	1.6	14.4	I-TEQ	Weiss *et al.*, 1994
Austria, Salzburg	Urban meadows and parks	1990-91	11	2.0	8.6	I-TEQ, ½ LOD	Boos *et al.*, 1992
Austria, Salzburg	Industrial sites	1990-91	5	4.1	12.5	I-TEQ, ½ LOD	Boos *et al.*, 1992
Brazil, Rio de Janeiro	Recreation areas		3	0.03	1.8	I-TEQ	Krauβ *et al.*, 1995
Brazil, Rio de Janeiro	Industrial regions		3	15	654	I-TEQ	Krauβ *et al.*, 1995
Brazil, Cubatão	Forest soil near industries		3	11	341	I-TEQ	Krauβ *et al.*, 1995
Canada, ON & US Midwest	Urban		47	0.1	78.5	I-TEQ, ½ LOD	Birmingham, 1990
Canada, ON & US Midwest	Industrial		20	1.7	101.8	I-TEQ, ½ LOD	Birmingham, 1990
Germany	Urban area		28	0.84	27.3	I-TEQ	NRW, 1991
Germany, Baden-Württemberg	Grassland near incinerator		5	2.1	10.2	I-TEQ	Nobel *et al.*, 1993
Japan	Tokyo, urban	1993-94	1	19.7		I-TEQ, LOD=0	Sakurai *et al.*, 1996
Spain, Catalonia	Industrial, near incinerator		12	0.22	1.26	I-TEQ	Schuhmacher *et al.*, 1996
Spain, Madrid	Industrial, near incinerator	1993	14	0.69	11.4	I-TEQ	Jiménez *et al.*, 1996
Spain, Madrid	Control	1993	2	0.69	0.71	I-TEQ	Jiménez *et al.*, 1996
Switzerland, Rheinfelden	Urban lawn soil		8	1.3	26.8	BGA	Gälli *et al.*, 1992
Switzerland, Rheinfelden	Urban meadow		17	1.1	16.0	BGA	Gälli *et al.*, 1992
UK	Urban sites	1988	5	4.88	87.3	I-TEQ, LOD=limit	HMIP, 1995
UK, Doncaster	Suburban/urban sites	1990	12	3	20	I-TEQ	Stenhouse and Badsha, 1990
UK, Belfast	Urban	1994	5	2.4	9.6	I-TEQ, LOD=0	HMIP, 1996
UK, Widnes	Urban	1993	5	7.7	230	I-TEQ, LOD=0	HMIP, 1996
UK, Wigan	Urban	1993	5	2.0	21	I-TEQ, LOD=0	HMIP, 1996
US, Minnesota	Near electricity generating station	1988	2	0.82	9.2	I-TEQ, LOD=0	Reed *et al.*, 1990
US, Ohio	Urban background	1995	14	3	33	I-TEQ, ½ LOD	Lorber et al., 1996

1 Where possible 'sites' are interpreted as geographically or otherwise distinct sampling locations.
2 Concentrations are reported on a dry weight basis.
3 In some instances, TEQ levels have been calculated using the congener data reported in the original reference.
4 BGA refers to TEFs proposed by the German Health Office, *OECD Environmental Data, Compendium, 1987*, Paris 1987.
5 Value in parenthesis is single outlier.
6 Organic weight basis.

Appendix I Overseas PCB soil data

This appendix provides a summary of the New Zealand Organochlorines Programme PCB contaminant level data (as reported in full in Appendix E), and details comparative data for PCB concentrations in soils overseas as reported in the published literature.

Table I1 Concentrations of PCBs in New Zealand and overseas soils

Country	Location type	Date sampled	Number of sites[1]	Concentration (µg kg^{-1} DW)[2] Min.	Max.	Data type	Reference
Reference/pristine							
New Zealand[3]	Indigenous forest	1996	8	0.14	1.20	Sum of 25 congeners	This study
New Zealand[3]	Indigenous grassland	1996	5	0.13	0.25	Sum of 25 congeners	This study
Antarctica[4]	Various	1988-89	5	1	23	Total PCBs	Morselli *et al*., 1991
Brazil	Forest		5	0.1	7.7	Total PCBs	Krauβ *et al*., 1995
Canadian Arctic	Background	1989-92	3	< 0.5		Total PCBs	Bright *et al*., 1995
Czechoslovakia	High mountain forest		6	31	137	Total PCBs and congeners	Holoubek *et al*., 1994
Norway	Remote woodlands	1990	12	5.3	30	Sum of 32 congeners	Lead *et al*., 1997
Spain	National Park and surrounds		17	0.46	18.6	Total PCB from isomers	Fernandez *et al*., 1992
UK, Rothamsted	Unimpacted	1992	1	12.7		Sum of 31 congeners	Alcock *et al*., 1995
Vietnam	Upland forest	1990	3	1.4	4.2	Total PCBs	Thao *et al*., 1993b
Rural/agricultural							
New Zealand[3]	Hill country pasture	1996	8	0.12	0.18	Sum of 25 congeners	This study
New Zealand[3]	Flat land pasture	1996	8	0.12	0.37	Sum of 25 congeners	This study
Ireland	Agricultural	1990-91	15	1.25	6.63	Total PCB from congeners	McGrath, 1995
Jordan	Various	1988	10	2.4	15	Sum of 45 congeners	Alawi and Heidmann, 1991
Russia, Moscow region	Agricultural	1989-90	11	3.2	1410	Total PCBs	Galiulin and Bashkin, 1996
Russia, Krasnodar region	Agricultural	1989-90	11	6.0	2470	Total PCBs	Galiulin and Bashkin, 1996
Taiwan	Paddy fields	1990	3	12	49	Total PCBs	Thao *et al*., 1993b
Taiwan	Garden	1990	5	1.6	22	Total PCBs	Thao *et al*., 1993b
Thailand	Paddy fields	1988-90	11	1.1	6.2	Total PCBs	Thao *et al*., 1993b
Thailand	Garden	1988	2	1.6	5.1	Total PCBs	Thao *et al*., 1993b
Uzbekistan, Samarkand	Agricultural	1989-90	14	0.1	433	Total PCBs	Galiulin and Bashkin, 1996
Vietnam	Paddy fields	1990	19	0.61	320	Total PCBs	Thao *et al*., 1993b

Table I1 Concentrations of PCBs in New Zealand and overseas soils (Cont.)

Country	Location type	Date sampled	Number of sites[1]	Concentration (µg kg^{-1} DW)[2] Min.	Max.	Data type	Reference
Urban/industrial							
New Zealand[3]	Provincial centre	1996	8	0.30	3.38	Sum of 25 congeners	This study
New Zealand[3]	Metropolitan centre	1996	15	0.23	9.74	Sum of 25 congeners	This study
Austria	Industrial/urban		26	6.4	95	Sum of 6 congeners	Weiss *et al*., 1994
Brazil, Rio de Janeiro	Recreational areas		3	0.26	58.2	Total PCBs	Krauβ *et al*., 1995
Brazil, Cubatão	Forest soil near industries		3	13.8	232	Total PCBs	Krauβ *et al*., 1995
Czechoslovakia	Urban and rural		9	9	35	Total PCBs	Holoubek *et al*., 1990
Ireland	Urban amenity	1992	4	2.69	3.12	Total PCB from congeners	McGrath, 1995
Ireland	Industrial	1993	7	0.24	9.39	Total PCB from congeners	McGrath, 1995
Italy, Turin	Close to motorway		3	13.2	82.3	Total PCBs	Benfenati *et al*., 1992
Taiwan	Roadside	1990	6	13	960	Total PCBs	Thao *et al*., 1993b
Thailand	Roadside	1988	2	1.4	2.9	Total PCBs	Thao *et al*., 1993b
UK, Doncaster	Suburban/urban sites	1990	12	2.1	11.1	Total PCBs	Stenhouse and Badsha, 1990
National surveys							
Scotland	All samples		30	21	362	Total PCBs	Bracewell *et al*., 1993
Scotland	Northern		8	29	124	Total PCBs	Bracewell *et al*., 1993
Scotland	Southern Highlands		8	112	362	Total PCBs	Bracewell *et al*., 1993
Switzerland	Various		18	6.5	29 (84.1)[5]	Sum of 7 congeners	Berset and Holzer, 1995
Wales, South	60% of samples		84	1.9	36	Total PCBs	Eduljee *et al*., 1987
Wales, South	All samples		84	1.9	1210	Total PCBs	Eduljee *et al*., 1987

1 Where possible 'sites' are interpreted as geographically or otherwise distinct sampling locations.
2 Concentrations are reported on a dry weight basis.
3 For the New Zealand data, concentrations given include half LOD values in the calculation of the congener sum.
4 Some human impact is expected at some sites.
5 Value in parenthesis is single outlier.

Table I2 Concentrations of PCB #28 + #31 in New Zealand and overseas soils

Country	Location type	Date sampled	Concentration (µg kg^{-1} DW) Min.	Max.	Reference
New Zealand	Indigenous forest	1996	< 0.06	< 0.2	This study
	Indigenous grassland	1996	< 0.05	< 0.2	This study
	Hill country pasture	1996	< 0.03	< 0.1	This study
	Flat land pasture	1996	< 0.03	< 0.03	This study
	Provincial centre	1996	< 0.03	< 0.2	This study
	Metropolitan centre	1996	< 0.02	< 0.2	This study
Czechoslovakia	High mountain		1.5	5.5	Holoubek *et al*., 1994
Jordan	Various	1988	0.2	0.2	Alawi and Heidmann, 1991
Switzerland	Various		0.2	0.6	Berset and Holzer, 1995
UK, North West	Various	1992	0.1	20	Alcock *et al*., 1993

Table I3 Concentrations of PCB #52 in New Zealand and overseas soils

Country	Location type	Date sampled	Concentration (µg kg^{-1} DW) Min.	Max.	Reference
New Zealand	Indigenous forest	1996	< 0.02	< 0.07	This study
	Indigenous grassland	1996	< 0.01	< 0.04	This study
	Hill country pasture	1996	< 0.01	< 0.02	This study
	Flat land pasture	1996	< 0.01	< 0.05	This study
	Provincial centre	1996	< 0.01	< 0.05	This study
	Metropolitan centre	1996	< 0.01	0.13	This study
Czechoslovakia	High mountain		0.56	2.1	Holoubek *et al*., 1994
Jordan	Various	1988	0.1	0.1	Alawi and Heidmann, 1991
Switzerland	Various		0.9	4.7	Berset and Holzer, 1995
UK, North West	Various	1992	0.1	6	Alcock *et al*., 1993
UK, Rothamsted	Unimpacted	1992	1.3		Alcock *et al*., 1995

Table I4 Concentrations of PCB #101 in New Zealand and overseas soils

Country	Location type	Date sampled	Concentration (µg kg^{-1} DW) Min.	Max.	Reference
New Zealand	Indigenous forest	1996	< 0.01	0.11	This study
	Indigenous grassland	1996	< 0.01	< 0.03	This study
	Hill country pasture	1996	< 0.01	< 0.03	This study
	Flat land pasture	1996	< 0.01	< 0.05	This study
	Provincial centre	1996	< 0.02	0.39	This study
	Metropolitan centre	1996	< 0.02	1.09	This study
Czechoslovakia	High mountain		1.2	4.1	Holoubek *et al*., 1994
Spain	National Park and surrounds		0.012	0.38	Fernandez *et al*., 1992
Switzerland	Various		2	10	Berset and Holzer, 1995
UK, North West	Various	1992	nd	11	Alcock *et al*., 1993
UK, Rothamsted	Unimpacted	1992	1.6		Alcock *et al*., 1995

nd = Not detected, detection limit typically 2-20 pg/g.

Table I5 Concentrations of PCB #153 in New Zealand and overseas soils

Country	Location type	Date sampled	Concentration (µg kg^{-1} DW) Min.	Max.	Reference
New Zealand	Indigenous forest	1996	< 0.01	0.17	This study
	Indigenous grassland	1996	< 0.01	< 0.02	This study
	Hill country pasture	1996	< 0.01	< 0.02	This study
	Flat land pasture	1996	< 0.01	0.070	This study
	Provincial centre	1996	0.065	0.58	This study
	Metropolitan centre	1996	0.040	1.62	This study
Czechoslovakia	High mountain		3	14	Holoubek *et al*., 1994
Jordan	Various	1988	0.3	1.8	Alawi and Heidmann, 1991
Spain	National Park and surrounds		0.054	0.49	Fernandez *et al*., 1992
Switzerland	Various		0.9	3.9	Berset and Holzer, 1995
UK, North West	Various	1992	0.1	17	Alcock *et al*., 1993

Table I6 Concentrations of PCB #138 in New Zealand and overseas soils

Country	Location type	Date sampled	Concentration (µg kg^{-1} DW) Min.	Max.	Reference
New Zealand	Indigenous forest	1996	< 0.01	0.25	This study
	Indigenous grassland	1996	< 0.01	< 0.03	This study
	Hill country pasture	1996	< 0.01	< 0.03	This study
	Flat land pasture	1996	< 0.01	0.095	This study
	Provincial centre	1996	0.10	0.88	This study
	Metropolitan centre	1996	0.067	2.68	This study
Czechoslovakia	High mountain		3.3	14	Holoubek *et al*., 1994
Jordan	Various	1988	0.2	1.7	Alawi and Heidmann, 1991
Spain	National Park and surrounds		0.037	0.85	Fernandez *et al*., 1992
Switzerland	Various		0.9	3.7	Berset and Holzer, 1995
UK, North West	Various	1992	0.1	3.3	Alcock *et al*., 1993

Table I7 Concentrations of PCB #180 in New Zealand and overseas soils

Country	Location type	Date sampled	Concentration (µg kg^{-1} DW) Min.	Max.	Reference
New Zealand	Indigenous forest	1996	< 0.01	0.071	This study
	Indigenous grassland	1996	< 0.01	< 0.01	This study
	Hill country pasture	1996	< 0.01	< 0.01	This study
	Flat land pasture	1996	< 0.01	0.026	This study
	Provincial centre	1996	< 0.02	0.24	This study
	Metropolitan centre	1996	< 0.02	0.71	This study
Czechoslovakia	High mountain		1.6	8.4	Holoubek *et al*., 1994
Jordan	Various	1988	nd	0.1	Alawi and Heidmann, 1991
Spain	National Park and surrounds		0.048	1.67	Fernandez *et al*., 1992
Switzerland	Various		0.2	4.6	Berset and Holzer, 1995
UK, North West	Various	1992	nd	128	Alcock *et al*., 1993
UK, Rothamsted	Unimpacted	1992	0.3		Alcock *et al*., 1995

nd = Not detected.

Appendix J Overseas organochlorine pesticide soil data

This appendix provides a summary of the New Zealand Organochlorines Programme data for a selected number of organochlorine pesticides (as reported in full in Appendix F), and details comparative data for pesticide concentrations in soils overseas as reported in the published literature.

Table J1 Concentrations of DDT residues in New Zealand and overseas soils

Country	Location type	Date sampled	Number of sites[1]	Concentration range (µg kg^{-1} DW)[2] Sum DDT	pp'-DDT	pp'-DDE	pp'-DDD	Reference
New Zealand	Indigenous forest	1996	8		0.034 - 2.70	0.048 - 2.69	< 0.01 - 0.13	This study
	Indigenous grassland	1996	5		0.28 - 1.76	0.28 - 1.57	0.052 - 0.27	This study
	Provincial centre	1996	8		0.80 - 121	0.58 - 86.9	0.033 - 28.5	This study
	Metropolitan centre	1996	15		0.53 - 340	0.96 - 469	0.077 - 10.4	This study
Canada, Ontario	Background (Ontario MfEE)	1992		120				Webber and Wang, 1995
Czechoslovakia	High mountain forest		6	26 - 111				Holoubek *et al*., 1994
Spain	National Park and surrounds		17		nd - 0.058	nd - 5.15	nd - 0.13	Fernandez *et al*., 1992
USA, Me	DDT treated forest	1993	7	270 - 1900				Dimond and Owen, 1996
USA, Me	Untreated forest	1993	4	nd - 11				Dimond and Owen, 1996
USA, NH	Deep forest litter	1988	5		7 - 24	11 - 19	1.5 - 7.2	Smith *et al*., 1993
USA, NH	Deep forest litter	1988	20		1 - 190	0.7 - 83	0.4 - 48	Smith *et al*., 1993
Australia, NSW	Agricultural	1981	20	10 - 1400	nd - 700	nd - 580	nd - 170	Wan *et al*., 1989
Australia, NSW	Agricultural	1987	9	nd - 1000	nd - 540	nd - 380	nd - 300	Wan *et al*., 1989
Canada	Agricultural	1987-89	9		5 - 5.8	4 - 340	nd - 12	Hebert *et al*., 1994
Canada	Agricultural	1992	30		nd - 49000	t - 7400		Webber and Wang, 1995
Canada, BC	Agricultural	1989	4	nd - 10	nd	nd - 10	nd	Szeto and Price, 1991
Canada, BC	Agricultural	1989	4	190 - 760	150 - 520	31 - 140	nd	Szeto and Price, 1991
China	Agricultural (summary)				1000 - 4000			Ji and Yu, 1996
India	Paddy - dry season	1988-89	10	0.3 - 4				Ramesh *et al*., 1991
India	Paddy - wet season	1988-89	10	0.9 - 7				Ramesh *et al*., 1991
India		1988-89	25	20 - 330	20[3]	10[3]	20[3]	Nair and Pillai, 1992
India	Various	1988-89	56	4 - 4400				Kawano *et al*., 1992
India	Agricultural	1991-92	10	nd - 940	nd - 450	nd - 100	nd - 290	Agnihotri *et al*., 1996
Ireland	Agricultural	1990-91	15	0.02 - 90				McGrath, 1995
Netherlands	Rural		30		nd - 160	nd - 94	nd - 80	Gaans *et al*., 1995
Russia		1995	4		0.096 - 16	0.049 - 10	0.022 - 2	Iwata *et al*., 1995
Russia (Moscow region)	Agricultural	1989-90	11	0.05 - 1180	nd - 1140	0.8 - 227	nd - 100	Galiulin and Bashkin, 1996
Russia (Krasnodar Region)	Agricultural	1989-90	11	0.7 - 2187	nd - 773	1.2 - 1000	nd - 408	Galiulin and Bashkin, 1996
Taiwan	Various	1990	14	2.4 - 78				Thao *et al*., 1993b
Thailand	Various, mainly paddy fields	1988-90	15	0.5 - 98				Thao *et al*., 1993b
USA, Ca		1989	3		nd - 1700	0.8 - 880	nd - 260	Odermatt *et al*., 1993
USA, Ca	Coastal	1985	93		3700[3]	2000[3]	370[3]	Odermatt *et al*., 1993
USA, Ca	Inland	1985			250[3]	230[3]	58[3]	Odermatt *et al*., 1993
USA, Tx	"Atypical" agricultural	1984-85	3		3200 - 7200	400 - 600		Hitch and Day, 1992
USA, Tx	"Typical" agricultural	1984-85	2		500 - 600	2300 - 2500		Hitch and Day, 1992

Table J1 Concentrations of DDT residues in New Zealand and overseas soils (Cont.)

Country	Location type	Date sampled	Number of sites[1]	Concentration range (µg kg^{-1} DW)[2] Sum DDT	pp'-DDT	pp'-DDE	pp'-DDD	Reference
Uzbekistan (Samarkand)	Agricultural	1989-90	14	2.8 - 1715	1 - 970	1 - 185	0.3 - 251	Galiulin and Bashkin, 1996
Vietnam	Various, mainly paddy fields	1990	22	0.7 - 1300				Thao *et al*., 1993b
Vietnam	Uncultivated	1991	11	1.5 - 38				Thao *et al*., 1993a
Vietnam	Agricultural	1991	14	1 - 290				Thao *et al*., 1993a
Ireland	Suburban garden	1992	3	0.6 - 11				McGrath, 1995
Ireland	Town garden	1992	12	4.6 - 1850				McGrath, 1995
Ireland	Urban amenity	1992	4	0.5 - 3.3				McGrath, 1995
Ireland	Industrial	1993	7	0.09 - 2.7				McGrath, 1995
Netherlands		1993	12	15[4]	6.8[4]	3.2[4]		Hendriks *et al*., 1995
USA	Metropolitan	1971	380	10 - 18000	10 - 5900	10 - 7900	10 - 6600	Carey *et al*., 1979

[1] Where possible 'sites' are interpreted as geographically or otherwise distinct sampling locations.
[2] Concentrations are reported on a dry weight basis.
[3] Values are arithmetic means.
[4] Values are geometric means.
nd = Not detected.
t = Trace.

Table J2 Concentrations of HCH residues in New Zealand and overseas soils

Country	Location type	Date sampled	Number of sites[1]	Concentration range (μg kg^{-1} DW)[2] Sum HCH	α-HCH	β-HCH	γ-HCH	Reference
New Zealand	Indigenous forest	1996	8		< 0.01 - < 0.03	< 0.01 - < 0.02	< 0.02 - < 0.04	This study
	Indigenous grassland	1996	5		< 0.01 - < 0.02	< 0.01 - < 0.03	< 0.01 - < 0.05	This study
	Provincial centre	1996	8		< 0.01	< 0.01	< 0.02 - 0.11	This study
	Metropolitan centre	1996	15		< 0.01 - < 0.02	< 0.01 - 0.068	< 0.02 - 0.067	This study
Canada	Agricultural	1992	30				nd - 2.2	Webber and Wang, 1995
India	Paddy (wet season)	1988-89	10	4 - 1100				Ramesh *et al*., 1991
India	Paddy (dry season)	1988-89	10	4 - 190				Ramesh *et al*., 1991
India		1988-89	25	1 - 230	10[3]		10[3]	Nair and Pillai, 1992
India	Various	1988-89	56	31 - 86000				Kawano *et al*., 1992
India	Agricultural	1991-92	10	nd - 430	nd - 200	nd - 28	nd - 210	Agnihotri *et al*., 1996
Ireland	Agricultural	1990-91	15	0.2 - 4				McGrath, 1995
Ireland	Suburban garden	1992	3	0.6 - 8.9				McGrath, 1995
Ireland	Town garden	1992	12	nd - 12				McGrath, 1995
Ireland	Urban amenity	1992	4	0.6 - 2.0				McGrath, 1995
Ireland	Industrial	1993	7	0.2 - 1.7				McGrath, 1995
Netherlands	Rural		30		nd - 2.4		nd - 4.4	Gaans *et al*., 1995
Netherlands			12		76[4]		88[4]	Hendriks *et al*., 1995
Russia		1995	4		0.012 - 3.7		0.007 - 2.4	Iwata *et al*., 1995
Russia (Krasnodar region)	Agricultural		11	nd - 32.8				Galiulin and Bashkin, 1996
Russia (Moscow region)	Agricultural		11	nd - 27				Galiulin and Bashkin, 1996
Spain	National Park and surrounds		7		nd - 0.017	nd - 0.44	0.38 - 1.94	Fernandez *et al*., 1992
Spain		1989	1	7.0	0.93	2.6	0.9	Hernandez *et al*., 1991
Taiwan	Various	1990	14	0.3 - 5				Thao *et al*., 1993b
Thailand	Various, mainly paddy fields	1988-90	15	0.1 - 0.7				Thao *et al*., 1993b
Uzbekistan (Samarkand)	Agricultural		14	nd - 70				Galiulin and Bashkin, 1996
Vietnam	Various, mainly paddy fields	1990	22	0.1 - 55				Thao *et al*., 1993b
Vietnam	Uncultivated	1991	11	0.1 - 2.1				Thao *et al*., 1993a
Vietnam	Agricultural	1991	14	0.1 - 0.8				Thao *et al*., 1993a

[1] Where possible 'sites' are interpreted as geographically or otherwise distinct sampling locations.
[2] Concentrations are reported on a dry weight basis.
[3] Values are arithmetic means.
[4] Values are geometric means.
nd = Not detected.

Table J3 Concentrations of aldrin and dieldrin in New Zealand and overseas soils

Country	Location type	Date sampled	Number of sites[1]	Concentration range (µg kg^{-1} DW)[2] Aldrin	Dieldrin	Reference
New Zealand	Indigenous forest	1996	8	< 0.01 - < 0.02	< 0.03 - 0.83	This study
	Indigenous grassland	1996	5	< 0.01 - < 0.02	0.12 - 0.57	This study
	Provincial centre	1996	8	< 0.01 - < 0.04	0.15 - 2.17	This study
	Metropolitan centre	1996	15	< 0.01 - 0.085	0.21 - 42.1	This study
Australia, NSW	Agricultural		8		170 - 200	McDougall *et al*., 1995
Canada	Agricultural	1992	30	nd - 5.7	nd - 39	Webber and Wang, 1995
Chile		1983		nd - 7	nd - 250	Ciudad and Moyano, 1988
India	Agricultural	1991-92	10	nd - 10	nd - 26	Agnihotri *et al*., 1996
India	Urban	1998-89	27	0.3 - 120	0.2 - 30	Nair *et al*., 1991
Netherlands		1993	12		4.1[3]	Hendriks *et al*., 1995
Netherlands	Rural		30		nd - 34	Gaans *et al*., 1995
Spain	National Park and surrounds		17		nd - 0.20	Fernandez *et al*., 1992
USA	Metropolitan	1971	380	nd - 2000	10 - 6000	Carey *et al*., 1979

[1] Where possible 'sites' are interpreted as geographically or otherwise distinct sampling locations.
[2] Concentrations are reported on a dry weight basis.
[3] Values are geometric means.
nd = Not detected.

Table J4 Concentrations of chlordane residues in New Zealand and overseas soils

Country	Location type	Date sampled	Number of sites[1]	Concentration range (μg kg^{-1} DW)[2]			Reference
				Sum Chlordane	α-Chlordane	γ-Chlordane	
New Zealand	Indigenous forest	1996	8		< 0.02 - < 0.06	< 0.02 - < 0.06	This study
	Indigenous grassland	1996	5		< 0.03 - < 0.06	< 0.03 - < 0.05	This study
	Provincial centre	1996	8		< 0.02 - 0.14	< 0.01 - 0.15	This study
	Metropolitan centre	1996	15		< 0.02 - 1.11	< 0.02 - 1.72	This study
Australia, NSW	Agricultural	1987-89	16	130 - 200			McDougall *et al*., 1995
Canada, BC	Agricultural	1989	4	nd - 170	nd - 48	nd - 63	Szeto and Price, 1991
Canada	Agricultural	1992	30	nd - 9.4			Webber and Wang, 1995
Russia		1995	4		nd - 0.004	nd - 0.004	Iwata *et al*., 1995
USA	Metropolitan	1971	380	10 - 140000			Carey *et al*., 1979

[1] Where possible 'sites' are interpreted as geographically or otherwise distinct sampling locations.
[2] Concentrations are reported on a dry weight basis.
nd = Not detected.

Table J5 Concentrations of heptachlor and heptachlor epoxide in New Zealand and overseas soils

Country	Location type	Date sampled	Number of sites[1]	Concentration range (μg kg^{-1} DW)[2]		Reference
				Heptachlor	Heptachlor Epoxide	
New Zealand	Indigenous forest	1996	8	< 0.01 - < 0.04	< 0.01 - < 0.06	This study
	Indigenous grassland	1996	5	< 0.01 - < 0.03	< 0.01 - < 0.02	This study
	Provincial centre	1996	8	< 0.01 - < 0.02	< 0.01 - < 0.03	This study
	Metropolitan centre	1996	15	< 0.01 - 0.061	< 0.01 - 12.1	This study
Australia, NSW	Agricultural	1987-89	16	160 - 400	10 - 50	McDougall *et al*., 1995
Canada	Agricultural	1992	30	nd - 2	nd - 3.1	Webber and Wang, 1995
Canada, BC	Agricultural	1989	4	nd	nd - 16	Szeto and Price, 1991
Chile		1983	8	nd - 5		Ciudad and Moyano, 1988
India	Agricultural	1991-92	10	nd - 1		Agnihotri *et al*., 1996
Netherlands	Rural		30		nd - 29	Gaans *et al*., 1995
Netherlands		1993	12		1.2[3]	Hendriks *et al*., 1995
Spain	National Park and surrounds		17		nd - 0.073	Fernandez *et al*., 1992
USA	Metropolitan	1971	380	nd - 130	10 - 2000	Carey *et al*., 1979

[1] Where possible 'sites' are interpreted as geographically or otherwise distinct sampling locations.
[2] Concentrations are reported on a dry weight basis.
[3] Values are geometric means.
nd = Not detected.