National Study of the Composition of Sewage Sludge

Prepared for the

New Zealand Water and Wastes Association

By

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Section 6 includes a list of fourteen New Zealand organisations that supplied information about previous sewage sludge analyses. This information was most useful and the permission to reproduce it is gratefully acknowledged.

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NATIONAL STUDY
OF THE COMPOSITION
OF SEWAGE SLUDGE

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FOREWORD

The Drainage Managers Group is a voluntary group of drainage authorities in New Zealand. It is a sub-group of the New Zealand Water and Wastes Association (NZWWA), a non-profit organisation, which has as a mission: "The advancement and application of fundamental and practical knowledge to natural water resources, water use and wastes."

Members of the Drainage Managers Group pay a levy to provide funds for research projects that have a common application to a large proportion of its members. Research projects are approved by the Group at annual meetings.

The Group is in the process of developing national guidelines for the beneficial reuse of biosolids. One of the intentions of this project was to provide information on the composition of biosolids in New Zealand.

The disposal and reuse of sewage treatment plant sludges is a national issue, so the Drainage Managers Group approved the two projects at their 1997 Management meeting.

Knowledge of the composition of the country's sewage sludges will help accelerate the process of reducing waste discharges to natural waters and the environment, which is in line with the Government's long-term environmental objectives and priorities. Therefore this project satisfied the requirements of the Ministry for the Environment's Sustainable Management Fund. The Drainage Managers Group is grateful for the Ministry's financial assistance.

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PART A

SECTION 1

INTRODUCTION

The application to the Ministry for the Environment's Sustainable Management Fund and the contract with the Ministry included a Section that explained the reason for this project.

"SECTION 3: THE PROJECT

3.1 Outline

Discharges of hazardous wastes to sewers can cause treatment processes to fail. This can result in unsatisfactory effluent being discharged to natural waters, or in incompletely digested sludge being pumped to lagoons where it can create a public health risk or bad odours.

Heavy metals and some intractable organic chemicals accumulate in the sludge. Sludges are used in domestic gardens, parks and reserves, dumped on landfills, in forests or spread on land. This may not always be environmentally sustainable. Run-off can pollute surface water, seepage can affect groundwater quality, and sludge can contaminate the soil and plants.

Sludges that achieve a prescribed standard in USA are termed `Biosolids' and are permitted to be applied to the land as a resource. NZWWA and other organisations are investigating whether overseas standards are acceptable for local soil and climate conditions; this study will assist that investigation.

Most councils that allow public use of sewage sludge rely on the Ministry of Health's recommendation that the sludge has aged sufficiently, to limit the effect of pathogens on humans. Very few councils know the environmental effects caused by the discharge of their sludge.

Many operators of sewage treatment plants in New Zealand have never tested their sludges for heavy metals or organic chemicals. This project will provide that information, cost-effectively.

It is intended to collect sludge samples from over the whole country, to be analysed for a full range of heavy metals, volatile organic chemicals, semi-volatile organic chemicals, polyaromatic hydrocarbons and halogenated organic chemicals, and some 'tentatively identified compounds'.

The samples will be tested using modern analytical equipment such as gas chromatograph/mass spectrometer (GC/MS) and inductively coupled plasma (ICP), which provide reliable, low-level results. The testing will be carried out by one laboratory so the results will be comparable.

A literature survey will compare these results with overseas sludges, and an attempt will be made to find cases of where the chemicals causing treatment failure have been identified and the levels that caused the failure.

The analytical results will produce a national benchmark for sewage sludge producers; they will be able to recognise any chemicals they have at relatively high concentration. By tracing the source they should be able to convince hazardous waste producers to implement a waste minimisation programme. This will reduce the environmental effects caused by sludge disposal. Also, the soluble fraction that is not taken up by the sludge will be found at a lower concentration in the sewage plant's final effluent.

3.2 The Problem or Issue at Stake

About 50-95% of heavy metals in sewage settle out in sedimentation tanks, or are adsorbed on to particles which become the raw (primary) sludge, or into organisms and become secondary (biological) sludge.

Some of the organic chemicals pass into the sludge phase, either because they are insoluble and are heavier or lighter than water, or because they are soluble in fats and oils, or because they are adsorbed on to solid particles, or are taken up by organisms which enter the sludge.

Aerobic biological treatment systems such as the activated sludge process depend on a healthy, vigorous growth of an assemblage of micro-organisms that live in and break down the sewage, converting it to an effluent that is suitable for discharge. The process can be interrupted seriously by discharges of toxic industrial wastes to sewers.

The anaerobic process in sludge digesters involves two steps. In the first step a wide range of anaerobic bacteria break down large molecules to smaller molecules, mainly acetic acid. The second part of the digestion process involves the methanogenic bacteria, which convert acetic acid to methane, carbon dioxide and water. The methanogenic stage is very sensitive to digestion conditions and can easily fail in the presence of toxic substances.

There have been many digester failures in New Zealand, most not reported. A Mangere failure was reported to the Operations and Research Group for Drainage in 1987. North Shore digesters failed in April 1996. These failures can be very costly. Undigested sludge may have to be pumped to lagoons where it can cause odour and health problems. The loss of gas requires alternative energy for the heating system. Large volumes of fresh seed material may have to be tankered in from another town.

Routine process control testing (falling gas production, low methane content, low pH, low alkalinity, high volatile acids) may suggest the presence of toxicity, but not its likely cause. Therefore samples have to be sent to specialist laboratories for a wider range of tests. But which?

A selection of heavy metals is usually requested but there is a problem when the results arrive -which heavy metals are present at toxic levels? Data exist which summarise results from other sewage treatment plants, usually overseas. If it is a large dataset, the range of concentrations reported is usually very large, which probably will not help an individual plant that may have had only one sample (presumably unusual) tested previously. Also, a town with little industry may have low levels of chromium (for example), but the digester may suffer when the concentration doubles (for example). Their problem level may still be lower than the chromium content in sludge with a higher industrial component, where the bacteria have possibly acclimatised to a much higher but consistent concentration. Therefore treatment plant managers need to know the typical composition of their sludge.

Which organic chemicals should be analysed in 'toxic' sludge? Until the last 3-4 years the range of organic chemicals that laboratories could test for reliably was very limited; analytical results frequently suffered from interferences or problems resulting from complex matrices. The analyses were very expensive. If a particular industry were suspected of 'spilling' the toxic substance, specific analyses could have been requested, otherwise a sewage treatment plant manager would not know which of thousands or organic chemicals to test for. Consequently there is not a lot of data available on the concentrations of organic chemicals in sewage sludges, either in New Zealand or even overseas at present.

Some laboratories in New Zealand have invested recently in gas chromatography/mass spectrometry, so it is possible now to identify and measure the concentrations of hundreds of organic chemicals. A 'toxic' sludge sample was sent to a laboratory for GC/MS analysis in April 1996 and it was found to contain many fairly unexpected chemicals, some in quite high concentrations. Many of these were hydrocarbons related to the petroleum industry and were included amongst the 'tentatively identified compounds'. But like the heavy metals situation -which of these organic chemicals were unusual, or at unusually high concentrations, and were they toxic in anaerobic digesters? The laboratory later found some of the same 'unusual' chemicals in a sludge sample from another town. This 'process of discovery' is probably occurring over the whole country, slowly and in a piecemeal manner, and without much communication between treatment plants.

The USEPA has established a set of guideline values which need to be satisfied before digested sludge can be applied to the land as Biosolids. The Drainage Managers Subgroup of NZWWA is currently involved in a Biosolids management project. It is likely that National Guidelines may be developed that are appropriate for New Zealand soil and climate conditions. It is important to know the range of concentrations of many of the chemicals found in New Zealand sludges. The findings from this analytical project will be an important part of the Drainage Managers Group's final report and the full data from this project will probably be included in an Appendix to the guidelines."

SECTION 2

SOME RECOMMENDATIONS

1. Sampling

It must be stressed that every care was taken to ensure that the participants in this project were aware of appropriate sampling techniques. Despite this, the analysts were not convinced that all sub-samples from each participant were really identical. Sampling is one of the most important steps in an analysis. People submitting sludge samples for analysis should ensure that their technique is suitable. Perhaps the guidance offered to participants in this project could be used as a starting point for developing a 'national sludge sampling' protocol once restrictions are imposed on sludge reuse/disposal.

Despite using 'correct' sampling techniques, it must be remembered that 12 scoops (say) of sediment collected from around an oxidation pond is only an approximation of what really has accumulated over a hectare (say). Everyone knows a morning grab sample of raw sludge could be quite different from an evening grab sample, and that Sunday sludge is likely to be different from Friday sludge. Likewise, the composition of raw sludge composited from a few daily grab samples over a dry week in March may differ during wet weather or at another time of the year. And weathered sludge on the outside of a stockpile will be different from sludge a metre in.

2. Units and the Dry Solids Test

When measuring the concentrations of the insoluble or adsorbed components of sludge it is normal to report the results in w/w units such as mg/kg. That may involve multiplying the concentration found in the aliquot tested (eg, mg/L) by 100 and then dividing by the % dry solids to get mg/kg. Despite paying hundreds of thousands of dollars for sophisticated equipment such as ICP or GC-MS, the accuracy of the final result will depend very much on the accuracy of the dry solids test. Despite its apparent simplicity, this test is not as reliable as many analysts think. Therefore in projects like this or for compliance type work, it is suggested that the dry solids determination be conducted in triplicate, and with the same level of QA as for the more sophisticated tests.

3. Sub-Sample Preparation

The sample that is submitted to the laboratory is meant to represent the 'real life' situation in the process being monitored, or in the environment. The laboratory cannot process the whole sample – it can only conduct its tests on a small portion, the sub-sample. The sub-sample taken for analysis is meant to represent the whole sample. Testing for soluble components in a liquid is relatively simple. Taking a sub-sample for testing for chemicals or bacteria that are insoluble or are attracted to solid particles in a liquid needs more care – usually an extensive shaking routine is sufficient. But if the sample is solid or semi-solid, like sludge, taking a representative sub-sample is extremely difficult.

For example, laboratories testing soil at contaminated sites have obtained some extremely high copper or lead results and have been asked to repeat the analyses. The repeat test can be quite different which is embarrassing for the laboratory to say the least! Very careful inspection of the sample has revealed paint flakes which contain either lead or copper; small pieces of lead head nail have been found too. Pond sediments may contain fragments of lead shot. The same particles can occur in sewage sludge.

The samples as supplied are not homogeneous. The laboratory dries and grinds a portion of the sample, and may use some that passes a sieve (say 2 mm), and then takes a sub-sample, say 1 g, for digestion. But does that 1 g contain a fragment of metal or corrosion product, or a soil particle that has absorbed oil, or a sooty particle containing some dioxins?

How does one overcome these problems in a consistent manner, nationally?

1. By grinding a portion of the sample to a very fine homogeneous powder; this is expensive and difficult to achieve in practice, and remember – the more handling a sample receives, the greater the risk of contamination.

2. Digest several (n) sub-samples and average the results, but costing n times the standard rate!

3. Carry out a 'standard but practicable' procedure for preparing a sub-sample, but routinely repeating all analyses that fall outside the 'regulation limit'. This approach will reduce the number of 'false positives' but will allow 'false negatives' to pass unnoticed.

Once again, without a 100% reliable solution, a standard approach needs to be developed.

4. Metals

Metals can be extracted from sewage sludges by a variety of digestion techniques, each with its own recovery efficiency. In an attempt to prepare a sub-sample for a 'total metal' analysis, laboratories over the years have used a variety of acids (hydrochloric sometimes, nitric frequently, and aqua regia at times as well). They have used different strengths of acids, for different times, and at different temperatures. They sometimes do this digest/extraction on the sample as delivered, on the sample after air or oven drying, or even on the ash residue after time in a high temperature furnace.

Concentrations in the extracts can be determined by a variety of instrumental techniques, each with its own limits of detection, and each suffering from its own analytical problems such as interferences and matrix complications. Colorimetric methods usually depend on the metal being present as an ion which will react with a reagent to form a colour, provided there is no interference and other conditions are exactly right. Atomic absorption measures atoms released from the sample at an appropriate temperature and flame condition, with significantly fewer interference problems. The temperature in a graphite furnace is even higher, thus releasing even more of the metal from its matrix and at a lower limit of detection, but often with increasing background interference. And so it goes on, with ICP, ICP-MS and ICP-OES, etc being used today.

The previous two paragraphs discuss laboratories' attempts to determine the total metal content. But increasingly, scientists are becoming aware that 'total' measurements may not be as appropriate as `bioavailable' measurements. What are these? Acid soluble? Acid extractable? Citrate extracts?

These problems need to be addressed before establishing standards or environmental limits. This discussion also needs to be considered when metals results from other surveys are compared with these results. If there is no such thing as a 'correct' result, the least we can say is that this survey has reported the results of 35 metals determined in 66 samples using the same or similar techniques on all 66 samples, so these results should at least be comparable!

5. Dioxins and PCBs

Some national standards have limits (or they are being developed) for concentrations of dioxins and PCBs in sewage sludges for a variety of disposal/usage options. These standards have not always been precise about the units. For example, sometimes the determinand is described as PCBs or PCBs (total); dioxins or dioxins (PCDD/PCDF). Sometimes the standard specifies an upper limit in concentration units, sometimes in toxic equivalents (TEQs). The TEQs may or may not have half the limit of detection (LOD) included for all congeners found at less than the LOD. Not all PCBs and dioxins are toxic so the TEQ approach will not include some dioxins that are found above their LODs.

There are 210 possible dioxins; ESR routinely reports results for 25 of them. There are over 200 PCB congeners, all man-made. ESR routinely report results for 24 of them, RJ Hill Laboratories report 30, not all the same; ie neither really reports 'total PCBs'. No doubt each tests for the `commoner' congeners so the respective 'totals' may not be very different. However, if the 'total + half LOD' approach is used, then a laboratory that reports more congeners will report a higher result for the same sample. The TEQ approach is more suitable for environmental compliance work and will be adopted in New Zealand, so as a minimum, the

13 PCB congeners with a TEF must be analysed. But if a PCB-free sample is tested by two laboratories using different LODs, the TEQs that include half the LODs could be quite different.

These problems need to be addressed before establishing standards or environmental limits and their associated compliance testing procedures. Analytical techniques need to be standardised too. For example, some laboratories do not 'correct' their results for the recovery of the surrogates, while others do.

6. Organochlorine Pesticides (OCPs)

If regulatory levels for OCPs are going to be set at about 0.02 mg/kg (20 µg/kg), then the sample clean-up, extraction and analysis used to measure them will need to be appropriate. Clean-up will have to ensure that the sludge samples do not present difficult matrix effects, the extraction will need to allow very low limits of detection (LOD) to be achieved, and the analytical techniques will need to ensure a high degree of specificity towards the OCP being measured. Performing such complex analyses at such low concentrations, in such 'dirty' samples will necessitate a carefully planned and conducted quality assurance programme of recovery spikes, surrogates, blanks and replicates.

As a rule of thumb, it is normal for laboratories to use a technique that has a limit of detection that is a fifth of the regulatory level, although with analyses and samples as complex as these, a tenth may be more appropriate. That means the LOD for OCPs should be about 0.002 mg/kg if regulatory levels are established at 0.02 mg/kg. This will be very challenging. Perhaps there are only one or two analytical techniques at present that could be approved for this type of work.

IN CONCLUSION: it is recommended that part of the exercise of determining guidelines for the reuse or disposal of sewage sludges should include establishing a sub-committee that is given the task of developing suitable sampling and analytical procedures for use in conjunction with the guidelines.

SECTION 3

THE SAMPLES THAT WERE COLLECTED, IN RELATION TO THE TREATMENT PROCESS

The Ministry for the Environment included as Special Conditions in the Project Agreement, that:

"ii) The Grantee shall provide details of the sampling and testing programme to the Minister including information on the range of analytes to be tested and the quality assurance measures to be used.
iii) The Grantee must have the approval of the Minister before commencing the sampling and testing programme."

Participants were sent a memo (approved by the Ministry) dated 12 February 1998, titled "Some Suggestions to Help with Sampling" - refer Appendix to this Section. As well, several participants rang for additional advice relating to their own specific circumstances.

The dry solids contents of the samples have been included in this section of the report. The concentrations of metals and organic substances have been reported (in Part B) in w/w units, usually mg of substance per kg of dry sludge.

A The Participants

All local authorities operating wastewater treatment plants were invited to participate. Depending on the number of samples they elected to submit, there was usually no charge. The final response was 21 local authorities provided 66 samples, representing 30 wastewater treatment plants and 2 composts.

Participants supplied the following information.

Carterton District Council

The samples were collected from the Carterton sewage treatment plant.

Raw sewage flows through the primary sedimentation tank with the settled sewage passing on to 2 oxidation ponds in parallel followed by a third pond, in series, prior to discharge to a stream.

Sludge from the sedimentation tank is pumped to 4 aerobic digesters. These are simple concrete tanks with forced air oxygenation of the sludge. Tanks 1 and 2 are joined, tanks 3 and 4 are joined.

The raw sludge sample was a composite of 5 grab samples collected between 0900 and 1700 on 31 March 1998. The sludge was 'thick' so needed to be collected by bucket. Dry solids content = 4.0%.

The other 2 samples were collected from the 5.5 m deep aerobic digesters. Sample MJF10 was collected from digesters 1 and 2 by taking equal portions from 0.5 m and 3 m above the bottom and another portion from just below the sludge surface, then combining the 6 sub-samples. Dry solids content = 3.4%. Sample MJF11 was collected from digesters 3 and 4. Dry solids content = 8.0%.

The samples were refrigerated, then despatched with 2 bags of ice cubes in the chillibin.

No rain fell at during the 3 days prior to sampling. There are no industries in Carterton large enough to affect the composition of sludge.

Central Otago District Council

The sample was collected from the Alexandra wastewater treatment plant.

The treatment process includes grit removal and milliscreening of raw sewage. The flow then passes through a circular aeration basin to a circular sedimentation tank that is within the aeration basin, ie the process is extended aeration/activated sludge. Some sludge from the sedimentation basin is transferred to a picket gate thickener and some is returned to the aeration basin. Sludge is drawn from the thickener 2-3 times a week and carted to a disposal area.

The thickened biological sludge was pumped into the truck on 18, 20, 27 and 31 March. Once the truck was full on these four occasions the truck drain valve was flushed 'clean' and grab samples were collected directly into new 1 L plastic bottles. The bottles were placed inside airtight plastic bags and placed in a refrigerator. The composite sample was prepared on 31 March by mixing equal parts of the four grab samples in a bucket and pouring into the analyst's bottles through a plastic funnel. The samples were couriered to the laboratory on 31 March. Dry solids content = 1.7%.

Less than 2 mm of rain fell between 18 and 31 March. There are no industries in Alexandra that would affect the quality of sludge, so the sludge should be almost entirely domestic.

Christchurch City Council

The samples were collected from the Belfast and Templeton oxidation ponds and the Bromley sewage works in Christchurch.

(a) Belfast
Raw sewage enters a 2 ponds in series system, with no pretreatment. Pond effluent enters the river.

A sediment sample was collected on 31 March from the Belfast oxidation pond. Dry solids content = 0.9%.

(b) Templeton
Raw sewage from the hospital and prison enters Imhoff tanks where sludge is removed in the cones. The settled sewage flows to oxidation ponds 1 and 2. Raw sewage from the township enters oxidation pond number 3 with no pretreatment. Pond effluents are sprayed on farmland.

A raw sludge grab sample was collected from the Imhoff tanks on 25 March. Dry solids content = 3.4%.

A sediment sample was collected on 1 April from oxidation pond number 3. Dry solids content = 4.6%.

(c) Bromley
Raw sewage flows via screens and grit arrestor to the primary sedimentation tanks from where scum and settled sludge are pumped to heated anaerobic digesters, along with settled secondary sludge from the biological filters. Settled sewage is processed by fixed growth reactors (a type of trickling filter) and then moves on to oxidation ponds. Digested sludge is transferred to sludge lagoons where supernatant is run off to allow thickening. After 4-6 weeks the lagooned sludge is dosed with polyelectrolyte and dewatered using a belt press. Later it is spread across land to dry.

A raw sludge sample (which includes scum) was collected from the sludge line leading away from the primary settling tanks. The sample was composited in a nalgene container during the week ending 24 March. Dry solids content = 3.0%.

A sample was collected on 20 March from the sludge line from the secondary settling tank which separates out sludge from the trickling filters (FGRs). The 24 hour composite sample of secondary sludge was collected into a nalgene container, mixed, and dispensed into the analyst's containers. Dry solids content = 2.3%.

A sample of anaerobically digested sludge was composited from sub-samples from each of the digesters. The sub-samples were collected at various times during an 8 hour period on 24 March. They were mixed thoroughly and dispensed into the analyst's containers. Dry solids content = 1.7%.

A sample was collected from the sludge lagoons on 18 March. The lagoons are fed with sludge from anaerobic digesters. Sub-samples were collected in a glass beaker and stirred with a glass rod. Dry solids content = 3.9%.

Two samples were collected from the sludge dewatering process. This is fed with sludge from the lagoons and dosed with polyelectrolyte. The composite samples comprised 2 handfuls (wearing gloves) of sludge per 1/2 hour during the afternoon plus a selection from the bin. The sub-samples were placed in a plastic bag and mixed by hand and fed into the analyst's containers . One sample (#2) was collected on 17 March and had a dry solids content of 20.8%; the other sample (#4) was collected on 18 March and had a dry solids content of 20.7%.

A sample of airdried sludge was collected on 18 March from 5-6 sites around the pile in the paddock. Using a plastic scoop, sub-samples were placed in a plastic bag, broken up and mixed and placed in the analyst's containers. Dry solids content = 93.9%.

A sediment sample was composited from sub-samples collected using a corer from a boat, from the distribution end of oxidation pond number 2. Dry solids content = 25.9%.

A sediment sample was composited from sub-samples collected from the discharge end of oxidation pond number 2. Dry solids content = 2.4%.

A sample of compost (a 50:50 mix of greenwaste/thickened biosolids) was supplied from the compost heap in the sludge building. It was collected on 17 March using a plastic scoop to fill a plastic bag and then into the analyst's containers. Dry solids content = 50.0%.

All samples were refrigerated until despatch. No rain fell during the sampling period. There are many small industries in Christchurch, none is expected to affect the composition of sludge.

Dunedin City Council

The samples were collected from the Tahuna wastewater treatment plant over the period 17-20 March.

After screening, the raw sewage flows through primary sedimentation tanks. Settled sludge and scum are collected, the polyacrylamide polyelectrolyte Zetag 63 is added (at about 3 mg/kg), and the sludge passes through a belt press. The dewatered sludge is then incinerated.

A scum sample was collected from the top of one of the sedimentation tanks, using a plastic sieve, each morning for 4 days. Dry solids content = 5.7%.

A daily sludge sample (raw sludge without any scum) was collected through a valve in the sludge pump gallery for 4 consecutive mornings. Dry solids content = 5.9%.

Dewatered sludge was removed from the belt press just prior to incineration on each of 4 consecutive mornings. Dry solids content = 29.0%.

All samples were stored in the refrigerator until the composite was prepared and added to the analyst's sample bottles.

No industries in Dunedin are expected to affect the composition of raw sludge. Very little rain fell during the sampling period.

Horowhenua District Council

The Levin wastewater plant comprises grit removal (the screens were not functioning at the time of sampling), primary clarification, trickling filters, secondary clarification, activated sludge (with waste activated sludge returned to the raw sewage). The mixture of raw settled sludge, scum and secondary sludge is digested anaerobically at 35°C, with the digested sludge being transferred to one of two lagoons (6.8 m deep). While one lagoon is being fed, sludge from the other is removed and placed on drying beds.

The raw and digested sludge samples were composited from daily samples collected during the week ending 24.3.98. The raw sludge dry solids content was 1.6%, and the digested sludge had a dry solids content of 1.7%. The sludge lagoon sample and the air dried sampled collected from the drying beds were made up from several sub-samples. The dry solids content of the lagoon sample was 8.8%, and the drying bed sample was 14.8%.

No industries are expected to have any significant effect on the composition of sewage sludge; there is a small zinc plating plant in Levin and a few dyers. Very little rain fell during the sampling period.

Hutt City Council

The samples were collected from the Seaview milliscreening plant and from the Wainuiomata wastewater treatment plant.

(a) Seaview
Collected 21 April. Dry solids content = 24.5%.

(b) Wainuiomata
The raw sewage is screened through a 15 mm mechanically raked bar screen before entering the primary sedimentation tanks where the scum and sludge separate out. The settled sewage is then treated by 2 low rate trickling filters in series and 2 high rate trickling filters (recirculation rate 2:1). After secondary sedimentation, the liquid enters a series of polishing ponds and then on to the river. Secondary sludge is returned to the raw sewage. Raw sludge is pumped to a mesophilic anaerobic digester. After digestion, sludge is stored in a cold digester from where it is poured out on to drying beds which are concrete based but fitted with drainage slots.

The raw sludge sample was collected on 21 April; 8 x 500 mL sub-samples were collected over 8 hours, mixed and dispensed into the analyst's bottles. The dry solids content = 7.0%.

The digested sludge sample was collected on 21 April; 8 x 500 mL sub-samples were collected over 8 hours, mixed in a bucket and dispensed into the analyst's bottles. Dry solids content = 4.0%.

The airdried sludge sample was prepared on 21 April by collecting sub-samples from each end of the bed, plus samples from the stored dry sludge (1 month old), and from sludge stored on-site for up to a year. The composite sample was prepared using the cone and quarter technique. Dry solids content = 30.9%.

Samples were refrigerated prior to dispatch. Little rain fell in the period immediately preceding sampling. There is little industry in the Wainuiomata area.

Invercargill City Council

The samples were collected from the Clifton wastewater treatment plant at Invercargill.

After screening, raw sewage passes through a grit removal pre-aeration tank to primary sedimentation tanks where the raw sludge and scum separate out; secondary sludge and sludge lagoon supernatant are returned to the inlet to the primary sedimentation tanks. The settled sewage is treated by fixed growth reactors and secondary sedimentation prior to discharge. Sludge is treated in anaerobic digesters at 35°C along with a substantial proportion of woolscour waste. Digested sludge is transported to landfill after lagooning.

The 'raw' sludge sample (which also contains secondary sludge) was collected as follows: 750 mL from each of the 3 raw sludge pumps on 17 April were stored in the refrigerator over the weekend; 750 mL from pumps 1 and 2 were collected on 20 April (tank 3 shut down); the two sub-samples were mixed and added to the sample containers. Dry solids content = 3.7%.

The anaerobic sludge sample was a mixture of 1 L from digesters 1 and 2 on 17 April and 1 L from digesters 1, 2 and 3 on 20 April. Dry solids content = 4.1%.

The woolscour liquor sample comprised 1.5 L collected 15 and 16 April, combined with 1 L collected 17 April and 1.5 L collected 20 April; sub-samples were stored under refrigeration prior to preparing the composite. Dry solids content = 9.8%.

The airdried sludge from the lagoon was sampled from approximately 10 points along a row of sludge which had been excavated from lagoon 2 three months earlier and allowed to air dry. The 10 sub-samples were mixed in a bucket and used to fill the sample bottles. Dry solids content = 34.8%.

The woolscour waste represents a significant proportion of the biodegradable load on the plant; that is why the waste was included in this project.

No other industries in Invercargill are considered likely to have a significant influence on the sludge composition. During the 8 days of sampling, 29 mm of rain fell; rain fell on 6 of those days with a maximum daily fall of 11 mm. This amount of rain is not expected to affect the raw sludge quality.

Kapiti Coast District Council

The samples were collected from the Paraparaumu and Otaki sewage treatment plants.

(a) Paraparaumu
The Paraparaumu plant serves a population of 20,000. Raw sewage is treated by the activated sludge process, extended aeration with biological nutrient reduction (nitrification/denitrification and phosphorus removal). Waste sludge from the secondary clarifiers is transferred to a dissolved air flotation unit where it is thickened, before transfer to lagoons, where it stays for a minimum of two years for ageing and consolidation. The lagoon that was sampled was filled during 1996 until mid-1997 and has not received DAF sludge. It was fed with waste activated sludge after gravity thickening to about 1% dry solids. It formed a crust in the lagoon; liquid from beneath the crust has been pumped out.

Three sub-samples of DAF thickened sludge were collected on 24 March, one mid-morning, one mid-day and one mid-afternoon; these were mixed thoroughly and used to fill the analyst's bottles. The Paraparaumu DAF thickened sludge dry solids content = 3.8%.

Core samples from the lagoon were taken on 25 March from the full depth of consolidated sludge (about 1.5 m) using a PVC pipe. Twelve sub-samples were taken from around the lagoon and thoroughly mixed before filling the analyst's bottles. The sludge lagoon sample had a dry solids content of 11.1%.

No rain fell for 9 days prior to sampling. There is very little industry in Paraparaumu.

(b) Otaki
Raw sewage from about 7000 population enters an aerated lagoon and then a clarifier.

Three sub-samples of clarifier sludge were collected on 24 March, one mid-morning, one mid-day and one mid-afternoon; these were mixed thoroughly and used to fill the analyst's bottles. The Otaki settled sludge dry solids content = 1.5%.

No rain fell for 9 days prior to sampling. About 20% of the sewage flow is from an abattoir. Other significant industries include a plastic recycling plant and a paint manufacturer.

Manawatu District Council

The samples were collected from the Feilding sewage treatment plant.

Raw sewage passes through 6 mm screens, a grit removal unit, aerated lagoons, then the primary sedimentation tanks. Settled sewage passes to trickling filters, a secondary clarifier and on to the river.

Anaerobic digesters operating at 32°C break down sludge received from the primary sedimentation tanks which is a mixture of raw sludge and biological sludge from the aerated lagoons, plus a small quantity of sludge from the secondary clarifier. The digested sludge is fed into a storage tank and then on to concrete drying beds in the summer, or sludge ponds.

A 3 L raw sludge sample was collected mid-way during the sludge draw-off on 17 March and refrigerated. Another 3 L sample was collected on 18 March and mixed with the previous sample and used to fill most of the laboratory bottles; the bottles for mercury and volatile organic chemicals were filled from just the 18 March sample. Dry solids content = 2.7%.

The anaerobic sludge sample was drawn from the sole digester (which is mixed) on 18 March. Dry solids content = 1.5%.

The airdried sludge sample was prepared by mixing in a plastic bag 8 sub-samples from each of the 6 drying beds. Dry solids content = 74.9%.

There was no significant rainfall before or during sampling. Many industries, predominantly food processing, discharge to the Feilding sewerage system. The largest are a potato, carrot and pea processing plant; and a lamb slaughtering and packing plant. These industries make up more than 50% of the total flow/load.

Manukau City Council

The sample was collected from the Beachlands-Maraetai wastewater treatment plant.

Raw sewage is milliscreened and then passes into a fully aerated lagoon where nitrification occurs; no sludge settles here. The effluent from this lagoon passes to three ponds in series which are partly aerated and where the sludge settles out.

The sample was composited from 4 grab samples collected on 1 April from around the centre of the third and final pond in the area where most of the sludge accumulates. Dry solids content = 7.2%.

No rain fell during the 2-3 days prior to sample collection. There are no industries discharging to the sewerage system that would affect the quality of sludge, so the sludge should be almost entirely domestic.

New Plymouth District Council

Sludge samples were provided from the New Plymouth wastewater treatment plant and the Inglewood oxidation pond.

(a) New Plymouth
Raw sewage from a population of about 52,400 is treated by the activated sludge process. The wasted activated sludge (average age about 9 days) is pumped to the sludge thickeners and a 2% (approx) sludge is dosed with polyelectrolyte and pumped to gravity belt thickeners, then passes through a belt filter press.

The dewatered biological sludge sample was composited over two days, 31 March/1 April. Dry solids content = 13.5%.

The industrial load in New Plymouth is about 20% of that in the raw sewage.

(b) Inglewood
Raw sewage from about 3,500 people passes through a Rotomat screen to remove coarse debris before entering the oxidation pond. The pond receives a significant amount of infiltration following heavy rain, about 5 times the dry weather flow.

The pond sediment sample was collected on 24 March by using a small submersible electric pump from a floating platform near the shore. The pump sank into the sludge at the bottom of the pond; when the pumped sludge visibly thinned the pump was shifted to collect the next sub-sample. The laboratory sample bottles were filled on site and stored in the refrigerator at the New Plymouth laboratory, to be couriered with the New Plymouth samples. Dry solids content = 1.8%.

North Shore City Council

The samples were collected from the North Shore wastewater treatment plant.

Raw sewage is screened, degritted, and passes to the primary sedimentation tanks where sludge settles and scum floats; these are combined in the raw sludge. Some settled sewage flows to trickling filters and some to a new activated sludge plant. These effluents pass through secondary clarifiers and on to the 2 deep oxidation ponds in series.

Trickling filter sludge is returned to the primary sedimentation tanks. Raw sludge (with scum) is pumped into the 37°C anaerobic digesters. Waste activated sludge is thickened in a dissolved air flotation (DAF) tank. This thickened DAF sludge combines with the digested sludge. The digested sludge and DAF sludge are mixed (about 2 parts digested:1 part DAF) and then is dosed with a cationic polyelectrolyte (at about 4 kg/t dry sludge), centrifuged and disposed of.

The composite raw sludge sample comprised daily sub-samples of 17-20 March plus 23-24 March. Dry solids content = 3.0%.

The digested sludge sample was a mixture from the 2 anaerobic digesters. Dry solids content = 1.7%.

The dewatered (centrifuged) sludge sample was composited from 4 grab samples taken over a 9 hour period. Dry solids content = 20.1%.

The pond sediment sample was composited from sub-samples collected from the bottom of the main pond at 6 places. Dry solids content = 1.5%.

About 30 mm of rain fell over 13-14 March with no other significant rainfall during the sampling period. The two main trade waste contributors are the sugar refinery (mainly flow and BOD) and the Rosedale Rd Landfill - the leachate has not been analysed.

Porirua City Council

The sample was collected from the Porirua wastewater treatment plant.

The wastewater treatment plant uses the extended aeration activated sludge process, operating with a sludge age of 16-20 days. The daily waste activated sludge (WAS) enters one of two picket fence thickeners before being dewatered by two belt presses, assisted by Zetag 53 polyelectrolyte. The WAS spends 24 hours in the thickener.

Each day, 23-27 March, a 200 mL sample of dewatered sludge was collected from the two belt presses and stored in the refrigerator. At the end of the week all 10 samples were composited in a common container, stirred gently, and a portion transferred to the laboratory's bottles and dispatched by courier. Dry solids content = 11.3%.

No trade wastes are expected to influence the composition of the sludge because they all comply with the general bylaw for permitted trade waste. Rainfall should not affect the sludge either; only 15.7 mm fell in March, all on 5 days between 6 and 15 March.

Rodney District Council

The samples were collected from the Warkworth and Army Bay sewage treatment plants.

(a) Warkworth
The raw sewage is treated in an activated sludge plant. Waste activated sludge is dosed with Zetag 57 polyelectrolyte to assist dewatering and is then spread over sand drying beds.

The airdried sludge sample was collected on 24 March and composited from 10 cores from various depths in a stockpile which had previously been removed from the sand drying beds. The sample bottles were placed in the chillibin with ice and dispatched to the laboratory. Dry solids content = 14.9%.

(b) Army Bay
The raw sludge which is removed from the raw sewage is dosed with hydrated lime to achieve a pH of >10 and is then processed through a centrifuge and stored in a skip which is emptied daily.

The mechanically dewatered sludge sample was composited from daily samples (stored under refrigeration) for a 6-day period up to and including 23 March. The sample bottles were placed in the chillibin with ice and dispatched to the laboratory. Dry solids content = 18.1%.

The only significant rainfall was just 14 mm which fell on 19 March. Neither sewerage system receives trade wastes.

Rotorua District Council

The samples were collected from the Rotorua wastewater treatment plant.

The plant plant includes screening, grit removal, and primary sedimentation prior to a modified activated-sludge plant using the Bardenpho process for nutrient removal, operating at a 10 day sludge age. The daily waste activated and primary sludges are independently dewatered by three belt presses-assisted by Zetag 57 polyelectrolyte. The waste activated sludge is kept in an aerobic environment for the retention of phosphorus in the sludge and thickened to a solids level of 3.4% by two dissolved air flotation (DAF) units prior to pressing. The primary sludge passes through a thickener following fermentation in a volatile fatty acid (VFA) fermenter.

Rotorua sewage is predominantly domestic with very little trade waste. An intensive trade waste programme is in operation to protect the nutrient-removing activated sludge process from contaminants.

The first three samples described below were composited over a period of 7 days. Samples were stored in the refrigerator in polypropylene containers.

The sample of raw sludge from the primary clarifiers was collected after gravity thickening but prior to dewatering. About one third of this sludge has been through the VFA generator system (10 days' mean residence time) where fermentation of some carbon to mainly acetic acid is achieved. The raw sludge sample had a dry solids content = 3.1%.

The thickened waste activated sludge (WAS) sample was collected prior to belt press dewatering. The WAS originates from the biological nutrient reactor (BNR) where the mixed liquor suspended solids (MLSS) is wasted on a daily basis to maintain a sludge age of about 12 days. The liquor is thickened in DAF units before going to the filter press. Although the WAS should be relatively high in nitrogen and phosphorus, the BNR did not perform very well during the sampling period. The waste activated sludge sample had a dry solids content = 4.2%.

The dewatered sludge sample is a mixture of the two preceding samples, after dewatering in the belt press. Polyelectrolyte is added to the mixed sludge to enhance dewatering. The dewatered sludge sample had a dry solids content = 29.6%.

The compost sample is a mixture of approximately equal parts of sawdust, green waste and mixed sludge. This sample was made up from many composites collected on 27 March from a large pile ready for sale. The compost sample had a dry solids content = 15.8%.

South Waikato District Council

The samples were collected from the Tokoroa wastewater treatment plant.

The raw sewage passes through a grit arrestor and screens before entering the primary clarifier. Primary effluent is passed over a high rate trickling (rock) filter and on to the intermediate clarifier. This effluent is passed over a secondary rock filter and on to the final clarifier. About a month before the samples were collected the FAST activated sludge system commenced operating between the secondary filter and final clarifier. Sludge from the three clarifiers is digested in a heated anaerobic digester, then into a consolidation tank before being transferred to drying beds or lagoons. The two lagoons are about 10 by 15 metres and about 1.0-1.5 m deep.

Samples were collected on 1 April from the two lagoons (north and south). The dry solids content in the north lagoon was 13.7% and 23.6% in the south lagoon.

There was no rain prior to sampling. No trade wastes are expected to have a marked influence on the composition of the sludge.

South Wairarapa District Council

The samples were collected from Featherston, Greytown and Martinborough oxidation ponds.

(a) Featherston
The raw sewage enters two oxidation ponds. Six sub-samples of pond sediment were collected from each pond and composited. The dry solids content = 1.3%.

(b) Greytown
The raw sewage enters two oxidation ponds. Six sub-samples of pond sediment were collected from each pond and composited. The dry solids content = 0.9%.

(c) Martinborough
The raw sewage enters a single oxidation pond. Nine sub-samples of pond sediment were collected and composited. The dry solids content = 1.0%.

Samples were collected from across the ponds from a dinghy. The core sampler was a 50 mm length of PVC tubing with a 50 mm brass non-return valve on the end - no glues were used in the construction. The sampler was pushed into the sediment until it met with solid resistance, then withdrawn and supernatant decanted off. All samples were collected, bottled, packed in ice and couriered to the analyst on the day of collection - 7 April.

There was no rain prior to sampling. None of the pond systems receives unusual trade wastes.

Timaru District Council

The sample was collected from the Pleasant Point township oxidation pond.

Raw sewage, without any screening, enters the two ponds in series system.

The sample was collected from the first pond. The pond was divided into a grid system at approximately 10 m spacings and samples were collected every 10 m along these lines. The samples were mixed thoroughly to prepare the composite. The individual samples were collected by inserting a tube into the sludge, sealing the open end, raising the tube out of the pond liquid, and tipping its contents into a bucket. The Pleasant Point oxidation pond No. 1 sediment sample had a dry solids content = 19.9%.

No rain had fallen for some days prior to sampling. There are no industries in Pleasant Point which are likely to affect the composition of the sediment.

Thames Coromandel District Council

The sample was collected from the Thames wastewater treatment plant.

The treatment process includes comminuters, an aerated lagoon that includes a settling zone, followed by an oxidation pond.

The sample that was tested was composited from nine sub-samples taken from the aerated lagoon on 16 April, and had a dry solids content of 0.9%.

The raw sewage contains wastewater from Coromandel Meat Processors (mainly BOD). The plant also receives wastes from the metal industry, mainly a car assembly plant, a large foundry, and component assemblers, contributing high levels of iron, chrome and nickel.

Watercare Services Ltd

The sludge samples were collected from the wastewater treatment plant at Mangere.

Raw sewage is screened and degritted en route to the primary settling tanks. Sludge and scum are pumped to the anaerobic digesters, along with the secondary sludge. Some settled sewage is pumped into the FGRs and some passes direct to the four oxidation ponds (the first three run in parallel with some recirculation). FGR effluent passes through a secondary clarification stage and on to the ponds. The anaerobic digesters operate at 37°C. Digested sludge is dosed with polyelectrolyte and dewatered by gravity belt filters and belt filter presses. The dewatered sludge is airdried on beds before being transferred to a stockpile. Trials are proceeding with lime stabilisation of the dewatered sludge.

The raw sludge sample was prepared from two daily sub-samples of the feed to the digesters, collected during the 7-day period 21-27 March. Sub-samples were stored in a refrigerator. This sample contains primary settled sludge, scum, and return from the secondary sedimentation tanks (biological sludge after the FGRs). Dry solids content = 4.0%.

The digested sludge sample was composited on 25 March from sub-samples collected from anaerobic digesters numbers 1-4 and 6-7. Sample taps on the recirculation lines were flushed for two minutes before collection. Dry solids content = 0.9%.

A sediment sample was collected from oxidation pond number 2 on 24 March. The composite was prepared from 10 core samples. Cores were collected by inserting a 4 m length of excelon tubing into the sediment; a bung was placed over the open end and the core extracted. The core was examined to check the absence of original substrate before being released into a bucket. A total of about 40 L of sub-samples were taken to the laboratory, thoroughly mixed, and added to the analyst's bottles. Dry solids content = 8.3%.

The mechanically dewatered sample (anaerobic digester sludge) was prepared on 26 March by collecting a series of sub-samples over a 2 hour period into a 10 L plastic bucket; the bucket was sealed between samplings to reduce contamination. The sub-samples were crushed and blended to prepare the composite. Dry solids content = 33.8%.

A sample of mechanically dewatered lime stabilised sludge (ex anaerobic digesters) was prepared on 27 March from a stockpile produced during a trial run in mid-February (the unit was out of action at the time other samples were being collected). The sample comprised a thorough mixture of 10 sub-samples taken from a variety of locations and depths around the pile. During sampling it was noted that the pile had a temperature of 60-65°C. Dry solids content = 44.6%.

The airdried sludge sample was made up from 10 cores collected on 26 March from the sludge drying beds by inserting a 4 m length of excelon tubing into the sludge; a bung was placed over the opening and the core extracted. The cores represented old and recent sludge, all which had weathered. Cores did not contain substrate. They (about 10 kg) were taken back to the laboratory in polythene bags where any stones, sticks or vegetation were removed prior to crushing and blending using the 'cone and quarter' technique. Dry solids content = 43.3%.

No rain fell during the sampling period; the inflow to the plant was 200,000-240,000 m^3/d, representing dry weather flow. There are many sources of trade wastes in Auckland, including electroplating, photographic processing, printing works, metal processing, tanneries, and leachate from landfills.

Western Bay of Plenty District Council

The sample was collected from the Te Puke wastewater treatment plant.

This treatment plant uses the extended aeration, activated sludge process. The sludge is wasted daily into anaerobic digesters. Digested sludge is dosed with the polyelectrolyte B430L and dewatered on a belt press.

On each of 17-20 March, a 200 mL sample of waste activated sludge was collected from the inlet to the digesters and stored in the refrigerator. On 20 March the four sub-samples were mixed and couriered to the analysts. The sample had a dry solids content = 1.4%.

At present, Te Puke has no trade waste entering the sewerage system.

B Brief Summary of the Types of Samples that were Submitted

(66 samples were received - refer to previous Section for more details)

Raw Sludges (16)
Carterton District Council, primary sludge
Christchurch City Council, Bromley, primary sludge
Christchurch City Council, Templeton, primary sludge ex Imhoff tanks
Dunedin City Council, Tahuna, scum from primary sedimentation tanks
Dunedin City Council, Tahuna, settled primary sludge
Dunedin City Council, Tahuna, mechanically dewatered primary sludge with polyelectrolyte
Horowhenua District Council, Levin, primary sludge
Hutt City Council, Lower Hutt, milliscreenings
Hutt City Council, Wainuiomata, primary sludge and some secondary sludge
Invercargill City Council, Clifton, primary and secondary sludge plus woolscour trade waste
Invercargill City Council, Clifton, woolscour trade waste
Manawatu District Council, Feilding, primary sludge
North Shore City Council, Rosedale, primary sludge with some secondary sludge
Rodney District Council, Army Bay, mechanically dewatered, lime dosed primary sludge
Rotorua District Council, Rotorua, primary sludge plus some ex fermenter
Watercare Services Ltd, Mangere, primary sludge with some secondary sludge

Anaerobic Sludges (22)
Christchurch City Council, Bromley, digested primary and secondary sludge
Christchurch City Council, Bromley, digested sludge ex sludge lagoon
Christchurch City Council, Bromley, airdried digested sludge
Christchurch City Council, dewatered (with polymer) digested sludge ex lagoon (x 2)
Horowhenua District Council, Levin, sludge ex digester
Horowhenua District Council, Levin, digested sludge ex sludge lagoon
Horowhenua District Council, Levin, digested sludge off drying bed
Hutt City Council, Wainuiomata, sludge ex digester - fed with primary and some secondary
Hutt City Council, Wainuiomata, airdried digested sludge ex beds
Invercargill City Council, Clifton, sludge ex digester
Invercargill City Council, Clifton, airdried digested sludge ex sludge lagoon
Manawatu District Council, Feilding, digested primary and some secondary sludge
Manawatu District Council, Feilding, dried digested sludge ex beds
North Shore City Council, sludge ex digester (fed with primary and some secondary)
North Shore City Council, mechanically dewatered (with polymer) digested sludge

South Waikato District Council, Tokoroa, north sludge lagoon
South Waikato District Council, Tokoroa, south sludge lagoon
Watercare Services Ltd, Mangere, sludge ex digester
Watercare Services Ltd, Mangere, airdried digested sludge ex beds
Watercare Services Ltd, Mangere, mechanically dewatered lime stabilised digested sludge
Watercare Services Ltd, Mangere, mechanically dewatered digested sludge

Aerobic Sludges (14)
Carterton District Council, samples from aerobic digesters (x 2)
Central Otago District Council, Alexandra, sludge ex extended aeration/activated sludge
Christchurch City Council, Bromley, FGR sludge ex secondary sedimentation tank
Kapiti Coast District Council, Otaki, sludge from clarifier after aerated lagoon
Kapiti Coast District Council, Paraparaumu, DAF thickened activated sludge/BNR
Kapiti Coast District Council, Paraparaumu, activated sludge ex lagoon (9-21 mths old)
New Plymouth District Council, New Plymouth, dewatered (with polymer) activated sludge
Porirua City Council, dewatered extended aeration/activated sludge (with polymer dosage)
Rodney District Council, Warkworth, dewatered (used polymer) activated sludge off beds
Rotorua District Council, Rotorua, DAF thickened activated sludge ex BNR
Rotorua District Council, mech. dewatered (used poly) activated sludge plus raw sludge
Thames Coromandel District Council, Thames, aerated lagoon, preceding oxidation pond
Western Bay of Plenty District Council, Te Puke, waste activated sludge

Oxidation Pond Sediments (12)
Christchurch City Council, Belfast, no pretreatment
Christchurch City Council, Bromley, 'full' pretreatment, near inlet to pond
Christchurch City Council, Bromley, 'full' pretreatment, near discharge from pond
Christchurch City Council, Templeton, some: primary pretreatment only; some: none
Manukau City Council, Beachlands/Maraetai, ponds after aerated lagoon
New Plymouth District Council, Inglewood, only pretreatment is screening
North Shore City Council, Rosedale, main pond after 'full' pretreatment
South Wairarapa District Council, Featherston, pond sediment
South Wairarapa District Council, Greytown, pond sediment
South Wairarapa District Council, Martinborough, pond sediment
Timaru District Council, Pleasant Point, no pretreatment, from first of 2 ponds in series
Watercare Services Ltd, Mangere, 'full' pretreatment

Compost Samples (2)
Christchurch City Council, equal portions greenwaste/thickened biosolids ex Bromley
Rotorua District Council, equal portions sawdust/greenwaste/mixed sludge

APPENDIX (to Section 3, on Sampling)

New Zealand Water & Wastes Association

Drainage Managers' Group

C/o David Ogilvie
PO Box 60217, Waitakere City
ph/fax 09 817 5478

Memo to …..

12 February 1998

NATIONAL STUDY OF THE COMPOSITION OF SEWAGE SLUDGE

SOME SUGGESTIONS TO HELP WITH SAMPLING

Thank you for confirming your participation in this project.

INFORMATION THAT I REQUIRE

URGENT

1. Shortly the analysts will be couriering sample bottles to you. **Please ring me or fax me (today if possible please) the address they should be sent to and the name of the person who will accept them.**

2. **Please pass this note on to that person after you have read it and attended to the first item.**

AFTER SAMPLING

1. At the back of this letter I have listed the samples that you agreed to collect. This letter also offers some suggestions for collecting reliable samples. **Please document carefully how you collected/ composited/stored, etc the samples and send that information to me. This information will be necessary when trying to understand atypical results, and will be helpful when I prepare the final report.**

2. **Also, please send me a paragraph or so that describes the wastewater and sludge treatment processes at the plants where samples will be collected. This will help when comparing results in the final report.**

SAMPLING

The analysts will provide additional requirements when they send you their bottles.

Introduction

This study has two main aims:

1. to compare the composition of sludges being processed at several New Zealand wastewater treatment plants, ie the 'operational' samples;

2. to measure the concentrations of chemicals that may affect the environment when sludge is discharged, ie the 'environmental' samples

For further information, refer to the letter of 10 Dec that accompanied the Reply Form.

To satisfy the first aim the analytical results should be reasonably representative of 'normal' conditions. This will assist in identifying problems in the future when process difficulties are encountered. So to prevent abnormal results masquerading 'as the norm' samples will need to be composited over a reasonably lengthy period. The quality of raw sludges/scums, etc probably vary hourly, whereas a sample from a digester will include sludges that arrived at the plant for several days or even weeks earlier.

To satisfy the second aim samples will need to represent the material that will be discharged to or spread about the environment, regardless of localised sludge storage conditions.

Sampling Suggestions - (any queries - please ring me)

Digester Feeds – these may include contributions from:

- raw settled sludge
- scum from settling tanks
- waste activated sludge
- extended aeration sludge
- nutrient reduction sludge
- filter biomass, etc

Ideally they should be composited over a week, with the accumulating sample stored under refrigeration - if this is not possible a daily composite comprising several aliquots will have to do.

Digester Contents
Digesting sludge will be a mixture of very recent raw sludge and raw sludge that arrived up to a few weeks earlier. Therefore a representative sample can be prepared by mixing thoroughly a grab sample from each digester. If the digester contents are not homogenous, top, middle and bottom sub-samples may need to be collected for composting.

Sludges from Lagoons and Sediments from Ponds
Core samples should be collected from the full depth of sludge/sediment but without any of the original substrate. A representative sample can be prepared from up to 10 cores collected across the full lagoon/pond area at the plant. The cores will need to be blended thoroughly so a portion can be abstracted for analysis.

Mechanically Dewatered Sludges
A sample composited over an hour or so should suffice if the sludge has been in a digester. If the sludge is raw or from a biological process, a week of daily composites will be advisable, with the accumulating sample stored under refrigeration. Sub-samples will need thorough blending to produce a good composite sample.

‘Dry’ Sludges may include sludge ex drying beds or other drying process. Cores should be collected from a large number of places (at least 10), depending on the arrangement. They should represent old and recent sludges, sludge, which has been under shelter, as well as that which has weathered. Some cores should be down to (but not including) the substrate. The cores can be collected in clean strong polythene bags; the contents can then be crushed and mixed thoroughly. Remove any stones, sticks, or vegetation, etc. Combine all the contents if more than one bag has been collected and mix well. A representative sample can be prepared by the 'cone and quarter technique'. This involves transferring the sludge to a clean surface to form a cone; divide this into four quarters and then form a new cone from each of the four quarters, one after another. Repeat this process. Then divide the cone into four quarters and nominate one of the quarters as the composite.

Sample Collection Techniques
Most of you will already have routine sampling procedures in place, but these procedures may not have been developed for trace analysis. Mostly commonsense prevails. Avoid using galvanised implements, avoid PVC especially if glued. Don't leave container lids on or near vehicles, dirty surfaces, or near fumes etc. Limit the number of transfers from container to container.

Please follow any instructions that the analysts send with the sample bottles.

Yours sincerely

David Ogilvie
Project Manager

SECTION 4

SOME REPORTED INCIDENTS OF INHIBITION IN THE ANAEROBIC DIGESTION PROCESS

4.1 PRELIMINARY COMMENT

Most of the information in this Section has been taken from the WPCF/WEF annual literature review journals in the period covering 1966-1998.

In earlier years several of the papers were written by people who managed wastewater treatment plants and who had observed digester failures.

There was an increasing trend over the years for the papers to have been written by researchers using bench scale digester units, solely for research purposes. Although this information may not always relate directly to the 'real world', most researchers would have designed their experiments to mimic the 'real world'; therefore their results will interest practitioners.

In comparison, studies of real digester failures are often less helpful because sometimes the cause of the problem has passed through the system before it was investigated, or has been diluted to the extent that its importance is no longer obvious. Samples are sometimes taken too late to be helpful, or not analysed for the correct determinands, so the real cause of the failure is often not discovered.

4.2 INTRODUCTION

4.2.1 Units

It is common to report the concentrations of chemicals in sludges on a weight for weight basis (w/w) after the sludge has been dried in a laboratory oven, eg mg of metal per kg of dry sludge.

However, most chemicals that inhibit anaerobic digestion do so while dissolved, so many inhibition studies analyse chemicals on a weight for volume basis (w/v), eg mg of metal per litre of digesting sludge.

To convert between units one must know the % dry solids content of the sludge. Say a digester sludge contains 20 mg/L zinc, and say the sludge is 2% dry solids (say SG = 1):

> 2% dry solids sludge (w/w) contains 2 g of solids per 100 g of sludge or 20 g/L
> so 25 mg Zn in 1 litre of 2% sludge = 25 mg Zn per 20 g of dry solids or 1250 mg/kg therefore in 2% sludge, 25 mg/L Zn is equivalent to 1250 mg/kg Zn.

Note also that a concentration of 22,000 mg/kg is the same as 2.2% (w/w).

4.2.2 The Species of Metal Determined

Many reports are less helpful to wastewater treatment plant managers than would at first appear because they do not include enough information that will help the reader, particularly whether the metals' analysis was for total, dissolved, acid soluble or other forms, or whether the species determined was the most appropriate.

For example, all raw sludges will contain some heavy metals, but:

- if the metal in the raw sludge is insoluble and remains insoluble in the digester, inhibition should not be a problem;
- if the metal arrives in a soluble state it will not settle out into the raw sludge; only the liquid that is pumped with the solids will enter the digester;

- some soluble metal passing through the primary sedimentation process may be adsorbed into or on to biomass which later settles out in the secondary sedimentation stage;
- if the dissolved sulfide content in the digester is high, the soluble metal may form insoluble sulfides and become much less inhibitory;
- if the wastewater receives treatment with air or oxygen, some of the metal may oxidise and become particulate, thus entering the sludge phase;
- sometimes metals may arrive at the plant in different forms, such as a discharge of metal cyanide complexes - the concentration may not increase greatly but its toxicity may.

This project attempted to determine the range of concentrations of a large number of compounds in a broad spectrum of New Zealand sludges, collected while the treatment process was operating `normally'. Logistically, total metals analysis seemed to be the most appropriate overall. Towns that have problems with anaerobic digester inhibition may need to test for different or additional species.

4.2.3 Other Factors

Many authors have noted that the concentration of a chemical that causes inhibition of anaerobic digestion will depend on a number of factors other than just its concentration. For example:

- the concentration of the hydrogen ion is measured by pH. 'Sick' digesters usually have a low pH (high hydrogen ion concentration and therefore normally a high volatile acid content -predominantly acetic acid). Although a low pH in the digester can be caused by acidic raw sludge, it is more usually the result of other problems. General anaerobic bacteria break down organic matter to volatile (fatty) acids which in turn are converted to methane, carbon dioxide and water by the methanogenic bacteria. It is this last step which is usually the rate determining or sensitive stage in the anaerobic digestion process;
- a higher concentration of an inhibiting substance can be tolerated if the bacteria in the digester have experienced some degree of acclimation;
- the amount of inhibition caused by specific chemicals is likely to vary from plant to plant, depending on the predominant bacteria in the digesting sludge;
- a high concentration of a potentially inhibiting substance in a short time (shock dose) may be more traumatic than an elevated concentration for a longer period;
- concentrations of other compounds in the digester may be such that synergistic effects become important;
- metals are either dissolved, complexed or insoluble, so lead for example is always lead, but organic compounds can be biodegraded, forming new substances, some of which could be more toxic than the parent compound (although the opposite is usually more common);
- methanogenic bacteria can be 'washed out' by high flows of low concentration raw sludge, allowing volatile acids to build up. Also, during overloading conditions the methanogenic bacteria cannot keep up with the production of fatty acids. Lower concentrations of inhibiting chemicals can cause problems during these periods;
- physical factors such as temperature and mixing need to be suitable for the sensitive and rate determining methanogenic bacteria;
- the short-term digester loading rate may be excessive (ie a 2-digester system where each is fed for a day/rested for a day - biological systems prefer steady conditions).

4.3 SOME NON-INHIBITORY SUBSTANCES

The data in the Sections that tabulate previous analyses and current survey generally describe the composition of 'normal' municipal sewage sludges while the digestion process has been operating as expected. Like many other areas of human behaviour, the selection of tests that are used to characterise sludges or to investigate problems tend to follow trends or fashions. The next few paragraphs discuss sludge properties from a slightly different angle.

The organic matter in wastewater sludges is ordinarily not susceptible to total oxidation or degradation. Generally, a significant percentage (40-60%) of the original organic residue remains after biological activity has virtually ceased. In a fairly unusual and extensive study, Higgins et al (1982) compared the organic composition of aerobic, anaerobic and composted sludges. Although their work does not discuss inhibition, it is a good summary of many of the fractions of organic chemicals that can be found in sludges, and as such may assist people who are analysing sludges.

They explained that the amount of organic breakdown could be indicated by the removal of volatile solids, chemical oxygen demand (COD), and total organic carbon (TOC). They summarised the percentage reduction found in the different sludge treatment processes in Table 4.1.

Constituent	Aerobic Stabilisation	Anaerobic Stabilisation	Compost Stabilisation
volatile solids	46.8	43.4	54.2
COD	65.3	55.7	75.7
TOC	56.9	47.8	69.3

Table 4.1: Percentage reduction in volatile solids, COD and TOC

The amount of these empirical organic fractions found in different sludges was summarised in Table 4.2.

Constituent	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
volatile solids	75.0	56.5	59.9	49.0
COD	77.2	39.6	49.9	34.6
TOC	39.4	25.1	30.1	22.1

Table 4.2: Organic composition of sludges (expressed as the % of the total solids)

The total grease and oil fraction (including fatty acids) makes up a significant part of domestic wastewater sludge. Higgins et al summarised this fraction in Table 4.3. The unsaponifiable matter is largely composed of aliphatic hydrocarbons, with lesser amounts of aromatic and oxygenated compounds - see Table 4.4.

Constituent	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
free fatty acid	6.4	0.68	0.17	1.66
unsaponifiables	2.9	3.32	3.97	3.35
glyceride fatty acids	1.0	0.45	0.32	0.28
Sum	10.3	4.45	4.46	5.49
total grease	11.0	4.90	4.60	5.92
% recovery	93.6	90.8	97.1	92.8

Table 4.3: Organic constituents of the ether soluble matter (expressed as the % of the total solids)

Constituent	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
total unsaponifiables	2.9	3.32	3.97	3.35
aliphatics	52.0	52.7	54.8	57.3
aromatics	26.5	21.6	20.4	24.2
oxygenated	18.6	21.7	20.1	14.5
% recovery	97.1	96.0	95.0	92.0

Table 4.4: Character of the unsaponifiable matter (as the % of the unsaponifiable matter)

They found that the free fatty acids (FFA) were composed mainly of saturated fatty acids (Table 4.5). The anaerobic process is particularly effective at breaking down free fatty acids, but the aerobic processes were found to be more effective with the unsaturated fatty acids.

Free Fatty Acids	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
Unsaturated:				
palmitoleic	2.4	2.0	trace	trace
oleic	26.6	9.6	1.7	4.5
linoleic	3.4	0.8	0.1	0.3
linolenic	0.7	2.0	trace	trace
Saturated:				
lauric	0.8	1.1	trace	0.1
myristic	3.6	3.0	0.3	2.1
palmitic	34.0	26.7	3.9	34.6
stearic	15.8	13.8	2.0	28.6
arachidic	0.4	0.2	trace	0.4
Total	87.7	59.2	8.0	68.6

Table 4.5a: Composition of the free fatty acids - nonester fatty acids (expressed as the percentage of the total FFA fraction)

Glyceride Fatty Acids	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
Unsaturated:				
palmitoleic	2.5	3.3	1.3	0.3
oleic	23.5	7.5	6.6	2.9
linoleic	2.7	0.4	2.1	1.1
linolenic	0.2	4.4	trace	trace
Saturated:				
lauric	0.6	1.2	0.6	0.2
myristic	2.8	3.1	2.8	1.4
palmitic	20.0	14.9	12.3	12.5
stearic	12.8	5.5	3.6	8.2
arachidic	0.6	0.2	0.3	0.1
Total	65.7	40.5	29.6	26.7

Table 4.5b: Organic composition of the glyceride fatty acids - ester fatty acids (expressed as the percentage of the total GFA fraction)

The miscellaneous alcohol-soluble matter fraction is usually a small part of sludges, and includes amino acids, carbohydrates and tannins - Table 4.6.

Constituent	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
amino acids	13.8	9.97	12.36	9.30
tannins	1.6	1.23	3.53	3.90
carbohydrates	2.2	1.42	2.03	2.12
Total alc. sol matter*	3.0	2.50	5.8	1.8

Table 4.6: Organic composition of the alcohol-soluble matter (expressed as the percentage of the alcohol-soluble matter) *expressed as % of total solids

The largest fraction in the sludges is the carbohydrate-lignin group, mainly cellulose. Composting was the most effective process in degrading cellulose, Table 4.7.

Constituent	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
pectins	1.0	-	-	-
hemicellulose	2.5	-	-	-
cellulose	32.2	12.9	15.7	7.2
lignin	13.6	9.5	12.1	10.5
Sum	49.3	22.4	27.8	17.7
ash	22.0	47.5	38.8	51.0
% of total solids	71.4	69.9	66.6	68.7

Table 4.7: Organic composition of the non-nitrogenous ether/alcohol-insoluble matter (expressed as the percentage of the total solids)

The amino acid nitrogen content expressed as a percentage of the total organic nitrogen appears in Table 4.8.

Amino Acid	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
alcohol soluble	2.1	1.1	3.4	1.7
alcohol/ether insoluble	64.0	48.0	50.6	43.3
Sum	66.1	49.1	54.0	45.0

Table 4.8: Amino acid nitrogen content of the alcohol-soluble and the alcohol/ether insoluble nitrogenous matter (expressed as the percentage of the total organic nitrogen content)

Amino acids were determined in the alcohol/ether-insoluble matter (Table 4.9) and in the alcohol soluble matter (Table 4.10).

Amino Acid	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
valine	1.23	0.59	0.81	0.40
leucine	1.14	0.65	0.82	0.66
isoleucine, glycine, proline	1.40	0.93	1.54	1.20
serine	0.60	0.55	0.16	0.90
threonine	0.87	1.22	0.27	0.70
alanine	0.39	0.35	0.42	0.42
hydroxyproline	0.33	0.35	ND	ND
cystine, methionine, aspartic acid	0.64	0.42	0.70	0.36
phenylalanine	0.80	1.05	0.60	0.32
arginine, glutamic acid	0.90	1.20	0.64	ND
tyrosine	0.25	0.38	0.20	0.60
Total (% of total solids)	8.97	7.70	7.28	5.56

Table 4.9: Amino acid content of the alcohol/ether insoluble matter (expressed as the percentage of the total solids)

Amino Acid	Raw Sludge	Aerobic Sludge	Anaerobic Sludge	Compost Sludge
valine	1.80	1.66	0.76	-
leucine	1.00	0.84	1.51	0.85
proline	1.23	0.25	2.13	0.84
isoleucine	4.72	3.59	1.27	2.76
glycine	0.15	0.11	0.05	0.84
serine	0.47	0.19	0.13	0.13
threonine	0.10	0.22	0.25	0.15
alanine	ND	ND	0.06	ND
glutamic acid	0.20	0.37	0.50	0.59
methionine	ND	ND	0.06	ND
hydroxyproline, aspartic acid	0.19	ND	0.07	ND
cysteine	0.02	ND	ND	ND
phenylalanine	0.16	0.16	0.15	0.16
arginine	ND	ND	ND	0.49
tyrosine	ND	ND	ND	0.38
cystine	ND	ND	ND	0.14
Total (% of total solids)	10.04	6.83	7.92	8.17

Table 4.10: Amino acid content of the alcohol soluble matter (as the % of the total solids)

4.4 METALS AND NON-METALS (other than organic chemicals)

The WEF (1996) included about 1½ pages on toxicity in anaerobic digesters in their MOP 11, based on work reported by the USEPA in 1979. They state that the most typical types of toxins are organic compounds, heavy metals, ammonia, sulfide, oxygen and salt, and they tabulate typical inhibitory levels (reproduced here). They point out that a digester can acclimate to a higher tolerance level, in time.

Most toxins only affect the micro-organisms in the digester if they are dissolved, either carried with the raw sludge or solubilised in the digester. Precipitation of the toxin in the digester will eliminate its inhibitory effect. WEF (1996) report the effect of ammonia as:

Ammonia Concentration as mg/L N	Effect
50-100	Beneficial
200-1000	No adverse effects
1500-3000	Inhibitory at pH 7.4-7.6
>3000	Toxic

Table 4.11: Effect of ammonia on anaerobic digestion

Hashimoto (1986) reported ammonia levels causing inhibition in the anaerobic digestion of cattle wastes: 2500 mg/L as N in unacclimated digesters and up to 4000 mg/L in acclimated digesters. Results also indicated that the assumption of steady state performance after four volume turnovers may be incorrect when dealing with inhibitory substances.

The effect of salty wastewater on biological treatment was studied by Smythe et al (1997). They conducted three projects with wastewaters containing up to 10% salt; anaerobic systems were able to handle salt concentrations up to 1.5%.

Pagilla et al (1997) found that *Nocardia* filaments from the activated sludge process caused foaming in anaerobic digesters, with a subsequent deterioration in performance.

WEF (1996) report the effect of metals as:

Cation mg/L	Stimulatory	Moderately Inhibitory	Strongly Inhibitory
calcium	100-200	2500-4500	8000
magnesium	75-150	1000-1500	3000
potassium	200-400	2500-4500	12000
sodium	100-200	3500-5500	8000

Table 4.12: Effect of light metal cations on anaerobic digestion

Metal Conc. in Digester	Dry Solids mg/kg	Soluble Metal mg/L
copper	9,300	0.5
cadmium	10,800	-
chromium III	26,000	-
chromium VI	22,000	3.0
iron	95,600	-
nickel	-	2.0
zinc	9,700	1.0

Table 4.13: Concentrations of some metals that severely inhibit anaerobic digestion

Masselli et al (1967) explained that if digester liquid contained excess sulfide (and this could be done by adding sulfate which would be reduced to sulfide), the concentration of all inhibitory metals except chromium would be reduced to less than 0.001 mg/L. Generally only 5% of the raw sewage flow ends up in the digester and this usually contains insufficient sulfate to precipitate the heavy metals. Lawrence and McCarty (1965) had shown that as much as 10% of the digested sludge dry solids could be precipitated heavy metals, without inhibiting digestion.

Digesters at a plant in Kentucky failed after several weeks of high metals content in the sludge. There was a suggestion that a shock dose of additional metals may have been the 'last straw' -operators had noticed a layer of cutting oil on the sewage the day before the failure. The digesters took 7 months to recover (no undigested sludge was wasted). The mean metals concentrations in mg/kg in the digester soon after the failure were:

cadmium:	393	chromium:	2650	copper:	1775	iron:	11,000
lead:	920	nickel:	1090	zinc:	5700		

The authors (Regan and Peters 1970) considered that digestion had been proceeding normally for several weeks at metals levels not dissimilar to the above prior to the sudden failure. Although these concentrations are less than those in Table 4.13, the effect of the shock dose on top of these high levels probably caused the failure.

Hayes and Theis (1978) fed bench anaerobic digesters (filled with domestic sludge) with stepwise increases of heavy metals and measured the change in gas production. They defined an inhibitory level as the concentration when a decrease first became evident, and toxicity was defined as the concentration at which total gas production was reduced by 70%. Toxic limits for cadmium were not reached. A summary of some of their work follows:

in mg/L	Cd	Cr III	Cr VI	Cu	Pb	Ni	Zn
inhibition	-	130	110	40	340	10	400
toxic limit	>20	260	420	70	>340	30	600

Alkan et al (1996) compared the toxic effects of shock loading and stepwise addition of trivalent chromium to anaerobic digesters. It was found that 500 mg/L was toxic when injected as a shock loading, whereas 1,140 mg/L was toxic when chromium was added in a stepwise manner to permit acclimation. A shock loading of 400 mg/L caused temporary inhibition with recovery taking place within a week. Fradkin and Kremer (1981) used chrome tanning solid waste for improving anaerobic digestion. They found chromium levels as high as 1120 mg/L had no adverse effect.

McDermott et al (1963) dosed raw sewage with copper salts and found that when the level rose to 15 and 25 mg/L, gas production in anaerobic digesters was subnormal. A digester receiving primary sludge and waste activated sludge showed that gas production reduced when the raw sewage copper content was 10 mg/L. This was confirmed by Barth (et al (1965), who stated that the same concentration of chromium, nickel and zinc did not have this effect, either when added singly or in combination.

Reid et al (1968) found that chromium VI from 25-85 mg/L and copper from 0.5-2.0 mg/L did not reduce gas production by more than 18 and 8% respectively.

Matsumoto and Noike (1979) studied the effects of 3000 mg/L of each of cadmium, chromium, copper, nickel and zinc on anaerobic digestion of sewage sludge. They also studied the effects of a mixture of these metals at concentrations of 200 and 400 mg/L each. All metals resulted in irreversible inhibition except chromium, which exhibited initial inhibition followed by rapid recovery; both the acid-formers and methane-formers were affected. Inhibition for the combined metals occurred at a lower total metals content than for each metal separately.

Combined primary sludge and waste activated sludge from a plant continuously receiving raw sewage with 10 mg/L nickel digested satisfactorily. Primary sludge from raw sewage containing 40 mg/L Ni also digested satisfactorily. However, under their test conditions, only 4% of the nickel had been removed by the primary treatment and 30% by the activated sludge process; digester sludge samples contained up to 300 mg/L Ni. (McDermott et al 1965).

A spill of electroplating wastes knocked out an anaerobic digester at Auckland's Mangere plant in 1987 (Ogilvie 1987). Compared with their normal range, the concentrations of four metals in the raw sewage increased noticeably: nickel (10-fold), chromium (3-fold), copper 2-fold) and zinc (up 40%). This was reflected in hourly raw sludge samples collected over 6 hours which averaged: 1900 mg/kg Ni (20 times higher than usual), 1590 mg/kg Cr (double the normal value), 1400 mg/kg Cu (4-fold increase) and 1210 mg/kg Zn (20% up). Earlier work at Mangere had shown that digestion is inhibited when the raw sludge copper and nickel levels increase 5-fold (chromium and zinc were not inhibitory at these increases).

In Preston (England) sludge from a combined domestic/industrial wastewater containing 25 mg/L zinc at dry weather flow underwent pilot anaerobic digestion testing; the raw sludge was about 3.5% Zn dry weight. Mather (1964) found that when the digester contents reached 3-4% zinc the process almost ceased entirely. The author concluded that the maximum permissible zinc concentration in the sludge was 2-2.5%.

Hsu and Pipes (1973) added water treatment plant alum sludge to bench scale anaerobic sewage sludge digesters and found that gas production fell when the aluminium content reached 1000 mg/L as Al (note that 1000 mg/L would be 50,000 mg/kg if the sludge had been 2% dry solids). Jackson-Moss and Duncan (1991) studied the effect of aluminium on anaerobic digestion. They noted inhibition when the raw sludge contained 2500 mg/L A13+; the digester contents were even higher.

Lithium salts are often used for tracer or mixing studies. Anderson et al (1991) found that 250 mg/L lithium was mildly inhibitory in batch bottles but a plug flow column was not affected by temporary exposure to 1000 mg/L.

Liu and Fang (1997) found molybdate inhibited sulfate reduction and benzoate degradation, and biogranules lost 50% of their methanogenic activity at 48 mg/L of molybdate, but activity was restored when molybdate was removed. Basu et al (1997) found sulfate reduction and 2- chlorophenol dehalogenation were completely inhibited at molybdate concentrations of 10 mM (1600 mg/L - presumably as MoO_4).

4.5 ORGANICS, GENERAL AND SUNDRY

Parkin and Miller (1983) studied the response of methane fermentation to the continuous addition of six selected industrial toxicants: ammonia, hydrazine, chloroform, formaldehyde, copper and nickel, at various concentrations, temperatures and retention times. Estimated lethal concentrations ranged from:

2,500-15,000 mg/L	ammonia N
9->50 mg/L	hydrazine
4->20 mg/L	chloroform
70->400 mg/L	formaldehyde
>100 mg/L	copper
120-210 mg/L	nickel

Generally, longer retention times (25-50 days) at 35°C promoted improved tolerance.

Swanwick et al (1968) showed that feed sludge containing 2.3% anionic detergents severely affected digestion by depressing the activity of the methane forming bacteria (this was in the days of the less biodegradable branched chain detergents, ie before the linear anionic surfactants or LAS). Khalil et al (1988) observed that the anionic detergent sodium dodecyl-benzene sulphonate inhibited methanogenesis at 30-50 mg/L, whereas the nonionic Tergitol and soap had little effect.

Pitter et al (1972) reported that there was no impairment of anaerobic sludge digestion when alkylbenzenesulphonates (ABS) were up to 1% of the dry solids (200 mg/L when in sludge of 2% dry solids); inhibition occurred at higher concentrations.

A study of the effects of synthetic detergents on sludge digestion was conducted at the Mangere plant in Auckland. Woodworth et al (1975) found inhibition occurred as follows: 500 mg/L hard anionic, 750 mg/L soft anionic and 100 mg/L cationic; nonionic detergents caused little inhibition even at 1500 mg/L.

Hanaki et al (1981) demonstrated that long chain fatty acids inhibited the anaerobic digestion process by observing long lag periods in methane production with increased fatty acids levels of 250-2000 mg/L as oleic acid. Koster and Kramer (1987) suggested that the order of inhibition by long chain fatty acids was lauric>oleic>myristic or capric>caprylic. The bactericidal effect of long chain fatty acids on anaerobic digestion was studied by Rinzema et al (1994), who found that a concentration of 6.7-9.0 mol/m3 (1150-1550 mg/L) of capric acid (n-decanoic acid) was lethal to acetogenic and methanogenic bacteria.

The effect of molecular structure of 53 petrochemicals on biomethanation was studied by Chou (1978). Chloro substitution, aldehydes, double bonds, and benzene rings exhibited toxicity to unacclimated cultures. Addition of hydroxyl groups and increased carbon chain length resulted in decreased toxicity.

Johnson and Young (1983) studied the effect of dosing 1, 5, 10, 50 and 100 mg/L of the 24 semi-volatile organic (SVOC) priority pollutants identified by the USEPA. At 100 mg/L, inhibition was caused by only 2-nitrophenol, 4-nitrophenol, 2,4-dichlorophenol, hexachlorocyclopentadiene, hexachloroethane, hexachloro-1,3-butadiene and nitrobenzene.

Inhibition by 2-nitrophenol, 4-nitrophenol and nitrobenzene was reversible under the test conditions because these chemicals were reduced to the less toxic amine group. Acclimation to hexachloroethane was noted. Adsorption played an important role in reducing the soluble fraction of these chemicals.

Sonoda and Seiko (1969) examined the effects of some higher unsaturated alcohols on anaerobic sludge digestion. They recommended the following minimum concentrations: 1000 mg/L hexyl alcohol, 500 mg/L heptyl alcohol, 200 mg/L octyl alcohol, 100 mg/L allyl alcohol, 500 mg/L crotonyl alcohol and 20 mg/L propargyl alcohol. They found that carbohydrates and lower saturated alcohols had no effect.

Pearson et al (1980) studied the effects of four common 'preservatives' used in US recreational vehicle wastewater systems when discharged to roadside wastewater treatment systems that include anaerobic digestion in their process. The chemicals examined were formaldehyde, zinc sulfate, phenol and a quaternary ammonium compound. A common commercial version of the latter contains various n-alkyl compounds (C12, C14, C16, C18), dimethyl benzyl ammonium chloride, dimethyl ethylbenzyl ammonium chloride, plus some EDTA. Gas production rates were halved in acclimated cultures by the following shock loadings: 100 mg/L formaldehyde, 700 mg/L (as Zn) zinc sulfate, 700 mg/L phenol, and 50 mg/L (as organic N) of the quaternary ammonium compound.

Fischer et at (1975) conducted anaerobic digestion trials on pig manure. Manure injected with the antibiotics tylosin and lyncomycin disrupted the digestion system.

Oremland (1981) studied the formation of ethane in anoxic estuarine sediments and made use of the specific methanogenic inhibitor 2-bromoethanesulphonic acid. Wildenauer et al (1984) found that methanogenic fermentation of cattle manure was inhibited by 20% 3mM (700 mg/L) of 2- bromoethanesulphonic acid (BESA) and 45% by 2-5 mg/L monensin; acclimation was possible.

The effect of 15 antimicrobial agents with different specificities and modes of action on methanogens in anaerobic digestion was examined by Sanz et al (1996). Varel and Hashimoto (1982) studied methane production by fermentor cultures acclimated to waste from cattle fed the antibiotics monensin, lasalocid, salinomycin or avoparcin. They found lasalocid and salinomycin had little effect but monensin and avoparcin caused initial inhibition that receded after an acclimation period.

4.6 ORGANICS - SPECIFIC

Bauchop (1967) reported that methane biosynthesis was inhibited when the chloroform concentration in the anaerobic fluid reached 0.6-1.4 mg/L; when carbon tetrachloride reached 0.08-0.5 mg/L; and when dichloromethane reached 136-340 mg/L. Similar work by Thiel (1969) found that methane formation was reduced by 50% when the chloroform concentration was 1.0 mg/L; when the carbon tetrachloride concentration was 2.2 mg/L; and when dichloromethane was 100 mg/L. Sykes and Kirsch (1972) found a concentration of 16 mg/L completely inhibited methanogenesis of sewage sludge anaerobic digesters.

Chynoweth (1971) found that 0.4 mg/L chloroform inhibited methanogenesis. Stickley (1971) found that although a shock dose of chloroform as low as 1 mg/L decreased gas yields, it took a continuous dose of 10-11 mg/L to produce a noticeable effect and a continuous level of 16 mg/L caused complete inhibition.

Lewin (1971) reported the following toxicant concentrations to have been causes for digestion failures in Oxford, England (the concentrations are mg/kg dry weight):

chloroform: 1.7 tetrachloroethylene: 3.6 trichloroethylene: 4.0;

and at 5000 mg/kg 1,2-dichlorobenzene, 1,3-dichlorobenzene and 1,4-dichlorobenzene were found to be toxic.

Digester inhibitions of four of the commonest organic chemicals used in US industry were examined by Stuckey et al (1980) using batch assays (which measure the toxicity threshold of a slug dose and hence usually give a conservative figure) and semi-continuous assays (which give a better indication of inhibitory effects when a digester receives a continuous supply of the chemical). The results follow:

	dichloromethane	vinyl acetate	ethylene dichloride	vinyl chloride
batch	<3.2	200-400	2.5	5-10
semi-continuous	1.8	1200	5-7	>64

The effect of some chlorinated solvents on anaerobic digestion was studied by Vargas and Ahlert (1987). The microorganisms exhibited tolerance for 1,1-dichloroethane with no apparent inhibition up to 35 mg/L. Reactors dosed with 2 and 4 mg/L 1,1,1-trichloroethane recovered after 20 days of zero gas production, with acclimation taking 33 days (compared with a 10 week period reported in other studies). Gas production fell to 40% at about 4 mg/L dichloromethane, 25 mg/L 1,1-dichloroethane, and 1.5 mg/L 1,1,1-trichloroethane.

Kenealy and Zeikus (1981) found that a concentration of 40 liN4 (7 mg/L) of iodopropane reduced the rate of methanogenesis by about 30%.

Hovious et al (1973) developed a reproducible procedure using a Warburg respirometer to quantify the inhibitory effects of toxicants on unacclimated micro-organisms. The following chemicals inhibited anaerobic digestion, producing a 50% reduction in activity, in the range of concentrations mentioned:

20-50 mg/L acrolein	50-100 mg/L formaldehyde
50-100 mg/L crotonaldehyde	500-1000 mg/L 2-ethyl-l-hexanol
100-300 mg/L methyl isobutyl ketone	300-1000 mg/L diethylamine
100 mg/L acrylonitrile	100 mg/L 2-methyl-5-ethylpyridine
150-500 mg/L ethylene dichloride	300-600 mg/L ethyl acrylate
300-1000 mg/L phenol	

The authors noted that inhibition was more severe when the volatile acids content was greater than 500 mg/L. Introducing crotonaldehyde, ethyl acrylate and phenol at gradually increasing dose rates resulted in acclimation and increasing resistance; for example, activity continued up to almost 700 mg/L crotonaldehyde. No acclimation was observed for sodium acrylate. Formaldehyde, ethyl acrylate, phenol and acrylonitrile exhibited synergistic inhibition.

The toxicity and biodegradation of formaldehyde in anaerobic methanogenic cultures was studied by Qu and Bhattacharya (1997). They found a concentration of 10 mg/L showed severe toxicity to an acetate-enriched methanogenic culture in a batch reactor, which did not become acclimated to formaldehyde even after 226 days.

Neufeld et al (1980) found that phenol concentrations above 686 mg/L inhibited the anaerobic decomposition of coal conversion and coke plant effluents. Toxic levels of some other phenols have been reported (Fedorak and Hrudey 1984):

phenol	2000 mg/L	p-cresol	1000 mg/L
2,5-dimethylphenol	500 mg/L	3,4-dimethylphenol	500 mg/L
3,5-dimethylphenol	500 mg/L		

Inhibitory substances in coal conversion wastewater were studied by Fox et al (1988). Both o-cresol and m-cresol should be maintained below their threshold level of 50 mg/L; p-cresol, being more readily degradable, is not such a problem. Wang et al (1988) found ethyiphenols to be particularly toxic.

The toxicity in anaerobic processes of some phenols and other organic chemicals found in coal conversion wastewaters (CCWW) were reported by Blum et al (1986). Constituents that caused inhibition at their concentrations in CCWW were phenol, resorcinol, catechol, o-cresol, 2,3- xylenol, and 4-ethylpyridine. Concentrations that caused 50% inhibition of the conversion of acetate or propionate to methane were (in mg/L):

1500-3000	phenol	2000-4000	catechol
750-1500	p-cresol	5000-8000	pyridine
5000-6000	aniline	2000-2400	2-indanol
100-700	1-naphthol		

Using batch anaerobic toxicity assay and chemostats with 15 day solids retention time, HaghighiPodeh and Bhattacharya (1996) examined the toxicity effects of nitrophenols in anaerobic treatment. They found 4-nitrophenol and 2,4-nitrophenol to be more toxic than 2-nitrophenol and 3-nitrophenol. Up to 20 mg/L of 2-nitrophenol and 4-nitrophenol caused reversible inhibition to methanogenesis and 20 mg/L of 2,4-nitrophenol caused irreversible inhibition.

Lank and Wallace (1970) found concentrations of acrylonitrile up to 20 mg/L were not inhibitory in anaerobic digestion, disagreeing with earlier reports that 10 mg/L was toxic.

Inhibition of anaerobic treatment by terephthalic acid and its aromatic byproducts was studied by Fajardo et al (1997). They found 50% reduction of methanogenic activity at concentrations of 4630 mg/L p-toluic acid, 810 mg/L 4-carboxybenzaldehyde, and 17,000 mg/L terephthalic acid.

McBride and Wolfe (1971) found 0.4 mg/L DDT reduced methane production by 75%.

Guthrie et at (1984) found that an unacclimated methanogenic culture was inhibited by 0.2 mg/L pentachlorophenol (PCP); an acclimated culture could metabolise up to 5 mg/L. Mikesell and Boyd (1986) found that a municipal anaerobic sludge digester which had acclimated to monochlorophenols for 2 years successfully degraded PCP even when up to 66% of the carbon was added as PCP.

Khodadoust et al (1997) studied the anaerobic treatment of PCP; nearly all the PCP was converted to 3- and 4-chlorophenols, and 4-chlorophenol inhibited methanogenesis at a concentration of 116 mg/L.

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SECTION 5

REGULATIONS

5.1 INTRODUCTION

Various regulatory bodies around the world have or are establishing limits, guidelines, standards, etc that will control the disposal of sewage sludges into (or the reuse of biosolids in) the environment. Various studies are underway in New Zealand too. The New Zealand Water and Wastes Association is developing national guidelines for the beneficial reuse of biosolids, so data generated by this project will be able to be used in the process of developing those guidelines.

However, until our national guidelines become available, an indication of the type of regulations used overseas and some New Zealand practices may be helpful.

5.2 NSW, AUSTRALIA

The NSW Government established a Sewage Sludge Subcommittee of the Chemical Advisory Committee, chaired by the EPA. They produced a draft report in October 1995 "Environmental Management Guidelines for the Use and Disposal of Biosolids Products". Their draft guidelines also discuss microbiological quality, vector attraction and odour control etc; these matters are outside the scope of this report.

Their Table 3-1 follows (note that they also considered Acceptance Concentrations for dioxins (polychlorinated dibenzodioxins and polychlorinated dibenzofurans) but they omitted them from the table subject to a review of studies being undertaken in the US. Note also that any contaminant concentration which exceeds the Acceptance Concentration for Grade D shall be graded Contaminant Grade E).

Note: there are eight isomers in the lindane group. Lindane is known as gamma-BHC (γ-BHC) and gamma-HCH (γ -HCH), and is the most frequently analysed isomer. The commonest of the others are a-BHC, B-BHC and 6-BHC; once again, HCH can be used in place of BHC. Presumably, the reference to BHC in the above table implies the sum of the isomers other than lindane.

Contaminant mg/kg dry wt	Grade A	Grade B	Grade C	Grade D
	*Note: Contaminant Acceptance Concentrations are **not** mean values, refer to Schedule 2*			
arsenic	20	20	20	30
cadmium	3*	5	20	32
chromium (total)	100	250	500	600
copper	100	375	2000	2000
lead	150	150	420	500
mercury	1	4	15	19
nickel	60	125	270	300
selenium	5	8	50	90
zinc	200	700	2500	3500
aldrin	0.02	0.2	0.5	1.0
BHC	0.02	0.2	0.5	1.0
chlordane	0.02	0.2	0.5	1.0
DDT/DDD/DDE	0.5	0.5	1.0	1.0
dieldrin	0.02	0.2	0.5	1.0
heptachlor	0.02	0.2	0.5	1.0
hexachlorobenzene	0.02	0.2	0.5	1.0
lindane	0.02	0.2	0.5	1.0
PCBs	0.3	0.3	1.0	1.0

Their Table 3-1: Contaminant Acceptance Concentration Thresholds (NSW EPA, 1995)
* likely to become 1 mg/kg

Schedule 2 describes two sampling regimes: batch and continuous, and are designed so that no more than 10% of the product is passed that should not be passed, and is based on the number of tests, the mean value and the standard deviation, therefore the mean needs to have a lower value than the Acceptance Concentration.

Each contaminant is to be graded A to E and the product takes the Grade of the lowest (worst) contaminant. A superior Grade may be obtained by blending and retesting. Any untested product shall be Grade E.

The following table is a combination of the NSW Tables 4-5 and 4-13, and shows the maximum concentrations of contaminants allowed in two classes of soil after biosolids' application. A ssuming the cadmium level in Grade A does change as predicted (see previous table), then the following table is simply a reproduction of the Grade A and Grade B conditions respectively, which means that Grade A soil can be used undiluted on agricultural land.

Contaminant (mg/kg dry wt)	**Maximum Allowable Soil Contaminant Conc. in Agricultural Land**	**Maximum Allowable Soil Contaminant Conc. in Non-Agricultural Land**
arsenic	20	20
cadmium	1	5
chromium (total)	100	250
copper	100	375
lead	150	150
mercury	1	4
nickel	60	125
selenium	5	8
zinc	200	700
aldrin	0.02	0.2
BHC	0.02	0.2
chlordane	0.02	0.2
DDT/DDD/DDE	0.5	0.5
dieldrin	0.02	0.2
heptachlor (+ epoxide)	0.02	0.2
hexachlorobenzene	0.02	0.2
lindane	0.02	0.2
PCBs	0.3	0.3

Their Tables 4-5 and 4-13: Maximum Allowable Soil Contaminant Conc. in Agricultural Land and Non-Agricultural Land after Application of Biosolids

It is proposed that Grade E Biosolids is only suitable for landfill disposal and for surface land disposal within the boundaries of the wastewater treatment plant site.

Grade D can also be used for forestry, plus soil and site rehabilitation. Grade C may be used for agriculture.

It is proposed that Grade B biosolids can be used in public contact sites and for urban landscaping as well. Grade A can additionally be used in home lawns and gardens.

5.3 SOUTH AUSTRALIA

Guidelines were produced by the ARMCANZ/ANZECC/NIIMRC Sludge Management Guidelines South Australian Peer Review Committee in October 1996: "South Australian Biosolids Guidelines for the Safe Handling, Reuse or Disposal of Biosolids". A draft version had been produced in October 1995: "Guidelines for the Use of Biosolids Produced from Wastewater Treatment Plants for Populations Greater than 1000 and for Smaller Plants that Receive Industrial Wastes".

Their Table A3 lists the maximum levels of metals allowed in soils. The significance of chromium is being monitored; in the future, maximum concentrations may be specified for chromium VI:

Contaminant mg/kg	Soils Used for Food Production	Non-Food Production Soils
arsenic	20	27
cadmium	3 (1)	11
copper	200 (125)	750
lead	200 (150)	300
mercury	1 (0.5)	9
nickel	60 (50)	145
zinc	250 (200)	1400

Their Table A3: Maximum permissible concentration of contaminants in soils - Note: the numbers in brackets, and the non-food column, were in the 1995 draft version.

Their Table A4 then defined the limits for contaminants in sewage sludge (biosolids):

Contaminant mg/kg	Grade A	Grade B	Grade C
arsenic	20	20 (27)	>20 (>27)
cadmium	3 (1)	11	>11
copper	200 (125)	750	>750
lead	200 (150)	300	>300
mercury	1 (0.5)	9	>9
nickel	60 (50)	145	>145
zinc	250 (200)	1400	>1400

Their Table A4: Upper limit of metal (total) concentrations for contaminant classification of biosolids. Note: the numbers in brackets were in the 1995 draft version.

Like the NSW draft guidelines, the South Australian version also recommended which grades were suitable for a range of disposal practices. They also limit the amount of heavy metals which can be applied annually to soils.

5.4 ARMCANZ

The Water Technology Committee of the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) produced "Guidelines for Sewerage Systems: Biosolids Management", Occasional Paper WTC 1/95, 1995. It was intended as a discussion and information paper. They established three grades of biosolids based on chemical contaminants. Grade C biosolids are only suitable for disposal at landfills, Grade B is suitable for disposal as landscape enhancement material and for addition to soil used for food production, forestry and rehabilitation; Grade A biosolids have unrestricted application. Their Table 3 lists the minimum levels for biosolids:

Contaminant mg/kg	Grade A	Grade B	Grade C
arsenic	20	75	any one or more contaminants with concentration levels exceeding Grade B; or untested product
cadmium	3	85	
chromium	400	3000	
copper	200	4300	
lead	200	840	
mercury	1	57	
molybdenum	4	75	
nickel	60	420	
selenium	3	100	
zinc	250	7500	
aldrin	0.2	2	
chlordane	0.2	2	
dieldrin	0.2	2	
DDT/DDD/DDE	1.0 (total)	5 (total)	
heptachlor	0.2	2	
hexachlorobenzene	0.2	2	
lindane	0.2	2	
PCBs	1.0 (total)	3.0 (total)	

Their Table 3: Biosolids classification according to chemical contaminant levels

5.5 EUROPE

(a) EC Directive 86/278/EEC specifies the upper limit for a range of grades of sewage sludge, as follows; Sweden has established its own Directive:

Contaminant mg/kg dry weight	EC Directive 86/278/EEC (best grade)	Swedish Directive SNFS 1994:2
cadmium	20	2
chromium	-	100
copper	1000	600
lead	1000	100
mercury	16	2.5
nickel	300	50
zinc	2500	800

Table 5.1: EC Directive 86/278/EEC upper limit for a range of grades of sewage sludge

(b) In July 1992 a limit of 100 ng/kg (pg/g) TEQ dry matter was established in Germany for PCDDs plus PCDFs (`dioxins') in sludges used in agriculture, set in conjunction with a sludge application rate limit of 5 tonnes of sludge (dry weight) per hectare over a three year period. Refer to Section B of this report for information on TEQs. Reported in "Dioxins and Furans in Sewage Sludges", a 1996 report by the Foundation for Water Research commissioned by the Dept of the Environment in the UK.

5.6 USA AND CANADA

The quality and therefore the practices available for biosolids disposal in the USA are governed by the EPA 503 Regulations. Sewage sludge or biosolids is considered to have 'exceptional quality' if it satisfies the following requirements (some New York compost standards are included for comparison):

Contaminant mg/kg dry weight	EPA 503 Exceptional Quality	DEC 360 *[1] Class I Compost
arsenic	41	-
cadmium	39	10
chromium	- *[2]	1000
copper	1500	1000
lead	300	250
mercury	17	10
molybdenum	18	-
nickel	420	200
selenium	100 *[3]	-
zinc	2800	2500

Table 5.2: 'Exceptional quality' biosolids (EPA 503 Regulations
*[1] DEC is the New York Department of Environmental Conservation
*[2] previously 1200, but removed because shown not to be risk-based
*[3] was 36, but based on risk assessment, increased to 100

Dioxins

A maximum permissible level of 150 pg/g I-TEQ (0.15 mg/kg) was suggested for use in Ontario agriculture by MD Webber and JA Nichols in "Organic and Metal Contaminants in Canadian Municipal Sludges and a Sludge Compost", Wastewater Technology Centre, 1995.

5.7 NEW ZEALAND

In 1992 the Department of Health produced "Public Health Guidelines for the Safe Use of Sewage Effluent and Sewage Sludge on Land". The Guidelines include the maximum acceptable concentrations of some metals in both sludge and in soil after sludge has been mixed into the soil. The Guidelines also discuss application rates and cumulative loading rates. The maximum acceptable concentrations of the metals appear in the following table:

Contaminant mg/kg dry weight	Limit in Soil	Limit in Sludge
arsenic	10	15
cadmium	3	15
chromium	600	1000
copper	140	1000
lead	300	600
mercury	1	10
nickel	35	200
zinc	300	2000

Table 5.3: Department of Health Guidelines, 1992

There are no New Zealand guidelines or standards etc yet relating to the organic chemicals in biosolids. The closest we have had so far are the proposed conditions relating to the Wellington Regional Council resource consent for the Living Earth Joint Venture Company Ltd (LEJV) application to market the biosolids that they wish to process from raw sludge co-composted with greenwaste. The resource consent outcome is still under appeal. Condition 12 for Discharge Permit WGN 970210 states inter alia that 95% of the samples of biosolids compost supplied for distribution from the co-composting plant under the permit shall meet the following standards (only the non-biological contaminants have been included in this table):

Determinand	Units (dry weight)	Standard
arsenic	mg/kg	20
cadmium	mg/kg	3
chromium	mg/kg	400
copper	mg/kg	270
lead	mg/kg	200
mercury	mg/kg	1
nickel	mg/kg	60
zinc	mg/kg	575
aldrin	mg/kg	0.02
chlordane	mg/kg	0.02
DDT/DDD/DDE	mg/kg	0.5
dieldrin	mg/kg	0.02
heptachlor	mg/kg	0.02
hexachlorobenzene	mg/kg	0.02
lindane	mg/kg	0.02
PCB (total as Aroclor 1242)	mg/kg	0.30
dioxins (PCDD/PCDF)	µg/kg TEQ* or as pg/g TEQ	0.05 50

Table 5.4: Some proposed resource consent conditions for the LEJV compost application
* half the limit of detection (LOD) values are to be included in the calculation when the determinand is less than the LOD.

Note that picograms per gram (pg/g) are equivalent to nanograms per kilogram (ng/kg), micrograms per tonne (µg/t) or ppt (w/w) (where t = trillion) on a dry weight basis. TEQs are toxic equivalents.

Apart from the inclusion of dioxins, the standards for organic chemicals in the above table have the same numerical value as those in the NSW Table 3-1.

5.8 SUMMARY

The concentration limits for contaminants in the 'best grade' of biosolids in different countries are summarised in Table 5.5. Refer to the previous six sub-sections when using this table because some conditional remarks are relevant.

Contaminant mg/kg dry wt	**NSW**	**Sth Aust**	**ARM-CANZ**	**EEC**	**Germany**	**Sweden**	**EPA 503**	**DoH**	**LEJV**
arsenic	20	20	20	-	-	-	41	15	20
cadmium	3	3	3	200	-	2	39	15	3
chromium	100	200	400	-	-	100	-	1000	400
copper	100	200	200	1000	-	600	1500	1000	270
lead	150	200	200	1000	-	100	300	600	200
mercury	1	1	1	16	-	2.5	17	10	1
molybdenum	-	-	4	-	-	-	18	-	-
nickel	60	60	60	300	-	50	420	200	60
selenium	5	-	3	-	-	-	100	-	-
zinc	200	250	250	2500	-	800	2800	2000	575
aldrin	0.02	-	0.2	-	-	-	-	-	0.02
BHC	0.02	-	-	-	-	-	-	-	-
chlordane	0.02	-	0.2	-	-	-	-	-	0.02
DDT etc, total	0.5	-	1.0	-	-	-	-	-	0.5
dieldrin	0.02	-	0.2	-	-	-	-	-	0.02
heptachlor	0.02	-	0.2	-	-	-	-	-	0.02
HCB *[1]	0.02	-	0.2	-	-	-	-	-	0.02
lindane	0.02	-	0.2	-	-	-	-	-	0.02
PCBs (total)	0.3	-	1.0	-	-	-	-	-	0.3
dioxins *[2]*[3]	-	-	-	-	0.10	-	0.15*[3]	-	0.05

Table 5.5: Summary of the concentration limits for contaminants in the 'best grade' of biosolids in some different countries
*[1] HCB is hexachlorobenzene
*[2] µg/kg TEQ (multiply by 1000 to get ng/kg or pg/g)
*[3] A maximum permissible level of 150 pg/g I-TEQ (0.15 mg/kg) was suggested for use in Ontario agriculture by TE Webber and Nichols in "Organic and Metal Contaminants in Canadian Municipal Sludges and a Sludge Compost", Wastewater Technology Centre, 1995.

SECTION 6

PREVIOUS ANALYSES OF NEW ZEALAND SEWAGE SLUDGES

6.1 INFORMATION SOURCES

All potential participants were asked to consider submitting copies of previous analyses of sludge samples for inclusion in the project report. The following were received.

Information was provided by:

1. G.P. Essenberg, Manager Engineering and Design Services, Selwyn District Council. This information was taken from a report Leeston Oxidation Pond: Sludge Assessment, written by Woodward-Clyde (NZ) Ltd, Christchurch, 20 January 1998. The samples were analysed by Hill Laboratories Ltd in Hamilton. The samples were collected 11.7.97 from 6 locations within the pond and analysed individually. Total metals were measured by ICP-MS (after acid digest), and are reported as mg/kg dry weight (methods stated for all analyses).

2. M.P. Bourke, Liquid Waste Manager, Christchurch City Council. This information was taken from a report written by Woodward-Clyde (NZ) Ltd, Auckland, 16 May 1996. Two samples were analysed: a sludge lagoon sample on 12.4.96, and a sample from the sludge stockpile which was probably about 5 years old. The analyst and methods were not stated in the information provided.

3. B. Turner, Waste Control Engineer, Dunedin City Council. The raw sludge at the Tahuna water pollution control plant was tested in December 97 and April 98 by Hill Laboratories Ltd. The methods were not stated in the information provided.

4. M. Rhodes, Manukau City Council. Sludge from the Beachlands-Maraetai lagoons 2-4 were tested by Grayson Laboratories Ltd on dried portions which contained no particles >2 mm. The methods and date were not stated in the information provided.

5. M. Rickard, Engineering Services Manager, Rodney District Council. Results of tests on a sample of sludge from the Whangaparaoa wastewater treatment plant were supplied (the analyst and methods were not stated in the information provided).

6. G. Jelley, Western Bay of Plenty District Council provided analytical results of a sample of sludge from Te Puke wastewater treatment plant in August 1996. The analyses were conducted by Hill Laboratories Ltd using APHA, AWWA WEF Standard Methods. Hill Laboratories used ICP-MS after acid digest.

7. C Jackman, Wastes Manager, Manawatu District Council. The sample was collected from the Feilding digested sludge consolidation tank in September 1996. The analyses were conducted by Hill Laboratories Ltd using APHA, AWWA WEF Standard Methods. Hill Laboratories used ICP-MS after acid digest.

8. W.H.L. Edgerley, then of Wellington City Council Citilab (now Environmental Laboratory Services Ltd, Lower Hutt) who authored a report Heavy Metal Concentrations in Wellington Sewage, in 1997. This report which was submitted by N Matthews of the Carson Group, includes test results of the raw sludge at the Karori Western Treatment Plant which uses the Anglian Kaldnes process. The samples included here were collected daily from 23 September - 4 October 1997. Total metals were analysed using ICP-MS.

9. Peter Arnott, Treatment Plant Manager, Invercargill City Council. The five airdried sludge lagoon samples had been collected in April 1993 and on another occasion, and were analysed by Southern Chemical Consultants Ltd. The analytical methods were not described.

10. Steve Singleton, Manager, Wastewater Treatment Plant, North Shore City Council. Samples were collected in March 1996 from anaerobic digester number 1 after it had failed. The analysis was conducted by RJ Hill Laboratories Ltd, methods were described. The purpose of this analysis was to identify any determinands that were present in unusually high concentrations, so low detection limits were not sought.

11. Ian Basire, Wastewater Treatment Manager, Kapiti Coast District Council. A sample of centrifuged sludge from Paraparaumu was tested semi-quantitatively in August 1994 by Spectrachem Analytical Ltd using X-ray fluorescence. Results were reported as percent dry solids, and the sum of the individual components = 100%.

12. Andy Bainbridge, Manager, Rotorua District Council Wastewater Treatment Plant. Samples of various sludges, compost and compost components tested 1989-95. The analytical methods were not described but are available from RDC - most of the samples were tested in a laboratory other than RDC.

13. Graham Morris, Trade Waste Officer, New Plymouth District Council. Composite samples of biological sludge after pressing, from the New Plymouth extended aeration plant; samples were collected on 2 December 1997 and 17 August 1998 and were tested for dioxins by the ESR in Wellington using the same method employed for this project.

14. Roger Lane of Wellington City Council and David Perkins of Waste Management NZ Ltd provided analytical results of several samples of Moa Point dewatered sludge collected during Aug/Sep 1998 for metals analysis, organochlorine pesticides, PCBs, and dioxins. The testing was conducted by Wellington Pathology Ltd, ESR and RJ Hill Laboratories Ltd.

6.2 METALS

Table 6.1: Some earlier analyses of metals in sludges.

Metal (dry weight)	**Leeston Pond Sediment**		**Christchurch 1996**		**Dunedin Raw**	**Manukau Lagoons**	**Whanga - paraoa**	**Rotorua**
(mg/kg)	**range**	**mean**	**lagoon**	**dry**	**range**	**range**		**range**
aluminium	-	-	6090	6350	-	-	-	2880-10000
antimony	-	-	5.7	5.8	-	-	-	-
arsenic	14-42	23.8	66	19	-	-	1.1	5-28
barium	-	-		-	-	-	-	-
beryllium	-	-	0.31	0.36	-	-	-	-
bismuth	-	-	-	-	-	-	-	-
boron	-	-	51	53	-	-	-	10-62
cadmium	2.3-3.7	2.9	5.4	5.1	1.2-1.9	0.5-1.1	16	1.0-4.0
calcium	-	-	46000	49000	-	-	-	3750-6530
chromium	36.8-47.5	43.9	1290	1110	82.0-93.9	21-28	-	37-682
cobalt	-	-	9.9	10.5	-	-	-	2.8-5.3
copper	217-351	277	367	371	253-367	180-340	-	150-484
iron	-	-	10900	11200	-	-	-	2440-4140
lead	136-278	188	226	242	181-235	27-44	22	9-192
lithium	-	-	8.0	9.4	-	-	-	-
magnesium	-	-	2630	2270	-	. -	-	740-10900
manganese	-	-	307	305	-	-	-	32-90
mercury	3.9-6.2	5.3	2.9	3.6	-	<0.5-0.9	2.7	1.3-4.8
molybdenum	-	-	8.9	12.7	-	-	-	0.7-7.3
nickel	23.0-31.5	26.3	96.3	86.4	27.0-30.5	7.4-13.0	-	5.4-23
potassium	-	-	1420	1020	-	-	-	670-14470
rubidium	-	-	-	-	-	-	-	-
selenium	-	-	<2	<2	-	-	-	1.1-3.3
silver	-	-	36.3	38.9	-	-	-	0.7-2.8
sodium	-	-	1140	486	-	-	-	272-856
strontium	-	-	-	-	-	-	-	15-40
tin	-	-	74.6	80.0	-	-	-	28.5-40.5
titanium	-	-			-	-	-	-
thallium	-	-	0.09	0.09	-	-	-	-
tungsten		-	-	-	-	-	-	-
vanadium	-	-	<10	12	-	-	-	-
zinc	820-1260	1000	1470	1490	534-776	720-1340	770	390-810
zirconium	-	-	-	-	-	-	-	-

Table 6.1 cont'd : Some earlier analyses of metals in sludges

Metal (dry weight)	**Te Puke**	**Fending**	**Wgtn West**	**Invercargill 5 samples**	**North Shore**	**Parapara -umu**	**Moa Point**	**Max**	**Min**
(mg/kg)		**digested**		**airdried ex lagoon**	**digester**	**(see note)**	**Act Sig Dewat.**		
aluminium	4030	17350	-	16000-18000	2960	4960		18,000	4,030
antimony	0.7	-	-	-	1	<10		5.8	0.7
arsenic	-	-	3.6	24-87	4.3	20	2.3-2.8	87	1.1
barium	-	-	-	-	-	180		180	-
beryllium	-	-	-	-	-	-		0.36	0.31
bismuth	-	-	-	-	-	10		10	-
boron	-	21.5	-	-	-	<1000		62	21
cadmium	-	1.8	1.0	<1	1.3	<10	2	16	0.5
calcium	-	-	-	11000-33000	-	10720		49,000	3,750
chromium	-	37	14.7	94-144	70	20	40-197	1,290	14.7
cobalt	1.1	6.9	1.6	<1-3	4	<10		10.5	<1
copper	-	147	285	141-277	308	190	216-380	484	150
iron	-	16300	4392	11200-13000	2400	3990		16,300	2,400
lead	-	45	43	140-335	106	70	37-50	335	22
lithium	-	-	-	-	1	-		9.4	1
magnesium	-	-	-	3600-4100	-	6050		10,900	740
manganese	-	605	65	151-480	95	90		605	32
mercury	-	-	-	<2-6	-	<10	1.4-4.4	6.2	<0.5
molybdenum	-	-	-	<0.1-0.8	3	<10		12.7	<0.1
nickel	-	17	8.9	17-64	73	20	5-18	96.3	5
potassium	-	-	-	5000-6600	-	11090		14,470	670
rubidium	-	-	-	-	-	10		10	-
selenium	-	-	-	-	-	<10		3.3	1.1
silver	-	-	-	-	-	<10		38.9	0.7
sodium	-	-	-	4000-7500	-	1230		7,500	272
strontium	-	-	-	-	-	50		50	15
tin	42.5	-	-	-	3.3	<10		80	3.3
titanium	-	-	-	2900	-	1220		2,900	1,220
thallium	-	-	-	-	-	<10		0.09	-
tungsten	-	-	-	-	-	30		30	-
vanadium	-	-	-		3	<10		12	3
zinc	-	785	465	540-1470	740	510	261-365	1,490	261
zirconium	-	-	-	-	-	20		20	-

Note: 5.5% (55,000 mg/kg) of the sample comprised hydrogen, helium, lithium and beryllium. All <10 mg/kg were: scandium, gallium, germanium, yttrium, niobium, rhodium, indium, tellurium, caesium, lanthanum, cerium, neodymium, samarium, godolinium, dysprosium, hafnium, tantalum, platinum, gold, thorium, uranium.

6.3 SUNDRY SUBSTANCES / TESTS IN SLUDGES

Table 6.2: Some earlier analyses of sundry substances/tests in sludges

Analysis	**Leeston Pond Sediment**		**Christchurch 1996**		**Dunedin Raw**	**Manukau Lagoons**	**Whanga -paraoa**	**Te Puke**	**Feilding**	**Invercargill ex lagoons**	**Paraparaumu see note**	**Rotorua**
expressed as dry matter	**range**	**mean**	**lagoon**	**dry**	**range**	**range**			**digested**	**airdried**	**centrifuges**	**range**
bulk density g/mL	0.33-0.8	0.6	0.38	0.42	-	-	-	-	-	-	-	-
cation exchange capacity *[1]	-	-	61	56	-	-	-	-	-	-	-	-
organic matter as %	7-57	35.7	60.5	58.5	-	20-29	80	-	-	48-55	-	-
organic carbon as %C	-	-	35.2	34.0	-	-	42	-	-	-	40.1*[2]	-
tot. kjeldahl nitrogen at %N	0.48-3.04	2.05	2.7	1.9	-	0.95-1.5	3.23	-	10	1.4-1.8	-	2.3
ammonia as mg/kg N	65-116	88	4900	3800	119-200	-	-	-	15900	-	-	-
nitrate as mg/kg N	<5	<5	20	194	-	-	-	-	2.5	-	-	-
nitrite as mg/kg N	-	-	23	6.6	-	-	-	-	-	-	-	-
total phosphorus as %P	0.08-0.39	0.25	1.11	1.34	0.36	0.24-0.36	-	1.16	2.22	0.4-1.1	2.06	0.15-1.04
bromide as mg/kg Br	-	-	-	-	-	-	-	-	-	-	10	-
chloride as mg/kg Cl	-	-	1090	132	-	-	-	-	-	300-1200	530	-
fluoride as mg/kg F	-	-	-	-	-	-	-	-	-	-	<1000	54-190
iodide as mg/kg I	-	-	-	-	-	-	-	-	-	-	<10	-
silica as % SiO_2	-	-	-	-	-	-	-	-	-	11-29	5	0.05
sulphate as mg/kg SO_4	-	-	1170	1700	-	-	-	-	1300	-	-	-
total sulphur as %S	-	-	-	-	-	-	-	0.58	-	0.45-0.8	0.78	0.41-0.88
total cyanide as mg/kg CN	-	-	1.0	5.2	-	-	-	-	-	-	-	-

*[1] units for cation exchange capacity (CEC) are milliequivalnets per 100g

*[2] total carbon

Note: Paraparaumu results are semi-quantitative, by x-ray fluorescence

6.4 COMPOST

Rotorua District Council provided some analytical data from samples of compost and the compost components that were tested in 1995/96. The following table shows the composition of the three components at the time: raw sludge, sawdust and greenwaste; compost is made by mixing approximately equal portions of the three. The table also shows the range of test results obtained from seven samples of compost tested 1995/97.

Table 6.3: Analysis of compost and its components, Rotorua

Determinand	Raw Sludge	Sawdust	Greenwaste	Compost
pH	-	-	-	7.2
% dry matter	2.7	49	35	46
% volatile solids	85	99	75	59
TKN	23,000	1000	7000	10,000-18,000
total phosphorus	3100	100	2300	5500-9600
total sulfur	4100	240	1300	1000-2700
C:N ratio	19	497	54	-
arsenic	9.7	4.9	18.4	7-42
boron	11	6.5	12	<5-26
cadmium	1.2	0.04	0.26	0.42-0.83
calcium	-	-	-	5300-7500
chromium	37	11	90	19-138
cobalt	5.3	<0.1	1.9	2.0-3.0
copper	150	8.6	74	76-220
lead	32	<0.2	14	16-33
magnesium	-	-	-	2300-2600
mercury	1.78	0.04	0.22	0.40-0.72
molybdenum	2.6	<0.1	0.78	1.4-2.2
nickel	10.5	0.8	22	5.6-13
potassium	670	550	3300	3000-6000
selenium	1.4	<0.5	<0.5	<1 - <2
tin	-	-	-	7.3-17
zinc	390	10	120	180-270

6.5 ORGANICS

6.5.1 Halogenated Hydrocarbons

Table 6.4: Halogenated Hydrocarbons

Chemical mg/kg dry weight	**Feilding**	**Christchurch**	**North Shore**
SVOC			
bis(2-chloroethoxy)methane	<0.5	<0.1	<6
bis(2-chloroethyl)ether	<0.5	<0.1	<6
bis(2-chloroisopropyl)ether	<0.5	<0.1	<6
4-chlorophenylphenylether	<0.5	<0,1	<6
hexachlorobutadiene	<0.05	<0.001	<0.16
hexachlorocyclopentadiene	<0.5	<0.1	<6
hexachloroethane	<0.5	<0.1	<6
VOC			
bromoform	<0.05	<0.001	<0.16
bromomethane	<0.05	<0.001	<0.16
carbon tetrachloride	<0.05	<0.001	<0.16
chlorodibromomethane	<0.05	<0.001	<0.16
chloroethane	<0.05	<0.001	<0.16
chloroform	<0.05	<0.001	<0.16
chloromethane	<0.05	<0.001	<0.16
1,2-dibromo-3-chloropropane	<0.05	<0.001	<0.16
1,2-dibromoethane	<0.05	<0.001	<0.16
dibromomethane	<0.05	<0.001	<0.16
dichlorobromomethane	<0.05	<0.001	<0.16
dichlorodifluoromethane	<0.05	<0.001	<0.16
1,1-dichloroethane	<0.05	<0.001	<0.16
1,2-dichloroethane	<0.05	<0.001	<0.16
1,1-dichloroethene	<0.05	<0.001	<0.16
1,2-dichloroethene (cis + trans)	<0.05	**0.15**	<0.16
dichloromethane	<0.25	**0.12**	<1
1,2-dichloropropane	<0.05	<0.001	<0.16
1,3-dichloropropane	<0.05	<0.001	<0.16
2,2-dichloropropane	<0.05	<0.001	<0.16
1,1-dichloropropene	<0.05	<0.001	<0.16
1,3-dichloropropene (cis + trans)	<0.05	<0.001	<0.16
tetrachloroethylene	<0.05	0.06	0.2
1,1,2,2-tetrachloroethane	<0.05	<0.001	<0.16
1,1,1,2-tetrachloroethane	<0.05	<0.001	<0.16
1,1,1-trichloroethane	<0.05	<0.001	<0.16
1,1,2-trichloroethane	<0.05	<0.001	<0.16
trichloroethylene	<0.05	**0.018**	<0.16
trichlorofluoromethane	<0.05	<0.001	<0.16
1,2,3-trichloropropane	<0.05	<0.001	<0.16
trichlorotrifluoroethane (freon 112)			
vinyl chloride	**0.1**	<0.001	<0.16

6.5.2 Halogenated Aromatics

Table 6.5: Halogenated Aromatics

Chemical mg/kg dry weight	Feilding	Christchurch	North Shore
VOC			
bromobenzene	<0.05	<0.001	<0.16
chlorobenzene	<0.05	<0.001	<0.16
2-chlorotoluene	<0.05	<0.001	<0.16
4-chlorotoluene	<0.05	<0.001	<0.16
1,2-dichlorobenzene	<0.05	**0.05**	<0.16
1,3-dichlorobenzene	<0.05	<0.001	<0.16
1,4-dichlorobenzene	**0.9**	**0.55**	**0.5**
1,2,3-trichlorobenzene	<0.05	<0.001	<0.16
1,2,4-trichlorobenzene	<0.5	<0.001	<0.16
SVOC			
4-bromophenylphenylether			
1,2-dichlorobenzene	<0.5	<0.1	<6
1,3-dichlorobenzene	<0.5	<0.1	<6
1,4-dichlorobenzene	<0.5	<0.1	<6
hexachlorobenzene	<0.5	<0.1	<6

6.5.3 Aromatics

Table 6.6: Aromatics

Chemical mg/kg dry weight	Feilding	Christchurch	North Shore
SVOC			
aniline	<0.5	<0.1	<6
benzyl alcohol	<0.5	<0.1	<6
nitrobenzene	<0.5	<0.1	<6
2,4-dinitrotoluene	<0.5	<0.1	<6
2,6-dinitrotoluene	<0.5	<0.1	<6
VOC			
benzene	<0.05	<0.001	<0.16
n-butylbenzene	<0.05	**0.53**	**0.4**
sec-butylbenzene	<0.05	**0.23**	**0.2**
tert-butylbenzene	<0.05	<0.001	<0.16
1,2-dimethylbenzene (o-xylene)	<0.05	**0.43**	**0.53**
1,3-dimethylbenzene (m-xylene) + 1,4-dimethylbenzene (p-xylene)	**0.2**	**0.59**	**0.33**
1,2-diethylbenzene			
1,3-diethylbenzene			
1,4-diethylbenzene			
ethylbenzene	**0.05**	**0.22**	**0.27**
2-ethyltoluene			
3- & 4-ethyltoluene			
isopropylbenzene (cumene)	<0.05	**0.14**	<0.16
n-propylbenzene	<0.05	**0.59**	**0.37**
4-isopropyltoluene	**4.4**	**1.2**	**16.3**
toluene	**2**	**0.27**	**0.5**
1,2,4-trimethylbenzene	**0.35**	**4.47**	**2.7**
1,3,5-trimethylbenzene	**0.1**	**1.53**	**1.0**

6.5.4 Phthalates/Plasticisers

Table 6.7: Phthalates/Plasticisers (all SVOC)

Chemical mg/kg dry weight	**Feilding**	**Christchurch**	**North Shore**
bis(2-ethylhexyl)phthalate	<1.0	**16**	<13
butylbenzylphthalate	<1.0	<0.2	<13
di-(2-ethylhexyl)adipate	<0.5		<6
diethylphthalate	<1.0	<0.2	<13
dimethylphthalate	<1.0	<0.2	<13
di-n-butylphthalate	<1.0	<0.2	<13
di-n-octylphthalate	<1.0	<0.2	<13

6.5.5 Polyaromatic Hydrocarbons

Table 6.8: Pol aromatic Hydrocarbons (all SVOC)

Chemical mg/kg dry weight	**Feilding**	**Christchurch**	**North Shore**
'The usual 16'			
acenaphthene	<0.1	<0.02	<1.3
acenaphthylene	<0.1	<0.02	<1.3
anthracene	<0.1	<0.02	<1.3
benzo[a]anthracene	<0.1	<0.02	<1.3
benzo[a]pyrene	<0.1	<0.02	<1.3
benzo[b]fluoranthene	<0.1	**0.03**	<1.3
benzo[g,h,i]perylene	<0.1	<0.02	<1.3
benzo[k]fluoranthene	<0.1	<0.02	<1.3
chrysene	<0.1	**0.02**	<1.3
dibenzo[a,h]anthracene	<0.1	<0.02	<1.3
fluoranthene	<0.1	**0.04**	<1.3
fluorene	<0.1	<0.02	<1.3
indeno[1,2,3-c,d]pyrene	<0.1	<0.02	<1.3
naphthalene	**0.2**	**1.73**	**0.17**
phenanthrene	<0.1	**0.3**	<1.3
pyrene	<0.1	**0.11**	<1.3
+ some 'fairly common' PAHs:			
carbazole (dibenzopyrrole)	<0.5	<0.1	<6
2-chloronaphthalene	<0.1	<0.02	<1.3
1-methylnaphthalene			
2-methylnaphthalene	<0.1	**0.7**	<1.3

6.5.6 Halogenated and Some Other Phenols

Table 6.9: Halogenated and Some Other Phenols (all SVOC)

Chemical **mg/kg dry weight**	**Feilding**	**Christchurch**	**North Shore**
o-cresol (2-methylphenol)	<0.5	<0.1	<6
m-cresol (3-methylphenol)	<0.5		
p-cresol (4-methylphenol)	<0.5	<0.1	**380**
phenol	<0.5	<0.1	<6
2-chlorophenol	<0.5	<0.1	<6
2,4-dichlorophenol	<0.5	<0.1	<6
2-nitrophenol	<0.5	<0.1	<6
p-chloro-m-cresol	<0.5	<0.1	<6
2,4-dimethylphenol	<0.5	<0.1	<6
pentachlorophenol			
2,4,5-trichlorophenol	<0.5	<0.1	<6
2,4,6-trichlorophenol	<0.5	<0.1	<6

6.5.7 Other Organics

Table 6.10: Some Other Organics

Chemical **mg/kg dry weight**	**Feilding**	**Christchurch**	**North Shore**
VOC			
2-butanone (MEK)			
carbon disulphide	<0.25	**0.08**	<1
methyl-t-butylether (MTBE)			
4-methylpentan-2-one (MIBK)			
styrene	<0.05	<0.001	<0.16
cyclohexane			
hexane			
nonane			
octane			
SVOC			
dibenzofuran	<0.5	<0.1	<6
3,3'-dichlorobenzidine	<0.5	<0.1	<6
isophorone	<0.5	<0.1	<6
N-nitrosodi-n-propylamine	<0.5	<0.1	<6
N-nitrosodiphenylamine	<0.5	<0.1	<6

6.5.8 Organochlorine Pesticides

Table 6.11: Organochlorine Pesticides (all SVOC)

Chemical mg/kg dry weight	**Christchurch**	**North Shore**	**Moa Point 18.8.98**	**Moa Point 1.9.98**
aldrin + isodrin	<0.01	<6	<0.008	<0.01
alpha-BHC	<0.01	<6	<0.008	<0.01
beta-BHC	<0.01	<6	<0.008	<0.01
gamma-BHC (lindane)	<0.01	<6	<0.008	<0.01
delta-BHC	<0.01	<6	<0.008	<0.01
chlordanes (oc + 13)	<0.02		<0.04	<0.05
DDT + isomers	<0.01	<6	<0.016	<0.02
DDE + isomers	**0.02**	<6	**0.02**	**0.02**
DDD + isomers	<0.01	<6	<0.016	<0.02
dieldrin	<0.01	<6	**0.05**	**0.04**
oc-endosulfan	<0.01	<6	<0.014	<0.01
p-endosulfan	<0.01	<6	<0.008	<0.01
endosulfan sulfate	<0.02	<6	<0.008	<0.01
endrin	<0.01	<6	<0.008	<0.01
endrin aldehyde	<0.03	<6	<0.008	<0.01
heptachlor	<0.01	<6	<0.008	<0.01
heptachlor epoxide	<0.01	<6	<0.008	<0.01
hexachlorobenzene			<0.008	<0.05
methoxychlor	<0.01		<0.008	<0.01

6.5.9 Polychlorinated Biphenyls (PCBs)

Table 6.12: Polychlorinated Biphenyls (PCBs)

Chemical mg/kg dry weight	Christchurch	Moa Point 18.9.98	Moa Point 1.9.98
PCB-28 (Tri)	<0.002	<0.008*	<0.01*
PCB-31 (Tri)	<0.002	*	
PCB-52 (Tetra)	<0.002	<0.008	<0.01
PCB-49 (Tetra)	<0.002	<0.008	<0.01
PCB-44 (Tetra)	<0.002	<0.008	<0.01
PCB-121 (Penta)	<0.002	<0.008	<0.01
PCB-60 (Tetra)	<0.002	<0.008	<0.01
PCB-101 (Penta)	<0.002	<0.008	<0.01
PCB-86 (Penta)	<0.002	<0.008	<0.01
PCB-81 (Tetra)	<0.002	<0.008	<0.01
PCB-77 (Tetra)	<0.002	<0.008	<0.01
PCB-110 (Penta)	<0.002	<0.008	<0.01
PCB-151 (Hexa)	<0.002	<0.008	<0.01
PCB-123 (Penta)	<0.002	<0.008	<0.01
PCB-149 (Hexa)	<0.002	<0.008	<0.01
PCB-118 (Penta)	<0.002	<0.008	<0.01
PCB-114 (Penta)	<0.002	<0.008	<0.01
PCB-153 (Hexa)	<0.002	<0.008	<0.01
PCB-105 (Penta)	<0.002	<0.008	<0.01
PCB-141 (Hexa)	<0.002	<0.008	<0.01
PCB-138 (Hexa)	<0.002	<0.008	<0.01
PCB-126 (Penta)	<0.002	<0.008	<0.01
PCB-159 (Penta)	<0.002	<0.008	<0.01
PCB-128 (Hexa)	<0.002	<0.008	<0.01
PCB-167 (Hexa)	<0.002	<0.008	<0.01
PCB-156 (Hexa)	<0.002	<0.008	<0.01
PCB-157 (Hexa)	<0.002	<0.008	<0.01
PCB-180 (Hepta)	<0.002	<0.008	<0.01
PCB-169 (Hexa)	<0.003	<0.008	<0.01
PCB-170 (Hepta)	<0.002	<0.008	<0.01
PCB-189 (Hepta)	<0.003	<0.008	<0.01
PCB-194 (Octa)	<0.002	<0.008	<0.01
PCB-206 (Nona)	<0.004	<0.008	<0.01
PCB-209 (Deca)	<0.004	<0.008	<0.01

* result is for PCB-28 + PCB-31

6.5.10 Dioxin Congeners

Table 6.13: Dioxin Congeners (note pg/g = mg/kg x 10^{-6} or mg/1000 tonnes)

Chemical pg/g dry weight		**Christchurch Sludge Lagoon 12.4.96**	**New Plymouth ex Belt Press 2.12.97**	**New Plymouth ex Belt Press 17.8.98**	**Moa Point 18.8.98**	**Moa Point 1.9.98**
	TE factor					
2378 TCDF	0.1	<3	1.09	1.25	1.23	1.41
Non 2378 TCDF	0	11	11.9	17.5	12.4	20.5
2378 TCDD	**1.0**	<1	3.18	2.97	<0.7	0.33
Non 2378 TCDD	0	<1	60.6	36.9	4.79	7.49
12378 PeCDF	0.05	<2	0.43	0.50	0.55	0.86
23478 PeCDF	**0.5**	<3	<0.7	1.25	1.11	1.67
Non 2378 PeCDF	0	20	23.6	20.2	11.0	20.5
12378 PeCDD	**0.5**	<3	<0.7	<1	0.97	4.25
Non 2378 PeCDD	0	10	18.3	15.8	7.67	16.4
123478 HxCDF	0.1	<4	<1	1.28	1.37	1.88
123678 HxCDF	0.1	3	0.72	0.92	1.06	1.59
234678 HxCDF	0.1	13	0.89	1.28	1.39	1.70
123789 HxCDF	0.1	<3	<0.3	<0.3	<0.4	<0.2
Non 2378 HxCDF	0	54	14.6	17.2	35.2	19.7
123478 HxCDD	0.1	2	<0.8	0.77	<0.7	0.56
123678 HxCDD	0.1	12	2.71	4.35	6.26	3.79
123789 HxCDD	0.1	<3	<2	1.91	2.43	1.60
Non 2378 HxCDD	0	50	26.2	30.9	27.6	24.6
1234678 HpCDF	0.01	115	19.5	19.7	27.2	24.2
1234789 HpCDF	0.01	4	<2	<2	1.38	<1
Non 2378 HpCDF	0	137	15.6	27.7	30.1	16.2
1234678 HpCDD	0.01	294	101	121	107	81.2
Non 2378 HpCDD	0	270	101	105	69.4	61.6
OCDF	0.001	173	59.8	93.9	94.1	22.3
OCDD	0.001	2770	1040	1050	964	737
	Sum of congeners	**3938**	**1500**	**1570**	**1410**	**1070**
	Sum including half LODs	**3950**	**1504**	**1572**	**1411**	**1071**
	Total I-TEQ	**8.91**	**6.05**	**7.35**	**4.85**	**6.40**
	Total I-TEQ + half LODs	**11.51**	**6.61**	**7.62**	**5.26**	**6.41**

Note: for values less than the detection limit, the toxic equivalent is the product of the TE factor and 0.5 times the detection limit.

SECTION 7

ORGANICS AND METALS FOUND IN OVERSEAS SLUDGES

7.1 EASTERN CANADA

An initiative was undertaken in 1995/96 to expand the 1993/94 organic and metal contaminant database for Canadian sludges and in particular to obtain information for eastern Canadian sludges. Five sludges were identified and the analysis and data handling techniques were as for the 1993/94 study. Results were presented as a supplement to the earlier study.

The results were published by M.D. Webber and J.A. Bedford of Wastewater Technology International Corporation (operator of the Wastewater Technology Centre and the Canadian Clean Technology Centre) in "Organic and Metal Contaminants in Canadian Municipal Sludges and a Sludge Compost: Supplemental Report", Report No. 1996-RES-3.

Note that < in the tables signifies that the mean concentration was less than the MDL.

7.1.1 Metals

Table 7.1: Metals in Eastern Canadian Sludges

Metal mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Conc**
		1	**2**	**3**	**4**	**5**	
antimony	7.5	63	55	45	24	37	68
arsenic	0.03	4	2	4	2	2	8
barium	1.5	677	688	300	568	379	707
beryllium	1	0.1	0.1	0.1	0.2	0.6	0.6
bismuth	2.5	7	5	5	7	2	15
boron	4	140	65	145	20	29	200
cadmium	0.01	9	12	4	1	1	25
chromium	0.02	194	134	157	21	59	241
cobalt	0.01	4	3	2	3	7	10
copper	0.02	1115	869	1240	435	728	1560
lead	0.04	98	70	83	34	36	120
mercury	0.01	1.6	1.0	0.8	1.4	1.0	4.5
molybdenum	0.05	11	10	6.4	4.6	2.6	19
nickel	0.03	45	52	37	12	13	73
selenium	0.03	2	2	2	1	1	5
silver	12.5	81	61	44	45	41	120
strontium	0.5	221	159	126	209	91	227
thallium	4	31	<4	3	<4	<4	88
tin	10	88	100	394	44	30	524
titanium	1	145	119	61	85	244	404
vanadium	1	23	14	21	8	27	36
zinc	0.03	834	826	797	330	190	1140
zirconium	0.05	15	20	7	17	12	47

The authors stated that the concentrations of metals were generally much less than maximum permissible values cited in guidelines/regulations for land application of sludge, and that several unregulated metals exhibited no unusually high values.

7.1.2 Halogenated Hydrocarbons

Table 7.2: Halogenated Hydrocarbons

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Cone**
SVOC		**1**	**2**	**3**	**4**	**5**	
bis(2-chloroethoxy)methane	3	<	<	<	<	<	<
bis(2-chloroethyl)ether	1.5	<	<	<	<	<	<
bis(2-chloroisopropyl)ether	1	<	<	<	<	<	<
4-chlorophenylphenylether	1	<	<	<	<	<	<
hexachlorobutadiene	1	<	<	<	<	<	<
hexachlorocyclopentadiene							
hexachloroethane	1	<	<	<	<	<	<
VOC							
bromoform	0.002	<	<	<	<	0.0003	0.003
bromomethane							
carbon tetrachloride	0.005	<	<	<	<	<	<
chlorodibromomethane	0.001	<	<	<	<	<	<
chloroethane							
chloroform	0.002	0.0001	0.0001	0.0002	0.0004	0.014	0.039
chloromethane							
1,2-dibromo-3-chloropropane							
1,2-dibromoethane	0.002	<	<	<	<	0.0001	0.003
dibromomethane	0.002	<	0.002	<	<	0.0001	0.025
dichlorobromomethane	0.001	<	<	<	<	<	<
dichlorodifluoromethane							
1,1-dichloroethane	0.002	<	<	<	<	<	<
1,2-dichloroethane	0.001	<	<	<	<	0.0001	0.0011
1,1-dichloroethene	0.01	<	<	<	<	<	<
1,2-dichloroethene (cis + trans)	0.002	0.005	0.003	0.0011	0.0005	0.0001	0.006
dichloromethane	0.008	0.008	0.005	0.010	0.019	0.006	0.065
1,2-dichloropropane	0.001	<	<	<	<	<	<
1,3-dichloropropane							
2,2-dichloropropane							
1,1-dichloropropene							
1,3-dichloropropene (cis + trans)							
1,1,1-trichloroethane	0.001	<	<	<	<	<	<
1,1,2-trichloroethane	0.002	<	<	<	<	0.0002	0.002
1,1,2,2-tetrachloroethane	0.002	<	<	<	<	<	<
1,1,1,2-tetrachloroethane							
tetrachloroethylene	0.001		0.0002	0.005	0.017	0.008	0.052
trichloroethylene	0.002	0.0008	0.0007	0.002	0.002	0.0008	0.012
trichlorofluoromethane							
1,2,3-trichloropropane							
trichlorotrifluoroethane (freon 112)							
vinyl chloride							

7.1.3 Halogenated Aromatics

Table 7.3: Halogenated Aromatics

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Conc**
VOC		**1**	**2**	**3**	**4**	**5**	
bromobenzene							
chlorobenzene	0.001	0.0003	0.002	0.0002	0.0002	0.0001	0.005
2-chlorotoluene							
4-chlorotoluene							
1,2-dichlorobenzene	0.005	0.003	0.002	0.009	0.003	0.001	0.024
1,3-dichlorobenzene	0.004	0.0002	<	0.0004	0.0003	0.0004	0.004
1,4-dichlorobenzene	0.005	0.023	0.047	0.035	0.019	0.010	0.078
1,2,3-trichlorobenzene							
1,2,4-trichlorobenzene	1	<	<	<	<	<	<
SVOC							
4-bromophenylphenylether	0.8	<	<	<	<	<	<
1,2-dichlorobenzene	1.0	0.01	<	0.10	<	0.02	0.90
1,3-dichlorobenzene	1.0	<	<	<	<	<	<
1,4-dichlorobenzene	1.0	0.60	1.70	1.20	0.50	0.20	2.80
hexachlorobenzene	1	<	<	<	<	<	

7.1.4 Aromatics

Table 7.4: Aromatics

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Conc**
SVOC		**1**	**2**	**3**	**4**	**5**	
aniline							
nitrobenzene	0.9	<	<	2.9	21.0	2.2	127
2,4-dinitrotoluene	0.7	<	<	<	<	<	<
2,6-dinitrotoluene	6	<	<	<	0.04	0.03	0.5
1,2-diphenylhydrazine	1	<	<	<	<	<	<
VOC							
benzene	0.001	0.0004	0.0004	0.0006	0.002	0.0006	0.009
n-butylbenzene							
sec-butylbenzene							
tert-butylbenzene							
1,2-dimethylbenzene (o-xylene)	0.003	0.041	0.024	0.006	0.033	0.007	0.171
1,3-dimethylbenzene (m-xylene) + 1,4-dimethylbenzene (p-xylene)	0.01	0.077	0.059	0.012	0.081	0.014	0.404
ethylbenzene	0.002	0.015	0.013	0.004	0.017	0.003	0.084
1,2-diethylbenzene	0.005	0.005	0.002	0.002	0.001	0.0014	0.015
1,3-diethylbenzene	0.003	0.019	0.006	0.004	0.012	0.004	0.058
1,4-diethylbenzene	0.005	0.048	0.024	0.016	0.039	0.014	0.185
2-ethyltoluene	0.004	0.084	0.011	0.011	0.025	0.011	0.108
3- & 4-ethyltoluene	0.01	0.287	0.031	0.032	0.095	0.041	0.454
isopropylbenzene (cumene)	0.004	0.008	0.0011	0.002	0.005	0.002	0.025
n-propylbenzene	0.003	0.042	0.006	0.007	0.018	0.007	0.075
4-isopropyltoluene							
toluene	0.002	0.362	0.937	7.487	0.385	0.067	17.8
1,2,4-trimethylbenzene	0.003	0.454	0.068	0.050	0.117	0.064	0.591
1,3,5-trimethylbenzene	0.005	0.139	0.019	0.016	0.035	0.021	0.178

7.1.5 Phthalates/Plasticisers

Table 7.5: Phthalates/Plasticisers (all SVOC)

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Conc**
		1	**2**	**3**	**4**	**5**	
bis(2-ethylhexyl)phthalate	1.5	240	245	179	157	47	452
butylbenzylphthalate	3.2	1.7	1.2	3.1	5.0	10.0	35
di-(2-ethylhexyl)adipate							
diethylphthalate	0.4	0.3	0.08	0.2	0.02	0.5	2.5
dimethylphthalate	0.5	<	<	<	0.02	<	0.2
di-n-butylphthalate	0.8	6	10	15	11	18	69
di-n-octylphthalate	0.3	10	27	5	5	3.8	71

7.1.6 Polyaromatic Hydrocarbons

Table 7.6: Polyaromatic Hydrocarbons (all SVOC)

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Conc**
`The usual 16'		**1**	**2**	**3**	**4**	**5**	
acenaphthene	0.6	0.6	0.4	0.2	0.4	0.3	1.3
acenaphthylene	0.5	0.1	0.1	0.1	0.2	0.1	0.9
anthracene	0.5	0.6	0.1	0.3	0.1	0.1	2.9
benzofrelanthracene	0.6	1.0	0.5	0.2	0.3	0.3	1.3
benzo[alpyrene	**0.4**	0.8	0.4	0.1	0.1	0.3	2.0
benzo[blfluoranthene	0.6	1.2	0.6	0.2	0.1	0.3	2.0
benzo[g,h,i]perylene	0.5	0.5	0.3	9.0	0.03	0.2	110
benzo[k]fluoranthene	0.3	0.4	0.2	0.1	0.03	0.1	0.7
chrysene	0.3	1.0	0.6	0.1	0.3	0.3	1.3
dibenzo[a,h]anthracene	0.4	<	<	<	<	0.02	0.3
fluoranthene	0.4	1.8	1.3	0.5	0.7	1.1	5.3
fluorene	0.5	0.8	0.6	1.0	1.2	1.4	6.3
indeno[1,2,3-c,d]pyrene	0.5	0.4	0.2	0.1	<	0.1	1.2
naphthalene	0.8	1.7	2.0	0.9	1.4	0.7	6.0
phenanthrene	0.6	3.0	2.2	2.7	2.3	3.8	12.0
pyrene	0.6	2.4	1.4	0.7	0.4	1.5	10.0
+ **some 'fairly common' PAHs:**							
carbazole (dibenzopyrrole)							
2-chloronaphthalene	0.6	0.03	0.2	0.3	0.02	0.04	2.3
1-methylnaphthalene							

7.1.7 Halogenated and Some Other Phenols

Table 7.7: Halogenated and Some Other Phenols (all SVOC)

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Conc**
		1	**2**	**3**	**4**	**5**	
o-cresol (2-methylphenol)							
m-cresol (3-methylphenol)							
p-cresol (4-methylphenol)							
phenol	0.3	0.5	2.6	6.0	5.0	1.3	19
2-chlorophenol	0.5	0.02	<	<	<	0.02	0.20
2,4-dichlorophenol	0.5	<	<	<	<	<	<
2-nitrophenol	5	<	<	<	<	<	<
4-nitrophenol	0.3	<	<	<	<	<	<
p-chloro-m-cresol	1	<	<	<	<	<	<
2,4-dimethylphenol	0.1	<	<	<	<	0.03	0.40
pentachlorophenol	1	<	<	<	<	<	<
2,4,5-trichlorophenol							
2,4,6-trichlorophenol	0.4	<	<	0.01	<	<	0.20

7.1.8 Some Other Organics

Table 7.8: Some Other Organics

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Conc**
VOC		**1**	**2**	**3**	**4**	**5**	
2-butanone (MEK)	1.5	240	245	179	157	47	452
carbon disulphide							
methyl-t-butylether (MTBE)							
4-methylpentan-2-one (MIBK)							
styrene	0.004	0.0001	0.0001	0.003	0.0003	0.0003	0.007
cyclohexane	0.006	<	<	<	<	0.0001	0.0007
hexane	0.008	0.004	0.0012	0.004	0.018	0.004	0.069
nonane	0.01	0.023	0.006	0.057	0.066	0.068	0.312
octane	0.01	0.002	0.004	0.058	0.016	0.011	0.102
SVOC							
dibenzofuran							
3,3'-dichlorobenzidine	0.5	<	<	<	<	<	<
isophorone	1.5	<	<	<	<	<	<
N-nitrosodi-n-propylamine	1	<	<	<	<	<	<
N-nitrosodiphenylamine	0.8	<	<	<	<	<	<

7.1.9 Organochlorine Pesticides and PCBs

Table 7.9: Organochlorine Pesticides and PCBs (all SVOC)

Chemical mg/kg, dry weight	**MDL**	**Mean Concentration of Four Samples of Five Sludges from Eastern Canada**					**Max Cone**
		1	**2**	**3**	**4**	**5**	
aldrin + isodrin	0.001	0.002	<	0.011	<	<	0.065
alpha-BHC	0.001	<	0.001	<	<	<	0.011
beta-BHC							
gamma-BHC (lindane)	0.001	0.002	0.003	0.018	0.016	0.016	0.062
delta-BHC							
chlordanes (a + 13)	0.001	0.010	<	<	0.001	<	0.041
DDT + isomers	0.005	<	<	<	0.025	0.001	0.233
DDE + isomers	0.001	0.014	0.016	0.010	0.003	<	0.053
DDD + isomers							
dieldrin	0.005	<	<	<	<	<	<
a-endosulfan	0.001	<	<	<	<	<	<
13-endosulfan	0.001	<	<	<	<	<	<
endosulfan sulfate							
endrin	0.005	<	<	<	<	<	<
endrin aldehyde							
heptachlor	0.005	<	<	<	<	<	<
heptachlor epoxide	0.001	<	<	<	<	<	<
hexachlorobenzene	0.001	<	<	0.002	0.006	<	0.026
methoxychlor	0.01	<	<	0.010	0.031	<	0.235
mirex	0.005	<	<	<	0.006	<	0.043
Total PCBs	0.5		<	<	0.3 *	<	<

* found in only one of six samples

The authors stated that there were essentially no organochlorines or PCBs.

An earlier study of 10 sewage sludges being applied to land in the Ontario area reported that 9 digested sludges contained 0.13-0.82 mg/kg total PCBs while the waste activated sludge contained 1.61 mg/kg. See Webber, M.D., Monteith, H.D. and Comeau, G.M. in J. WPCF, 1983, 55, Number 2, pp187-195.

Sewage sludges from the five eastern Canadian towns (as above, WTI 1996) were tested for organochiorine pesticides for six consecutive months from September 1996. The results are summarised in Table 7.10.

Organochlorine	MDL	No. < MDL	Positive Results
aldrin	0.001	28 of 30	0.02-0.06
a-BHC	0.001	29 of 30	0.011
y-BHC (lindane)	0.001	15 of 30	0.01-0.05
cc-chlordane	0.001	28 of 30	0.01-0.02
y-chlordane	0.001	26 of 30	0.003-0.02
a-endosulfan	0.001	30 of 30	-
13-endosulfan	0.001	30 of 30	-
dieldrin	0.005	30 of 30	-
endrin	0.005	30 of 30	-
heptachlor	0.005	30 of 30	-
heptachlor epoxide	0.001	30 of 30	-
hexachlorobenzene	0.001	26 of 30	0.004-0.02
methoxychlor	0.01	28 of 30	0.10-0.23
mirex	0.005	28 of 30	0.02-0.04
o,p-DDT	0.005	27 of 30	0.01-0.06
p,p-DDE	0.001	20 of 30	0.01-0.04
p,p-DDT	0.005	29 of 30	0.17

Table 7.10: Organochlorine pesticides (mg/kg dry weight) found in Canadian sewage sludges. Note MDL is the method detection limit which involves a determination of the analytical precision of low concentration samples which are processed through the entire analytical method.

The pesticide found most frequently was y-BHC (lindane), in half the samples, six of which were greater than 0.02 mg/kg (the LEJV standard -see Table 5.4) but none excessively.

The next commonest was p,p-DDE (4,4-DDE), found in one third of the samples, but the total DDT plus isomers were well below LEJV.

One sludge sample contained more aldrin than the LEJV standard (New Zealand). All other organochlorine pesticides were found only spasmodically and at levels less than the LEJV standard. Note that dieldrin was not detected.

7.1.10 Dioxin Congeners

(PCDDs are polychlorinated dibenzodioxins; PCDFs are polychlorinated dibenzofurans).

Table 7.11: Dioxin Congeners
(note pg/p = mg/kg x 10-6, µg/t or mg/1000 t

Chemical pg/g dry weight		**Range found in 6 towns, 4 samples ea**	**Minimum reported positive value**
	TE factor		
2378 TCDF	0.1	1.5 - 13	NA
Non 2378 TCDF	0		
2378 TCDD	1.0	all <?	NA
Non 2378 TCDD	0		
12378 PeCDF	0.05	<7 - 1.6	0.6
23478 PeCDF	0.5	<7 - 9	1
Non 2378 PeCDF	0		
12378 PeCDD	0.5	<7 - 13	2
Non 2378 PeCDD	0		
123478 HxCDF	0.1	<? - 12	2
123678 HxCDF	0.1	<7 - 4	1
234678 HxCDF	0.1	<7 - 4.5	2
123789 HxCDF	0.1	all <?	NA
Non 2378 HxCDF	0		
123478 HxCDD	0.1	<? - 2.6	1
123678 HxCDD	0.1	<7 - 32	3
123789 HxCDD	0.1	<? - 24	1
Non 2378 HxCDD	0		
1234678 HpCDF	0.01	14 - 172	NA
1234789 HpCDF	0.01	all <?	NA
Non 2378 HpCDF	0		
1234678 HpCDD	0.01	96 - 380	NA
Non 2378 HpCDD	0		
OCDF	0.001	53 - 450	NA
OCDD	0.001	900 - 5080	NA
Total Toxic Equivalents + half LODs		**3.2 - 32.1**	

Note 1: for values less than the detection limit, the toxic equivalent is the product of the TE factor and 0.5 times the detection limit

Note 2: detection limits were not reported in the above study; they would have varied anyway, depending on the dry solids content of the individual samples. For congeners with less than values for minima, the lowest reported 'real' level found in the 24 samples has been included to give an indication of detection limit.

The authors stated that the above PCDD/PCDF levels were low. Dioxin testing included a sludge that had produced a relatively high result in the earlier survey: 374 pg/g toxic equivalents (TE), although results from other samples from that town were 6, 10 and 14. The high result was above the maximum permissible level of 150 pg/g suggested for use in Ontario agriculture by TE Webber and Nichols in "Organic and Metal Contaminants in Canadian Municipal Sludges and a Sludge Compost", Wastewater Technology Centre, 1995.

7.2 UNITED STATES OF AMERICA

7.2.1 Source 1

National Sewage Sludge Survey: Availability of Information and Data, and Anticipated Impacts on Proposed Regulations, USEPA, 40 CFR Part 503, Federal Register Vol. 55, No. 218, 9 November, 1990.

The National Sewage Sludge Survey data were collected August 1988-September 1989. EPA sampled 180 publicly owned treatment works and analysed their sludges for more than 400 pollutants. The National Sewage Sludge Survey, a massive undertaking, was conducted to obtain credible analytical data in order to characterise the quality of the final sludge.

The EPA summarised this large amount of analytical data (>80,000 results) by tabulating results for what they called "the 28 pollutants of concern". These are summarised below.

Metals

Table 7.11: Some Metal in US Sludges (Source 1)

Metal mg/kg, dry weight	found in x% of samples	mean concentration
arsenic	80	10
beryllium	23	0.4
cadmium	69	7
chromium	91	119
copper	100	741
lead	80	134
mercury	63	5
molybdenum	53	9
nickel	66	43
selenium	65	5
zinc	100	1202

Polyaromatic Hydrocarbons

Table 7.12: Some PAHs in US Sludges

Chemical mg/kg, dry weight	found in x% of samples	mean concentration
SVOC		
benzquipyrene	3	<0.001

Aromatics

Table 7.13: Some Aromatics in US Sludges

Chemical mg/kg, dry weight	found in x% of samples	mean concentration
VOC		
benzene	0	<0.001

Phthalates/Plasticisers

Table 7.14: Some Phthalates/Plasticisers in US Sludges

Chemical mg/kg, dry weight	found in x% of samples	mean concentration
SVOC		
bis(2-ethylhexyl)phthalate	92	75

Halogenated Hydrocarbons

Table 7.15: Some Halogenated Hydrocarbons in US Sludges

Chemical mg/kg, dry weight	found in x% of samples	mean concentration
SVOC		
hexachlorobutadiene	0	<0.001
VOC		
trichloroethylene	1	<0.001

Other Organics

Table 7.16: Some Other Organics in US Sludges

Chemical mg/kg, dry weight	found in x% of samples	mean concentration
SVOC		
N-nitrosodimethylamine	0	<0.001

Organochlorine Pesticides

Table 7.17: Some Organochloiine Pesticides in US Sludges

Chemical mg/kg, dry weight	**found in x% of samples**	**mean concentration**
SVOC		
aldrin + isodrin	3	0.002
gamma-BHC (lindane)	0	<0.001
chlordanes (a +()	0	<0.001
DDT + isomers	2	0.03
DDE + isomers	1	<0.001
DDD + isomers	0	<0.001
dieldrin	4	<0.001
heptachlor	0	<0.001
hexachlorobenzene	0	<0.001
toxaphene	0	<0.001

PCB Congeners

Table 7.18: Some PCB Congeners in US Sludges

Name of PCB mg/kg, dry weight	**found in x% of samples**	**mean concentration**
PCB-1016	0	<0.001
PCB-1221	0	<0.001
PCB-1232	0	<0.001
PCB-1242	0	<0.001
PCB-1248	10	0.08
PCB-1254	8	119
PCB-1260	9	0.16

7.1.2 Source 2

Trace Organics and Inorganics in Distribution and Marketing Municipal Sludges, by Baird, R. and Gabrielian, S.M., of Los Angeles County Sanitation Districts, for USEPA Office of Research and Development, Health Effects Research Laboratory, 1988. Published by US Dept of Commerce National Technical Information Service (NTIS), PB88-160585.

This study tested 67 sludges from 26 US cities for 15 trace metals and 121 toxic organic compounds, and also characterised selected sludges for non-target organic chemicals which might predominate in individual sludges. The sludges were stabilised products (today we would call these 'biosolids') which were being distributed and marketed for various land applications. Results were expressed as wet weight, only the metals were also expressed in dry weight results. The metal results are tabulated below. Organic chemical results are discussed but not tabulated.

Metals

Table 7.19: Some Metals in US Sludges (Source 2)

Metal **mg/kg, dry weight**	**Maximum**	**Minimum**
antimony	9.4	4.7
arsenic	22	7.0
barium	394	137
beryllium	0.5	0.2
cadmium	47	6.3
chromium	558	113
copper	1540	444
lead	380	199
manganese	465	147
mercury	2.6	1.3
nickel	320	35
selenium	13	2.2
silver	85	34
thallium	<0.02	
zinc	1570	773

Organics

As would be expected for stabilised sludges, very few volatile compounds were detected. One sample contained toluene and one sample contained 4-dichlorobenzene.

DDE and DDD metabolites were found quite often; chlordanes were found occasionally and heptachlor was found once, all below the then current draft criteria for land disposal.

PCB (Arochlor 1248) was detected in two samples.

Only three priority pollutants were detected: bis(2-ethylhexyl)phthalate was found in every sample; naphthalene and phenol were found in two samples.

Low levels of some PAHs were measured: chrysene (3 samples), fluoranthene (4 samples), phenanthrene (7 samples) and pyrene (18 samples).

N-nitrosodimethylamine, 2-nitrophenol and di-n-butylphthalate were found once.

7.3 OTHER COUNTRIES (DIOXINS)

An excellent source of information on dioxins is "Dioxins and Furans in Sewage Sludges", produced in 1996 by the Foundation for Water Research, commissioned by the Department of the Environment in the UK. The following information has been taken from that publication.

Table 7.20 summarises dioxin analyses from some national studies reported in "Dioxins and Furans in Sewage Sludges". It was reported that 2,3,7,8-TCDD was generally found at or not much higher than its limit of detection, ie internationally it is an insignificant contributor of TEQ in most sewage sludges; OCDD generally makes the greatest contribution, followed by 1,2,3,4,6,7,8-HpCDD. The values of 0.5 and 4100 pg/g TEQ in the table were stated to be the lowest and the highest ever reported at the time of conducting their literature survey. The report also stated that the octa and hepta CDDs were the dominant congeners found around the world.

The report also predicts that the amount of dioxin TEQs that will be applied to agricultural land in the UK will fall by about 10% in the next few years, despite a 50% increase in the amount of sludge applied.

Table 7.20: Summary of dioxin analyses the number of samples tested (units pg/g or ng/kg)

Study	**No.**	**Sum PCDDs and PCDFs**	**I-TEQs**
Germany 1986	15	50,000 mean	-
Germany 1988	28	-	28-1,560; median 90
Germany 1992	13	-	20-177; median 37; mean 47
Sweden 1989	2	-	23 mean
Switzerland 1994	30	-	6-4100; median 54; mean 357
Sweden 1990	2	-	40 raw; 31 digested
Sweden	4	60,000 mean	160 mean
USA 1988	239	-	0.5-2320; median 37; mean 83
Germany 1991	72	1,700-150,000; 20,000 mean	-
Germany 1992		-	9-72; median 21
UK 1989	11	-	150-200
UK 1993		-	53 in industrial; 23 in rural towns
UK 1995	12	-	19-206

Where No. represents the number of studies reported, and I-TEQ are the International Toxicity Equivalents

PART B
Results of the NZWWA Survey

PART B

RESULTS OF THE NZWWA SURVEY

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INTRODUCTION

Who Was Involved in The Project?

All local authorities operating wastewater treatment plants were invited to participate. Ultimately the project involved 21 local authorities, submitting 66 samples that were collected from 29 different wastewater treatment plants. The treatment plants were in urban and rural areas, they included large complex works and simple pond systems, anaerobic and aerobic treatment processes, plants from Invercargill to Warkworth. See Section 3 (b) in Part A for a list of participants.

The Analytical Work

Three laboratories were involved with the analytical work, reporting the concentrations of 354 determinands, which produced a total of approximately 18,000 results for inclusion in the tables.

The project had two distinct purposes: one to produce data on the levels of chemicals that could affect the treatment process (the operational suite), and the other to determine what environmental concerns there may be when sewage sludge is disposed of or reused (the environmental suite). The laboratory work cost about $90,000. To enhance the cost effectiveness of the analytical work, not all analyses were performed on all samples, and in the case of the organochlorine pesticides, the environmental suite was analysed at a much lower (and more expensive) limit of detection.

The laboratories were told that they would receive 'sewage sludge samples' and to provide sample containers suitable for samples as low as 1% dry solids through to 'dry' samples. In fact, the lowest dry solids was 0.9% and the driest was 93.9%. That meant the laboratories processed some samples as though they were 'waters' and some as though they were 'soils'. The split was rather arbitrary at times and sometimes depended more on the nature of the sample than its % dry weight. The split also varied for groups of determinands, and sometimes the analytical techniques used on the 'water' and 'soil' samples were different. This could lead to slight inconsistencies in the results, which is unfortunate, but at the same time, unavoidable in a large project of this nature. The analytical techniques used would have minimised differences.

The 'water' samples were reported in w/v units but were converted to w/w, based on their % dry solids content. This enabled all results to be compared on the same basis. This comparison was possible when all samples contained the determinand at a level greater than its limit of detection. However, it is very difficult to compare a result of <5 mg/kg with <0.1 mg/kg, or a result of <5 mg/kg with 0.05 mg/kg! The variation in the limits of detection was largely unavoidable. Apart from samples being tested as 'water' or 'soil', some samples contained more interfering substances than others - for example, volatile fatty acids (VFA) interfered with some analyses and the VFAs could range from just a few mg/kg up to thousands.

Checking the Analyses

Once the results were tabulated it was possible to identify atypical maximum or minimum concentrations. The analysts were asked to confirm these results. Initially this involved checking their worksheets to confirm that instrument readings or peaks had been noted correctly and that the subsequent arithmetic was performed accurately. A few samples were re-analysed.

Some of the samples presented serious matrix problems for some of the organic analyses, which raised the normal limit of detection (LOD) and made correct identifications more difficult, particularly at levels close to the limit of detection. That means that it is not as simple as one might think to compare the result for a sample containing 0.2 mg/kg of a compound when the LOD was 0.2 mg/kg with a sample reported as containing 0.020 mg/kg when its LOD was 0.001 mg/kg. The 0.2 mg/kg result has a very much higher level of uncertainty than the 0.020 mg/kg result.

The metals analyses were repeated on four samples; most repeats were in close agreement with the original result, including many of the 'outliers'. However, the digest of one sample contained about 20,000 mg/kg copper (2%!) which was confirmed; however, digesting a second sub-sample produced a result of about 400 mg/kg, which matched other samples from the same treatment plant. This shows how difficult it is to analyse such complex samples.

For most determinations, samples were tested either as though they were waters or as soils or sediments, resulting in different digestion or sample preparation procedures being used. A few samples were repeated, treating the 'water' sample as a 'soil' sample and vice versa. Generally agreement between the two approaches was very good, but results for a few determinands were a little different, suggesting a standard technique for all sludges is desirable.

Organic analyses were only reported when the surrogate recoveries were within each laboratories acceptance criteria; any that fell outside these were repeated. The surrogate recoveries were reported and are available.

The dry solids determination was an important component in the accuracy of many of the results. The importance of this test should not be under-estimated when testing sludges.

How Have the Results Been Reported?

Results have been presented in four fairly logical groups: raw sludges, anaerobic sludges, aerobic sludges and pond sediments. The two compost samples were included with the pond sediments results (simply for convenience). There were no other obvious categories. Refer to Section 3 in Part A for a description of the samples and treatment processes.

The raw sludges made up the 'tightest group', but even then, there were samples that were 'that little bit different'. For example, the raw sludges included a scum sample and a sample of milliscreenings - these produced some rather interesting, and as one would expect, sometimes atypical results. A large proportion of the load on the Invercargill plant is from woolscourers; it was decided to include that waste in the project on the basis that other towns may also receive woolscour wastes. Two 'final' sludges (Tahuna and Army Bay) were included with the raw sludges too, because they do not receive any biological treatment.

The anaerobic sludges made a logical group, but even then, they comprised 'fresh' sludge from digesters, sludge that may have been in a lagoon for years, sludge that had been dewatered with polyelectrolyte or treated with lime. Those containing polyelectrolyte may contain approximately 5 mg/kg of the product.

The aerobic sludges included samples from an aerobic digestion process, trickling filters, waste activated sludge, biological nutrient removal, and aerated lagoons. In some of these plants the raw sludge had been removed from the sewage prior to the aerobic process, while at other plants the aerobic process treats all the raw sewage.

Even the category of pond sediments was not straightforward. Some ponds are basically a tertiary treatment or polishing process that have never seen raw sludge. Other ponds treat all the raw sewage, raw sludge and sometimes even screenings included (and maybe even tankers of waste). Sediments from ponds that have never been desludged could present a history of past practices. Both compost processes sampled include greenwaste with the sludge.

Why Does the Concentration of Some Inert Chemicals Change as the Sludge is Processed?

(a) An Increase in Concentration

Say a raw sludge sample contains 33.7 mg of chromium per kg of dried sludge and that the volatile solids content of this sludge is 80%. That means a kg of the dried sludge contains 800 g volatile solids and 200 g of inert solids, 33.7 mg of which is Cr. In this example chromium is 16.85% of the inert matter.

If this sludge is processed in an anaerobic digester, some of the volatile matter will be broken down, but the chromium, being inert, remains. After digestion, a kg sample of sludge may contain only 60% volatile solids, ie 600 g volatile solids plus 400 g inert solids. Chromium will still be very close to 16.85% of the inert matter, so 1 kg of the digested sludge contains 67.4 mg Cr, ie it is now double the concentration it was in the raw sludge. This assumes that soluble chemicals such as sodium and potassium are not wasted by draining off supernatant from the digester - a practice that is less common these days.

If the raw sludge is treated in such a manner that the final sludge is only 40% volatile solids, a kg of the final sludge will contain 600 g of inert solids, of which 16.85% will be chromium. That means the final sludge will contain 101.1 mg/kg chromium, ie nearly three times the concentration of the raw sludge.

(b) A Decrease in Concentration

Some inert materials such as metals may be elutriated from a pond sediment over time if they are soluble or become so in the anaerobic, low Eh, low pH, high carbon dioxide rich environment (eg manganese). Dry sludge stockpiled in the open or on beds may also lose some of the more soluble metals due to rain. Some ponds may contain sediments that are many years old and may reflect practices that are no longer allowed, or conversely the sediments may not contain very high levels of newer compounds or of compounds that have increased in usage in recent years. Some normally fairly soluble metals such as zinc may be released from pond sediments over time as the organic matter holding them is broken down.

Do You Want Some More Information about Dioxins, OCPs and PCBs?

The Ministry for the Environment is conducting the National Organochlorines Programme, to determine the levels of dioxins, PCBs and organochlorine pesticides in the New Zealand environment. One aspect of the work is a National Inventory for Dioxins, which includes an assessment of the entry of dioxins into the environment. Some information on the Programme is available on the Ministry's homepage: http://www.mfe.govt.nz

SECTION 1

METALS

ANALYTICAL METHODOLOGY

Solid Samples (for Ca, Mg, Na, K, Fe, Mn, Al, Be, V and Zn)
Samples were dried, digested using boiling aqua regia, followed by analysis using a TJA IRIS ICP-OES (inductively coupled plasma –optical emission spectrometry).

Liquid Samples (for Ca, Mg, Na, K and Be)
Samples (as received) were digested with nitric acid using microwave digestion, followed by analysis using a TJA IRIS ICP-OES.

Mercury
Mercury in the 'solid' samples was determined by drying the sample, digesting it in boiling aqua regia, then measuring the concentration using cold vapour AAS (atomic absorption spectroscopy). The 'water' samples were digested with nitric acid using microwave digestion, then the mercury was determined by cold vapour AA spectroscopy.

The Other Metals
Samples were digested using boiling aqua regia. Analysis was by ICP-MS (inductively coupled plasma – mass spectrometry) using a VG PlasmaQuad 2 instrument.

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Apart from beryllium (all but one sample), selenium (several samples), tellurium (most samples), thallium (two samples), and vanadium (two samples) the concentrations of metals were well above their limits of detection (LOD). The LODs are apparent when referring to Tables B 1.1 - B 1.4.

ANALYTICAL RESULTS

Results for the metals (both trace and common) appear in Tables B 1.1 - B 1.4. Some previous New Zealand results appear in Table 6.1 in Part A. Some results from an Eastern Canadian survey appear in Table 7.1 and two US surveys in Tables 7.11 and 7.19.

The split between 'trace' and 'common' is unavoidably rather arbitrary and may not suit all readers. To prevent confusion, the same units have been used for both, even though some big numbers are needed.

Some metals were included in this survey because they can inhibit biological treatment processes, and because some may cause undesirable environmental effects when the sludge is disposed of or reused. Others were included to give an indication of the nutrient contribution if the sludge is disposed of to land.

The USEPA priority pollutants list includes antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium and zinc.

Discussion
Table B 1.5 compares the median values of different sludge types, taken from Tables B 1.1 - B 1.4. Refer to the discussion in the Introduction to Part B on why some chemicals may increase or decrease in concentration as the sludge is processed.

Table B 1.5 is not intended to give a quantitative comparison of the different sludge types because obviously the sludges are from a variety of towns, have a range of ages, and have been stored in differing situations. However, it is interesting to see how the concentrations vary between the different categories.

Table B 1.5 also includes an indication of the range of concentrations 'commonly' used in various national land disposal or reuse regulations (taken from Table 5.5 in Part A). Table B1.5 indicates that 'median sludges' tested in this survey should have no problem with arsenic, cadmium, chromium, lead and nickel. However, median levels of copper, mercury, molybdenum, selenium and zinc fell in this range of regulation values; this is a little strange in the case of molybdenum and selenium which are often deficient in New Zealand soils.

There are several national standards or guidelines etc for metals in sewage sludges (see Table 5.5), the 'acceptable' concentrations often depending on the sludge use, or its method of disposal. The concentrations usually refer to 'total metals', but the meaning of 'total' is not always defined. Whether a metal in a sludge will cause an undesirable environmental effect will depend on how much of the total metal is soluble, becomes soluble, or which may become bioavailable in time as a result of various chemical or biological mechanisms. No national standards or guidelines have taken this into account yet. The metals' results from this survey are reported as 'total metal'.

The metals that changed the least between raw sludge and the pond sediments were antimony, boron, mercury, calcium, potassium and sodium. The metals that increased the most were caesium, gallium, tin and aluminium. The highest potassium concentrations were found in the aerobic sludges; the Paraparaumu and Rotorua waste activated sludges had the highest concentrations of all samples tested – these two plants practise biological nutrient removal.

Table B 1.5: Comparison of median values of different sludge types, taken from Tables B 1.1 -B1.4

Sludge Type:	Raw	Aerobic	Anaerobic	Pond Sediments	'Typical' Regulation Level
mg/kg dry wt					
% ds	4.0	4.3	17.5	3.5	
antimony	0.8	0.9	1.8	1.1	-
arsenic	4.6	6	10	11	15-40
barium	142	236	270	227	-
beryllium	-	-	-	-	-,
bismuth	1.3	2.8	3.5	5.0	-
boron	11	21	20	17	-
cadmium	0.87	1.74	1.80	2.21	3-40
caesium	0.4	0.5	0.7	2.1	-
chromium	34	35	81	129	200-600
cobalt	2.3	2.1	3.7	6.0	-
copper	159	365	418	549	200-1000
gallium	1.0	1.3	2.4	5.1	-
lanthanum	2.9	3.4	5.7	11.0	-
lead	47	58	87	112	200-300
lithium	4	3	6	18	-
mercury	1.0	2.2	3.0	1.5	1-15
molybdenum	2.3	3.9	4.8	4.2	4-18
nickel	11	17	30	32	60-400
rubidium	4.5	7.3	7.2	11.9	-
selenium	1.4	4.0	4.0	<5.6	3-100
silver	4.1	14.1	12.4	6.1	-
strontium	45	84	89	77	-
tellurium	-	-	-	-	-
thallium	0.05	0.09	0.10	0.19	-
tin	1.5	2.7	26.5	15.9	-
uranium	0.33	0.58	0.62	1.04	-
vanadium	5.5	7.0	11.4	24.2	-
zinc	411	669	1031	832	250-2000
aluminium	4152	8245	10238	23250	-
calcium	16996	14717	25450	12433	-
iron	3109	5696	10191	14550	-
magnesium	1732	3615	2550	2906	-
manganese	104	199	286	217	-
potassium	2367	4918	1785	3196	-
sodium	3143	2130	1690	3595	-

Tables B 1.1 - B 1.4 include 35 metals results for 66 samples or 2310 individual results. People being what they are, they will scan these tables, taking particular interest in the maximum levels. This almost instinctive process runs the risk of spending too much time and effort on possible `outliers'. Sometimes the maximum result can be an artifact of the analysis or the sampling.

The sample with a maximum value could simply contain a freak particle in a section of non-homogeneous sludge, or could have been collected on an atypical day. As well as the maximum and minimum values, Tables B 1.1 - B 1.4 include the median value (50-ile) and the interquartile range (25-75-ile). This comprises the 'middle half' of the results, and they look very different from the maximum and minimum values. However, not all maximum or minimum results give false indications! Note how the North Shore samples consistently had one of the highest nickel results, and how consistent the copper results were in the three Levin anaerobic sludges. As discussed in the Introduction to Part B, maximum and minimum values were confirmed.

Table B 1.6 summarises the two or three highest values for each metal, by sludge type.

Some results in Table B 1.6 warrant comment. The Invercargill woolscour sample produced two remarkable concentrations: 263 mg/kg of rubidium and 152,000 mg/kg (15.2%!) potassium; these concentrations were reflected in the Invercargill digested samples.

Lime treatment of raw sludge is practised at Army Bay and lime stabilisation of digested sludge is practised at Mangere, which explains their high calcium levels.

If a water treatment plant that uses alum discharges its wastes to the sewerage system, the aluminium concentration in the raw sludge will increase by about 2000 mg/kg - this is about half of the median concentration found in the raw sludges tested in this project.

There have been suggestions that a town water supply that corrodes copper tubing could be the cause of a large proportion of the copper in its sewage sludge. If the corroding tubing causes the copper content of the raw sewage to increase by 0.4 mg/L and all the copper ends up in the raw sludge, the raw sludge copper content will increase by about 250 mg/kg. This is about the level that some national standards, guidelines etc are set, and is near the upper end of the interquartile range found in this study.

The Levin raw sludge sample contained some of the highest concentrations of antimony, barium, boron, cadmium, copper, molybdenum, strontium, sodium and zinc. The sodium concentrations were particularly high in the raw and digested sludges (over 20,000 mg/kg or 2%) which is quite surprising for such a soluble metal. Salt is used in the dyeing process, which is quite prevalent in Levin. Levin's digested sludges were high in copper, zinc and sodium too.

The Dunedin scum, Invercargill raw sludge and Feilding raw sludge also contained several of the higher levels of metals.

Table B 1.6: Summary of the two or three highest values of each metal by sludge types, taken from Tables B1.1 - B1.4

	Raw	Anaerobic	Aerobic	Pond Sediments
mg/kg dry wt				
Antimony	4.8 Levin 4.0 Bromley 3.4 Mangere	22.3 Mangere dewatered 19.6 Mangere digested	3.6 Bromley second. 2.4 Carterton 3/4	12.7 Mangere 6.5 Bromley
Arsenic	141 Wainuiomata 13 Hutt milliscreen 10 Bromley	38 Mangere digested 27 Bromley lagoon	10 Warkworth, Rotorua WAS, Bromley second.	51 Bromley 49 Mangere
Barium	518 Levin 212 North Shore	670 Mangere digested 629 Bromley digested	451 Te Puke 377 Carterton 1/2	825 Bromley 574 Belfast
Bismuth	4.5 Carterton 3.3 Templeton	6.4 Invercargill lagoon 5.4 Bromley digested	6.2 Te Puke 5.9 Carterton 1/2	75 Inglewood 40 Bromley
Boron	27 Bromley 23 Levin 20 Hutt milliscreen	82 Mangere digested 64 Bromley lagoon	82 Alexandra 41 Warkworth	40 Belfast 35 Bromley
Cadmium	1.72 Levin 1.65 Tahuna scum	5.77 Bromley lagoon 5.73 Mangere airdried	2.81 Bromley sec. 2.19 Warkworth	32.5 Bromley 21.2 Inglewood
Caesium	1.39 Rotorua 0.96 Feilding	1.6 Wainui airdried 1.2 Mangere digested Bromley digested	3.3 Rotorua WAS 1.2 Warkworth	6.1 Belfast 3.1 Bromley
Chromium	445 Bromley 156 Mangere	1331 Bromley lagoon 1159 Bromley digested	804 Bromley second 205 New Plymouth	4000 Bromley 1460 Mangere
Cobalt	5.6 Bromley 3.5 Invercargill 3.3 Tahuna scum	36 Mangere airdried 14 Mangere digested	6.5 Warkworth 6.1 Bromley second	72 Mangere 20 Belfast
Copper	763 Levin 315 Templeton 298 Dunedin dewat	789 Levin lagoon 624 Levin airdried 612 Levin digested	563 Carterton 1/2 484 New Plymouth	2294 Inglewood 1996 Bromley
Gallium	3.6 Invercargill 2.7 Feilding	4.0 Mangere digested 3.5 Bromley lagoon	2.9 Carterton 1/2 2.5 Otaki	21.0 Belfast 16.6 Inglewood
Lanthanum	7.8 Invercargill 7.2 Tahuna scum	16.5 Bromley lagoon 10.4 Bromley digested	9.3 Carterton 1/2 7.7 Carterton 3/4	63 Belfast 30 Bromley
Lead	184 Tahuna scum 158 Invercargill	501 Mangere airdried 268 Bromley digested	154 Bromley second 151 Carterton 1/2	904 Bromley 792 Mangere
Lithium	9.5 Invercargill 8.3 Feilding	15.3 Bromley digested 15.0 Mangere digested	10 Carterton 1/2 6 Bromley second	108 Belfast 31 Bromley
Mercury	6.1 Carterton 1.8 Tahuna scum	8.0 Wainui digested 6.6 Wainui airdried	15.6 Carterton 1/2 14.0 Carterton 3/4	24.7 Inglewood 11.0 Bromley
Molybdenum	6.0 Feilding 6 .0 Bromley 4.2 Levin	17.8 Bromley lagoon 17.3 Bromley digested	14 Bromley second 6 Warkworth	17.5 Bromley 15.6 Inglewood
Nickel	205 North Shore 30 Army Bay 30 Bromley	254 Nth Shore dewater 202 North Shore digest	132 New Plymouth 60 Bromley second	425 Bromley 337 North Shore
Rubidium	263 Woolscour 22 Feilding 20 Invercargill	249 Invercargill digest 27 Invercargill lagoon	17 Para'umu DAF 16 Rotorua WAS	56 Belfast 30 Greytown
Selenium	12 Templeton 5 Levin	6.5 North Shore digest 6.0 Wainui airdried	6 Te Puke	18 Inglewood 11 Belfast
Silver	15 Dunedin dewat 12 Army Bay	61 Nth Shore dewater 46 Bromley dewatered	162 Warkworth 62 Porirua	55 Mangere 19 Rotorua compost
Strontium	107 Invercargill 98 Levin	185 Bromley lagoon 175 Mangere + lime	137 Carterton 1/2 112 Carterton 3/4	278 Inglewood 230 Bromley
Thallium	0.26 Feilding 0.12 Levin + Rotorua	0.20 Mangere airdried 0.18 Bromley	0.16 Carterton 1/2	1.18 Inglewood

(cont'd)	Raw	Anaerobic	Aerobic	Pond Sediments
mg/kg dry wt				
Tin	24 Tahuna scum 20 Army Bay	86 Bromley dewatered 80 Mangere airdried	310 New Plymouth 63 Warkworth	103 Mangere 61 Beachlands
Uranium	0.7 Tahuna scum 0.6 Feilding	1.7 Bromley digested 1.7 Bromley lagoon	1.5 Alexandra 1.2 Bromley second	21.6 Inglewood 7.4 Belfast
Vanadium	18.9 Invercargill 14.4 FeiMing	33.7 Mangere airdried 30.5 Bromley lagoon	27.7 Warkworth 13.0 Carterton 3/4	132 Inglewood 91 Belfast
Zinc	1213 Levin 900 Invercargill	1669 Bromley lagoon 1630 Levin lagoon	1860 New Plymouth 1026 Bromley sec	5292 Bromley 4483 Inglewood
Aluminium	18200 Invercargill 10630 Feilding	20560 Mangere digested 20500 Mangere airdried	73800 N. Plymouth 15200 Warkworth	90000 Inglewood 62440 Belfast
Calcium	58300 Army Bay 30270 Tahuna scum	150000 Mangere + lime 55390 Bromley lagoon	33200 Carterton 3/4 28370 Carterton 1/2	44610 Inglewood 34110 Belfast
Iron	14030 Invercargill 8690 Tahuna scum	23200 Wainui airdried 21900 Mangere airdried	13800 Warkworth 8790 Rotorua dewat	69780 Belfast 46780 Inglewood
Magnesium	5260 Fending 3780 Invercargill	5760 Mangere digested 4430 Mangere airdried	8950 Para'umu DAF 8850 Para'umu lag	16780 Belfast 7000 Inglewood
Manganese	385 Feilding 202 Invercargill	562 Fending airdried 554 Bromley lagoon	440 New Plymouth 400 Warkworth	988 Belfast 542 Inglewood
Potassium	152000 Woolscour 12110 Feilding 6540 Invercargill	133660 Invercargill dig 10270 Mangere digest	17080 Par'umu DAF 14000 Rotorua WAS	8620 Belfast 5710 Martinboro'
Sodium	23690 Levin 8300 Woolscour 5680 Dunedin raw	20120 Levin digested 16670 Mangere digested	7130 Otaki 7110 Thames	8600 Martinboro' 7420 Mangere

The higher concentrations of chromium were usually found in Bromley and Mangere samples, while the North Shore samples contained the most nickel. The higher concentrations of mercury were found at Wainuiomata, Carterton and Inglewood.

Of all the pond sediment samples, Inglewood also contained the highest or high levels of bismuth, cadmium, copper, gallium, molybdenum, selenium, strontium, thallium, uranium, vanadium, zinc, aluminium, calcium, iron, magnesium and manganese. The Bromley and Belfast pond sediments also contained quite high concentrations of many metals.

One of the purposes of this project was to find how many sludges may be considered to be unsuitable for unrestricted 'reuse' some time in the future. Ten metals often have national standards or guideline values to regulate the use or disposal of sewage sludge. In the absence of any New Zealand 'standards' certain values have been selected and placed in Table B1.7. The sludges tested in this project have been compared with these numbers to show what percentage would 'fail', ie be considered unsuitable for unrestricted reuse. It has been assumed that the `standard' is in 'total metal' units.

	`Standard' mg/kg	Raw Sludges	Anaerobic Sludges	Aerobic Sludges	Pond Sediments and Composts
No. of samples		*16*	*22*	*14*	*14*
arsenic	1	6	14	0	36
cadmium	3	0	27	0	36
chromium	400	6	32	7	21
copper	250	25	73	71	64
lead	200	0	14	0	43
mercury	1	50	82	64	64
molybdenum	4	19	64	50	50
nickel	60	6	45	14	29
selenium	3	19	59	57	0
zinc	300	63	91	93	86

Table B 1.7: Percentage of samples from this survey failing a notional 'standard'

Some observations from this table include:
- at least half of all samples would fail the zinc and mercury 'standards'
- apart from raw sludges, at least half would fail copper and molybdenum 'standards' too
- why try to 'reuse' treated sludges when it would be easier to gain approval (regarding the metals' content) to 'reuse' raw sludges, but would that be the most suitable approach for public health or environmental concerns?
- why should it be so difficult to 'reuse' sludges containing 'high' levels of some metals that are often deficient in New Zealand soils?
- how relevant are 'total metal' standards?
- a national sampling, digestion/extraction and analytical technique will be needed if sewage sludge use is to be regulated in New Zealand.

The results from the current survey are not significantly different from the results of New Zealand sludges tested earlier (Table 6.1 in Part A).

Sludges from Eastern Canada (Table 7.1) contained higher concentrations of antimony, barium, boron, chromium, copper, molybdenum, silver, strontium, thallium, tin and lower concentrations of selenium and zinc.

Compared with US sludges (Tables 7.11 and 7.19), the New Zealand sludges in this survey contained less antimony, cadmium, chromium, copper, lead, molybdenum, nickel, silver and zinc.

RAW SLUDGES **METALS (TRACE and COMMON)**

Local Body:	Carterton	Christchurch Bromley	Christchurch Templeton	Dunedin Tahuna	Dunedin Tahuna	Dunedin Tahuna	Horowhenua Levin	Hutt Wainuiomata	Hutt Seaview	Invercargill	Invercargill	Manawatu Fielding
mg/kg dry wt	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	RawSlg	Milliscreens	Raw Slg	Wool Scour	
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2	115685/4
%DS	4.0	3.0	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7	9.8	2.7
Antimony	0.7	4.0	1.0	0.4	0.4	2.5	4.8	0.8	0.5	0.5	<0.02	0.5
Arsenic	4.0	10.0	2.6	1.7	1.8	3.0	6.3	141	13.0	6.8	0.7	5.2
Barium	176	144	237	66	52	139	518	118	25	239	10	165
Beryllium	<2.5	<1.6	<2.9	<8.5	<8.8	<6	<6.2	<6	<6	<2.7	<1.0	<3.7
Bismuth	4.45	1.00	3.29	0.41	0.85	1.00	2.81	1.20	0.20	1.95	0.01	1.37
Boron	8.0	27.1	5.3	7.1	4.2	8.0	22.5	12.0	20.0	11.4	6.6	15.2
Cadmium	0.87	1.20	0.71	0.63	0.87	1.65	1.72	0.64	0.29	1.26	0.08	1.50
Caesium	0.45	0.33	0.38	0.27	0.16	0.50	0.56	0.40	0.10	0.76	0.36	0.96
Chromium	14.3	445	10.8	33.1	30.1	86.2	55.4	61.6	21.4	34.3	2.6	15.6
Cobalt	1.40	5.60	1.18	1.14	0.55	3.30	2.56	2.00	0.90	3.54	1.23	3.04
Copper	206	128	315	147	92	298	763	264	117	171	6	136
Gallium	1.45	0.80	1.00	1.03	0.58		1.69			3.59	0.17	2.67
Lanthanum	3.5	2.9	5.1	3.0	2.5	7.2	3.7	2.8	0.6	7.8	0.8	4.8
Lead	92.8	60.0	27.8	60.3	32.9	184	95.0	48.2	18.5	158	1.1	32.0
Lithium	4.7	3.3	3.1	2.3	1.5		4.8			9.5	5.1	8.3
Mercury	6.08	0.30	0.65	0.90	0.71	1.78	1.56	0.84	0.13	1.05	<0.01	1.04
Molybdenum	1.8	6.0	2.6	1.0	1.5	3.3	4.2	1.2	1.0	2.6	0.03	6.0
Nickel	9.3	30.4	5.0	8.5	3.9	24.8	11.3	10.8	9.3	15.7	2.2	10.7
Rubidium	6.5	4.2	4.7	5.4	3.4	7.2	11.3	2.5	2.7	20.2	263.2	21.7
Selenium	2.8	1.2	12.4	0.8	1.8	<2	5.0	3.0	<2	<1.35	<0.51	<1.85
Silver	2.6	8.8	0.8	1.1	1.2	14.9	5.6	3.5	2.8	5.5	<0.10	9.4
Strontium	56.3	63.0	42.1	34.9	41.2	47.0	97.5	43.6	43.0	107	15.1	78.5
Tellurium	<0.04	<0.05	<0.06	<0.03	<0.33		<0.13			0.05	<0.02	<0.07
Thallium	0.08	0.02	0.07	0.04	0.02	0.07	0.12	0.04	<0.02	0.10	0.03	0.26
Tin	0.70	2.40	0.76	0.20	0.14	23.6	0.50	19.6	9.80	7.89	<0.51	2.15
Uranium	0.28	0.35	0.49	0.33	0.35	0.74	0.34	0.25	0.05	0.48	0.16	0.57
Vanadium	7.0	4.6	5.0	5.4	3.4	11.9	9.4	5.5	<0.005	18.9	3.1	14.4
Zinc	420	4.2	421	239	244	594	1213	265	150	903	74	830
Aluminium	5575	2280	3176	4203	2832	8900	6813	5410	1570	18216	1490	10630
Calcium	13500	23900	18412	7000	30265	9370	29562	18400	14100	18730	3408	15592
Iron	3150	2520	2574	3068	1770	8690	5144	5980	1850	14027	211	7333
Magnesium	1925	2040	1347	1949	1042	2020	3312	1200	1510	3784	1510	5259
Manganese	110	104	59	46	32	103	188	128	69	202	129	385
Potassium	3025	3510	1788	2118	1425	1460	6081	1160	1600	6540	152040	12111
Sodium	3925	4240	1588	5678	3930	1630	23688	960	740	1605	8296	3185

RAW SLUDGES METALS (TRACE and COMMON)

Local Body:	North Shore	Rodney: Army	Rotorua	Watercare						
	Rosedale	Bay - Mech		Mangere		**MAX.**	**MIN.**		**Interquartile**	
mg/kg dry wt	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg		***Not including the***			**Range**	
Lab No:	115900/1	115840/1	116021/1	116306/1		***Woolscour sample***		**MEDIAN**	**25-ile**	**75-ile**
%DS	3.0	18.1	3.1	4.0		29.0	1.6	4.0	3.1	7.7
Antimony	0.8	0.6	1.4	3.4		4.8	0.4	0.8	0.5	1.9
Arsenic	3.3	4.0	8.1	6.0		141	1.7	4.6	2.9	7.1
Barium	212	94	145	126		518	25	142	87	185
Beryllium	<3.3	<6	<3.2	<2.5		-	-	-	-	-
Bismuth	2.10	1.30	1.35	0.45		4.45	0.20	1.25	0.75	1.98
Boron	11.0	10.0	16.8	13.0		27.1	4.2	11.2	7.8	15.6
Cadmium	0.96	0.64	1.10	0.30		1.72	0.30	0.87	0.64	1.21
Caesium	0.30	0.20	1.39	0.20		1.39	0.10	0.37	0.25	0.52
Chromium	50.3	56.9	15.5	156		445	10.8	34	16	58
Cobalt	3.03	2.50	2.74	1.68		5.60	0.55	2.3	1.2	3.0
Copper	232	114	180	78		763	78	159	116	240
Gallium	1.17		0.81	0.63		3.59	0.58	1.02	0.76	1.51
Lanthanum	1.7	1.4	1.8	1.0		7.8	0.6	2.9	1.6	4.0
Lead	46.7	22.9	56.1	14.6		184	14.6	47	27	68
Lithium	1.5		5.5	3.2		9.5	1.5	4.0	2.9	5.2
Mercury	1.50	1.36	1.10	0.50		6.08	0.13	1.04	0.68	1.43
Molybdenum	2.9	1.8	3.1	2.0		6.0	1.0	2.3	1.4	3.2
Nickel	205	29.7	5.8	15.0		205	3.9	10.8	7.8	18.0
Rubidium	3.4	1.7	4.0	4.0		21.7	1.7	4.5	3.4	8.2
Selenium	3.0	3.0	3.2	<1.25		12.4	0.8	1.4	2.0	3.2
Silver	4.1	11.5	7.5	2.4		14.9	0.8	4.1	3.5	8.1
Strontium	52.3	61.5	22.4	30.5		107	22.4	45	40	62
Tellurium	<0.07		<0.06	<0.05		0.05				
Thallium	0.05	0.03	0.12	0.03		0.26	0.02	0.05	0.03	0.09
Tin	0.47	20.4	1.45	1.00		23.6	0.14	1.5	0.6	8.8
Uranium	0.28	0.16	0.32	0.12		0.74	0.05	0.33	0.23	0.38
Vanadium	8.0	8.1	3.5	4.3		18.9	3.1	5.5	4.4	8.7
Zinc	513	458	400	245		1213	150	411	244	534
Aluminium	5700	4100	3355	2950		18216	1490	4152	2920	5978
Calcium	19500	58300	9097	10200		58300	7000	16996	9993	20600
Iron	3467	3840	2368	2090		14027	1770	3109	2298	5353
Magnesium	1930	1390	1539	1360		5259	1042	1732	1383	2025
Manganese	75	95	57	117		385	32	104	66	128
Potassium	1753	730	2319	2415		12111	730	2367	1565	4153
Sodium	3100	690	3065	3575		23688	690	1343	1601	4008

ANAEROBIC SLUDGES **METALS (TRACE and COMMON)**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata	Wainuiomata
mg/kg dry wt	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digested Slg	Slg lagoon	Air Dried ex Beds	Digester Slg	Air Dried Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2	116891/3
%DS	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0	30.9
Antimony	4.5	2.0	4.2	4.5	0.5	1.4	2.2	2.3	0.6	1.3
Arsenic	16	27	18	18	4	4	5	5	7	12
Barium	629	192	242	249	50	419	409	392	175	226
Beryllium	<5.9	<2.6	<6	<6	<6	<5.9	<6	<6	<2.5	<6
Bismuth	5.4	5.4	3.7	3.8	0.6	3.1	3.6	3.4	4.0	2.8
Boron	82	64	47	45	7	22	17	17	15	18
Cadmium	4.88	5.77	3.76	3.93	0.48	1.74	4.96	2.78	1.62	1.18
Caesium	1.0	1.1	0.6	0.6	1.2	0.6	0.6	0.6	0.8	1.5
Chromium	1159	1331	812	840	114	52	87	76	21	38
Cobalt	10.9	13.0	10.1	10.0	3.4	1.9	2.5	2.2	2.6	4.8
Copper	530	569	430	435	44	612	789	624	4.5	404
Gallium	3.2	3.5				1.5			2.1	
Lanthanum	9.9	10.4	7.0	6.8	16.5	3.5	4.8	4.5	7.1	8.8
Lead	268	256	192	191	46	84	102	85	76	66
Lithium	15	13				4			5	
Mercury	2.82	5.23	2.94	3.43	0.37	1.76	3.02	2.65	8.00	6.63
Molybdenum	17.3	17.8	12.4	14.0	0.6	4.2	4.6	4.7	2.6	2.2
Nickel	91.2	101	85.1	88.9	15.5	10.0	26.2	18.1	14.5	22.1
Rubidium	13.3	11.2	5.7	5.7	9.8	10.8	5.7	6.5	7.3	7.0
Selenium	5.3	5.6	4.0	4.0	<2	4.1	5.0	4.0	4.5	6.0
Silver	10.6	4.7	42.4	45.7	2.7	4.3	41.6	36.7	2.8	8.2
Strontium	156	185	127	127	20	64	88	65	102	91
Tellurium	<0.12	<0.05				<0.12			<0.05	
Thallium	0.18	0.18	0.10	0.10	0.08	0.11	0.10	0.09	0.13	0.10
Tin	1.3	14.3	74.5	86.2	7.7	0.9	50.2	47.8	7.7	39.0
Uranium	1.74	1.74	1.12	1.11	0.78	0.35	0.42	0.40	0.65	0.55
Vanadium	14.7	30.5	7.1	7.6	18.8	7.6	9.1	9.4	7.3	10.1
Zinc	1594	1669	1200	1210	140	1065	1630	1380	743	560
Aluminium	11412	14026	8530	8810	10000	6706	8820	8450	10475	12400
Calcium	48294	55385	41500	42900	5230	14765	24200	18200	28750	24800
Iron	9882	14359	10500	10900	13900	3988	6440	6120	12875	23200
Magnesium	4065	3949	2390	2550	3040	2276	2020	1820	1958	2990
Manganese	369	554	438	463	195	108	180	144	177	304
Potassium	6412	4000	1190	1200	1580	4659	1330	1300	2408	1430
Sodium	6294	3077	550	590	<50	20117	3030	3210	1825	850

ANAEROBIC SLUDGES **METALS (TRACE and COMMON)**

Local Body:	Invergargill	Invergargill	Manawatu	Manawatu	North Shore	North Shore	Sth Waikato	Sth Waikato	Watercare	Watercare
			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere	Mangere
mg/kg dry wt	Digester Slg	Lagoon. Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth Lagoon	Sth LAgoon	Digester Slg	Dewatered Slg
Lab No:	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2	116306/4
%DS	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7	0.9	33.8
Antimony	0.8	1.4	0.4	0.9	1.5	1.6	0.7	2.0	19.6	22.3
Arsenic	6	13	3	8	6	5	8	11	38	25
Barium	100	155	111	171	436	291	109	334	670	339
Beryllium	<2.4	<6	<6.8	<6	<5.9	<6	<6	<6	<11	<6
Bismuth	0.6	6.4	0.8	1.8	4.1	3.5	0.9	4.7	3.3	2.8
Boron	11	17	12	11	21	15	32	14	56	26
Cadmium	0.50	1.44	0.94	1.41	1.88	1.86	0.52	2.28	1.98	1.56
Caesium	0.7	0.6	0.6	0.9	0.6	0.4	1.6	0.5	1.2	0.7
Chromium	19	46	11	30	73	93	20	54	681	472
Cobalt	2.1	4.9	2.1	3.1	3.1	3.2	2.8	4.0	14.0	11.6
Copper	59	211	92	165	379	445	114	354	557	484
Gallium	2.4		1.7		2.5				4.0	
Lanthanum	4.5	5.9	3.3	6.6	4.1	3.0	3.3	5.4	6.6	5.4
Lead	27	147	20	48	102	83	20	89	124	106
Lithium	7		6		3				15	
Mercury	0.32	2.77	3.45	0.74	3.88	3.95	0.42	5.80	3.89	2.99
Molybdenum	1.2	1.8	3.8	4.0	4.9	4.8	1.8	5.8	13.4	11.3
Nickel	15.6	28.8	6.9	15.8	202	254	5.5	30.4	77.8	75.6
Rubidium	249	27.5	17.2	12.6	7.1	2.8	7.0	2.5	18.8	6.2
Selenium	1.2	1.9	<3.3	2.0	6.5	5.0	<2	6.0	<5.5	3.0
Silver	7.8	14.1	7.2	14.3	5.5	61.1	7.3	29.5	9.9	41.2
Strontium	47	54	60	74	101	70	24	103	123	86
Tellurium	<0.05		<0.67		<0.12				<0.22	
Thallium	0.06	0.09	0.15	0.17	0.11	0.07	0.09	0.13	0.18	0.13
Tin	11.3	30.5	0.7	22.4	1.7	49.9	11.7	72.6	7.0	56.1
Uranium	0.31	0.75	0.37	0.64	0.49	0.55	0.36	0.90	0.77	0.60
Vanadium	12.2	29.8	9.0	17.8	11.8	11.1	5.3	7.8	25.6	14.6
Zinc	359	676	562	740	982	816	211	1580	1567	1280
Aluminium	9293	13700	5821	12100	11529	9950	5470	9630	20556	14800
Calcium	9951	14300	13100	13700	33882	22400	5660	31600	34778	26100
Iron	6878	16900	5097	11600	5353	7190	4920	5380	12000	10800
Magnesium	2383	3190	3470	2460	3700	2210	1980	2100	5756	27500
Manganese	154	268	323	562	124	131	178	164	486	389
Potassium	133660	9330	9655	1990	5353	1520	3370	990	10266	1090
Sodium	9049	650	3930	230	10705	920	420	690	16667	830

ANAEROBIC SLUDGES   METALS (TRACE and COMMON)

Local Body:	Watercare	Watercare						
	Mangere	Mangere					**Interquartile**	
mg/kg dry wt	Lime Stabilised	Air Dried Slg					**Range**	
Lab No:	116306/5	116306/6		**MAX**	**MIN**	**MEDIAN**	**25-ile**	**75-ile**
%DS	44.6	43.3		93.9	0.9	17.5	3.9	33.1
Antimony	15.4	15.8		22.3	0.4	1.8	1.0	4.4
Arsenic	17	14		38	3	10	5	17
Barium	323	322		670	50	270	172	379
Beryllium	<6	<6		-	-	-	-	-
Bismuth	2.2	4.5		6.4	0.6	3.5	2.4	4.0
Boron	21	29		82	7	20	15	31
Cadmium	1.41	5.73		5.77	0.48	1.8	1.4	3.5
Caesium	0.6	1.0		1.6	0.4	0.7	0.6	1.0
Chromium	3.4	989		1331	11	81	40	629
Cobalt	10.5	35.9		35.9	1.9	3.7	2.7	10.4
Copper	354	548		789	44	418	247	544
Gallium				4.0	1.5	2.4	2.0	3.3
Lanthanum	4.9	8.5		16.5	3.0	5.7	4.5	7.0
Lead	78	501		501	20	87	69	141
Lithium				15.3	3.0	6.2	5.1	13.7
Mercury	1.70	3.55		8.00	0.32	3.0	2.0	3.9
Molybdenum	10.9	7.1		17.8	0.6	4.8	2.9	11.2
Nickel	71.2	128		254	5.5	30	16	88
Rubidium	5.2	8.9		249	2.5	7.2	5.8	12.3
Selenium	3.0	4.0		6.5	1.2	4	3	5
Silver	32.6	33.6		61.1	2.7	12.4	7	36
Strontium	175	139		185	20	89	64	126
Tellurium				-	-	-	-	-
Thallium	0.10	0.20		0.20	0.06	0.10	0.09	0.15
Tin	41.1	79.7		86.2	0.7	26	8	50
Uranium	0.58	1.02		1.74	0.31	0.62	0.44	0.87
Vanadium	12.0	33.7		33.7	5.3	11.4	8.1	17.0
Zinc	997	1520		1669	140	1031	692	1485
Aluminium	11700	20500		20556	5470	10238	8813	12325
Calcium	150000	34400		150000	5230	25450	14416	34684
Iron	7960	21900		23200	3988	10191	6200	12656
Magnesium	2550	4430		5756	1820	2550	2227	3400
Manganese	324	467		562	108	286	167	426
Potassium	1000	1500		133660	990	1785	1308	5180
Sodium	730	1690		20117	<50	1690	690	3930

AEROBIC SLUDGES **METALS (TRACE and COMMON)**

Local Body:	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua	Rodney
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New plymouth	Mechanically	Warkworth
mg/kg dry wt	Digesters 1/2	Digesters 3/4	Secondary Slg	Biological Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered	Air Dried Slg
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1	115840/2
%DS	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3	14.9
Antimony	0.6	2.4	3.6	0.5	0.7	1.1	0.6	0.8	0.9	1.3
Arsenic	9	9	10	4	4	6	5	4	4	10
Barium	377	266	370	184	232	173	128	234	173	252
Beryllium	<2.3	<6	<4.3	<5.9	<6.7	<6	<2.6	<6	<6	<6
Bismuth	5.9	4.3	2.9	2.1	2.5	4.4	2.3	1.5	2.3	4.1
Boron	11	9	36	82	13	15	21	29	30	41
Cadmium	1.91	1.82	2.81	1.27	1.76	1.82	1.23	1.44	1.21	2.19
Caesium	0.9	0.7	0.5	0.2	0.4	0.5	0.3	0.1	0.5	1.2
Chromium	23.7	52.9	804	10.1	40.3	33.9	15.9	205	36.3	42.8
Cobalt	2.5	4.2	6.1	1.6	1.5	2.2	1.1	2.0	1.7	6.5
Copper	563	397	383	372	237	264	201	484	359	470
Gallium	2.9		1.7	0.8	2.5		1.1			
Lanthanum	9.3	7.7	5.1	1.6	2.1	4.0	1.9	1.4	3.7	3.1
Lead	151	126	154	38	54	56	55	57	43	74
Lithium	10.1		6.0	2.7	3.1		2.3			
Mercury	15.6	14.0	0.8	3.7	0.9	3.4	1.8	0.6	0.9	12.0
Molybdenum	3.2	3.1	14.0	3.5	5.4	3.5	3.0	5.1	3.1	6.1
Nickel	16.5	33.7	60.4	12.4	7.3	14.4	7.6	132	19.9	27.2
Rubidium	10.7	7.2	7.3	5.8	8.8	8.1	17.1	3.7	6.9	4.9
Selenium	5	5	3	<3	<3	4	3	3	4	5
Silver	4.0	14.7	8.9	23.9	2.6	39.4	4.2	26.9	62	162
Strontium	137	112	93	111	73	88	59	80	67	87
Tellurium	<0.05		<0.09	<0.12	<0.13		<0.05			
Thallium	0.16	0.11	0.10	0.04	0.07	0.07	0.05	0.09	0.06	0.10
Tin	2.7	44.1	1.4	1.5	1.0	51	1.4	310	38.5	63.4
Uranium	0.54	0.48	1.15	1.46	0.35	0.48	0.46	0.43	0.63	0.69
Vanadium	12.6	13.0	12.2	3.5	4.0	8.7	3.9	11.5	4.8	27.7
Zinc	835	679	1026	544	592	659	524	1860	567	684
Aluminium	11372	9770	6522	4235	11200	9490	4211	73800	6330	15200
Calcium	28372	33200	21348	20882	13533	15900	11816	12000	11500	17300
Iron	7628	8150	6826	2535	2807	7670	2658	6100	5250	13800
Magnesium	2395	2050	2248	5135	3020	8850	8947	3570	3660	3670
Manganese	267	265	224	82	178	181	104	440	131	400
Potassium	2698	1400	4565	7353	6633	5810	17079	3030	5270	2890
Sodium	1907	770	3957	2353	7133	810	2526	1270	940	1080

AEROBIC SLUDGES **METALS (TRACE and COMMON)**

Local Body:	Rotorua	Rotorua	Thames Coro.	Western BOP						
	Waste		Thames	Te Puke					**Interquartile**	
mg/kg dry wt	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS					**Range**	
Lab No:	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**MEDIAN**	**25-ile**	**75-ile**
%DS	4.2	29.6	0.9	1.4		29.6	0.9	4.3	1.9	11.3
Antimony	1.1	1.4	0.2	0.7		3.6	0.2	0.9	0.6	1.3
Arsenic	10	8	4	5		10	4	6	4	9
Barium	238	279	37	451		451	37	236	176	276
Beryllium	<2.4	<6	<11	<7.1						
Bismuth	2.7	2.9	0.2	6.2		6.2	0.2	2.8	2.3	4.3
Boron	21	9	20	26		82	9	21	13	30
Cadmium	1.77	1.45	0.14	1.71		2.81	0.14	1.7	1.3	1.8
Caesium	3.3	1.1	0.1	0.5		3.3	0.1	0.5	0.3	0.9
Chromium	16.6	39.4	2.2	20.6		804	2.2	35	18	42
Cobalt	3.2	5.5	0.4	1.4		6.5	0.4	2.1	1.6	3.9
Copper	357	220	21	4.7		563	21	365	244	405
Gallium	1.3			1.3		2.9	0.8	1.3	1.2	2.1
Lanthanum	2.8	6.2	0.3	3.7		9.3	0.3	3.4	1.9	4.8
Lead	62	60	15	61		154	14.8	58	55	71
Lithium	5.4		0.9	2.4		10.1	0.9	2.9	2.4	5.6
Mercury	1.3	2.7	0.6	6.4		15.6	0.6	2.2	0.9	5.7
Molybdenum	5.5	4.3	0.7	4.7		14.0	0.7	3.9	3.1	5.3
Nickel	7.4	22.8	16.7	12.1		132	7.3	17	12	26
Rubidium	15.6	3.6	5.3	12.6		17.1	3.6	7.3	5.4	10.2
Selenium	4	4	<5.6	6		6	<3	4.0	3.6	5.0
Silver	4.2	16.7	2.1	11.4		162	2.1	14.1	4.2	26
Strontium	39	91	28	56		137	28	84	61	92
Tellurium	<0.05		<0.22	<0.14						
Thallium	0.11	0.09	<0.05	0.09		0.16	0.04	0.09	0.07	0.10
Tin	2.7	47.6	2.1	1.7		310	1.0	2.7	1.5	47
Uranium	0.77	0.75	0.06	0.69		1.46	0.06	0.58	0.47	0.74
Vanadium	3.8	7.0	<1.1	5.0		27.7	3.5	7.0	4.0	12.2
Zinc	519	996	147	681		1860	147	669	549	797
Aluminium	5452	13085	1378	7000		73800	1378	8345	5672	11329
Calcium	8714	22500	5733	13071		33200	5733	14717	11862	21231
Iron	4143	8793	967	5293		13800	967	5696	3141	7659
Magnesium	8738	2283	1109	5229		8947	1109	3615	2311	5205
Manganese	104	217	42	297		440	42	199	111	267
Potassium	14000	1050	2233	10071		17079	1050	4918	2746	7173
Sodium	2476	546	7111	5857		7133	546	2130	975	3599

POND SEDIMENTS/COMPOST **METALS (TRACE and COMMON)**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston	Greytown
mg/kg dry wt	Pond Sed. Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Ex Lagoon 3	Pond Sediment	Pond Slg	Pond Sediment	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1	116452/2
%DS	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3	0.9
Antimony	5.0	6.5	0.6	0.09	1.1	3.0	1.1	0.31	0.44
Arsenic	5.0	51	43	3.3	11.0	42	12.7	3.1	7.8
Barium	105	825	574	61	249	494	537	82	239
Beryllium	<6	<4.1	<11	<2.2	<6	<5.6	<6.7	<7.7	<11
Bismuth	3.0	40.2	9.1	1.4	4.0	75	10.8	3.1	6.0
Boron	6	35	40	5	9	21	19	10	16
Cadmium	2.15	32.5	5.22	0.43	2.27	21.2	6.49	1.80	1.48
Caesium	1.2	3.1	6.1	1.2	2.8	2.2	2.5	1.6	2.6
Chromium	195	4000	100	11	34	192	328	158	24
Cobalt	4.9	15.9	19.9	3.2	2.4	16.9	11.5	2.2	5.0
Copper	205	1996	547	59	551	2294	727	212	604
Gallium		8.0	21.0	3.2		16.6	8.3	2.5	5.1
Lanthanum	15.9	30.4	62.8	11.8	6.0	30.2	5.9	6.2	14.6
Lead	252	904	281	21	64	367	274	67	98
Lithium		31.1	108	15.7		19.3	10.6	16.3	20.0
Mercury	3.4	11.0	3.0	0.3	0.7	24.7	4.7	0.5	1.7
Molybdenum	0.8	17.5	13.3	0.7	2.8	15.6	5.3	0.5	1.8
Nickel	129	425	60	7	18	54	337	10	14
Rubidium	10.0	28.3	55.8	11.9	9.7	13.1	12.0	17.3	30.3
Selenium	<2	8.3	11.1	1.3	6.0	17.8	9.3	<3.8	<5.6
Silver	8.4	8.3	3.3	0.6	2.7	8.4	6.9	2.8	5.2
Strontium	24	230	176	23	63	278	105	28	39
Tellurium		<0.08	<0.22	<0.04		<0.11	<0.13	<0.15	<0.22
Thallium	0.08	0.51	0.60	0.09	0.17	1.18	0.21	0.15	0.24
Tin	27.7	21.5	10.3	0.5	61.0	27.5	7.7	1.7	1.6
Uranium	0.88	4.5	7.37	0.90	0.99	21.56	2.17	0.59	1.09
Vanadium	16.4	49.6	91.1	13.5	38.3	132	40.0	10.8	24.4
Zinc	437	5292	2222	149	1840	4483	2193	613	554
Aluminium	9710	28167	62444	8978	21200	90000	33400	9538	18333
Calcium	5620	24417	34111	4348	11000	44611	13867	3423	5867
Iron	14800	33083	69778	10696	16000	46778	21000	6962	13000
Magnesium	2990	5625	16778	2348	1810	7000	2587	1823	2822
Manganese	208	513	988	121	231	542	191	88	227
Potassium	1520	4750	8622	1920	1880	4933	2787	2692	5211
Sodium	210	3958	4778	1609	1690	4611	6200	3231	4889

POND SEDIMENTS/COMPOST **METALS (TRACE and COMMON)**

Local Body:	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua						
	Martinborough	Pleasant Point	Mangere		Bromley						**Interquartile**	
mg/kg dry wt	Pond Sediment	Pond Slg	Pond Slg		Compost	Compost					**Range**	
Lab No:	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**MEDIAN**	**25-ile**	**75-ile**
%DS	1.0	19.9	8.3		50.0	15.8		50.0	0.9	3.5	1.4	13.9
Antimony	1.0	0.04	12.7		3.0	1.6		12.7	0.04	1.1	0.5	3.0
Arsenic	11.0	1.4	49		30	9.0		51	1.4	11	5.7	39
Barium	271	29	70		215	202		825	29	227	88	438
Beryllium	<10	<0.5	7.0		<6	<6		7				
Bismuth	13.4	0.7	7.4		2.1	2.0		75	0.7	5.0	2.3	10.4
Boron	23	2	30		32	12		40	2	17	9	28
Cadmium	2.29	0.19	16.6		2.04	1.58		32.5	0.19	2.2	1.6	6.2
Caesium	2.0	0.3	1.3		0.9	2.1		6.1	0.3	2.1	1.3	2.6
Chromium	28	4	1460		414	27		4000	4	129	27	295
Cobalt	3.4	1.2	72.4		7.8	7.0		72.4	1.2	6.0	3.2	14.8
Copper	940	30	704		204	351		2294	30	549	2.7	721
Gallium	4.4	1.1						21.0	1.1	5.1	3.2	8.3
Lanthanum	10.2	3.6	8.6		13.0	2.5		62.8	2.5	11.0	6.1	15.6
Lead	94	10	792		126	53		904	10	112	65	279
Lithium	18.3	3.5						108	3.5	18.3	15.7	20.0
Mercury	1.0	0.2	3.5		1.2	1.4		24.7	0.2	1.5	0.8	3.5
Molybdenum	4.5	0.2	12.1		3.8	4.7		17.5	0.2	4.2	1.0	10.4
Nickel	19	2	289		45	12		425	2	32	13	112
Rubidium	26.1	3.6	11.0		9.2	10.0		55.8	3.6	12	10	24
Selenium	<5.0	0.4	6.0		2.0	4.0		17.8	0.4	<5.6	2.5	9.1
Silver	3.9	0.4	54.9		16.2	18.7		54.9	0.4	6.1	3.0	8.4
Strontium	112	16	139		91	31		278	16	77	29	132
Tellurium	<0.20	<0.01										
Thallium	0.22	0.03	0.22		0.09	0.08		1.18	0.03	0.19	0.09	0.24
Tin	2.5	0.1	103		34.6	38.3		103	0.1	15.9	1.9	33
Uranium	2.62	0.34	1.70		0.81	0.54		21.6	0.34	1.04	0.8	2.5
Vanadium	24.0	5.7	38.9		12.2	7.0		132	5.7	24	12.5	40
Zinc	939	92	2090		724	518		5292	92	832	527	2168
Aluminium	38100	3372	29700		9150	5039		90000	3372	12250	9247	32850
Calcium	18200	1864	15000		22300	7640		44611	1864	12433	5682	21275
Iron	12100	3864	26200		14300	4163		69778	3864	14550	11047	24900
Magnesium	4010	794	3900		3460	1851		16778	794	2906	1975	3983
Manganese	204	67	402		408	146		988	67	217	157	407
Potassium	5710	774	2130		3780	3605		8622	774	3196	1972	4888
Sodium	8600	342	7420		470	541		8600	210	3595	808	4861

SECTION 2

GENERAL PARAMETERS / SUNDRY SUBSTANCES

ANALYTICAL METHODOLOGY

Samples for total nitrogen and total kjeldahl nitrogen were dried, then digested using boiling sulphuric acid and a selenium catalyst. The ammonium-N produced was converted to ammonia-N under alkaline conditions and steam distilled into a trapping solution of boric acid. The released ammonia-N was then determined quantitatively by titration with dilute sulphuric acid.

Total phosphorus samples that were considered 'solids' were dried, then digested using boiling aqua regia, followed by analysis using a TJA IRIS ICP-OES (inductively coupled plasma –optical emission spectrometer). The samples that were treated as 'waters' were digested 'as is' using nitric acid and microwave digestion, followed by analysis using a TJA IRIS ICP-OES.

Volatile fatty acids were determined by placing a known volume or weight in a distillation flask,acidifying with sulphuric acid, and distilling off the volatile acids. The distillate was then titrated with standardised sodium hydroxide solution (APHA 5560C).

Total solids or % dry matter were determined gravimetrically by drying for a minimum of 2 days (or longer as required) at 40°C. The lower than normal temperature was chosen to limit losses of volatile compounds.

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. The limits of detection (LOD) for volatile fatty acids are apparent when referring to the Tables B2.1 – B2.4; nutrient concentrations were above their LODs.

ANALYTICAL RESULTS

Volatile fatty acids, nitrogen and total phosphorus results appear in Tables B2.1 - B2.4. The potassium results have been included as well (after converting from mg/kg as in Tables B 1.1 - B1.4 to % w/w) so NPK ratios could be calculated.

The volatile fatty acids were tested on the operational rather than the environmental suite of samples, whereas the nutrients were included in the environmental suite.

Total volatile acids were analysed on 9 of the samples on a w/w basis, and on 23 on a w/v basis because the samples appeared 'more liquid'. Being more liquid, the specific gravity of these four samples would be approximately 1, so 100 mL would weigh about 100 g. Therefore for most purposes the results reported as g/m3 can be considered to be mg/kg acetic acid equivalent.

Total nitrogen was analysed on 30 of the samples, on a w/w basis. Total kjeldahl nitrogen was analysed on 4 of the samples because they appeared 'more liquid'; these were reported on a w/v basis. Being more liquid, the specific gravity of these four samples would be approximately 1, so 100 mL would weigh about 100 g. Therefore for most purposes the four results reported as g/100 mL N can be considered to be approximately the same as g/100 g N.

Total nitrogen (TN) equals total kjeldahl nitrogen (TKN) + total inorganic nitrogen (TIN).

TKN equals organic nitrogen + ammonia.

TIN equals nitrite + nitrite.

In most sludge samples (particularly the anaerobic sludges) the TIN concentration is low, therefore TN is approximately equal to TKN.

Discussion

The low volatile fatty acids (VFA) content in the raw sludge sample from the Imhoff tanks at Templeton suggests that the sludge may have been digested. Apart from that sample and the Feilding raw sample the WA range in raw sludges was 1840 - 6760 g/m3. Only three of the eight anaerobic samples contained more than 100 g/m3 VFA, with a maximum of 722.

Total nitrogen in the three raw sludges tested fell in the range of 1.6 - 2.7%. The 15 anaerobic samples ranged from 0.17 - 4.04% as N, but ignoring the Bromley sample of old sludge that had obviously leached, the range was 1.28 - 4.04% (median 3.0%). The total nitrogen content was higher in the 5 aerobic sludges, ranging between 2.5 - 6.7% (median 4.8%). In the 11 pond sediments the range was 0.26 - 5.4% (median 2.1%).

Total phosphorus in the three raw sludges tested fell in the range of 0.4 - 0.6%. The 15 anaerobic samples ranged from 0.18 - 2.2% as P, but ignoring the old Bromley sample, the range was 0.4 - 2.2% (median 1.1%). The total phosphorus content was higher in the 5 aerobic sludges, ranging between 0.9 - 3.5% (median 1.7%). In the 11 pond sediments the range was 0.14 - 2.3% (median 1.0%).

In comparison, chicken manure usually contains 2-4% N, about 2% P and about 1-2% K. Sewage sludge appears to contain fairly similar levels of nitrogen, a little less phosphorus, and substantially less (about a fifth to a tenth) potassium.

Compost samples analysed by RJ Hill Laboratories usually contain 0.2 – 0.7% of all three, tested `as received'. On this basis, compost from sewage sludge plus greenwaste contains more nitrogen.

The ratios of N:P:K varied somewhat. The median ratio of the three raw sludges was approximately 15:3:1. In the anaerobic samples it was 22:8:1; in the aerobic sludges it was 16:6:1; and in the pond sediments/composts it was 8:3:1 (or 16:6:2).

RAW SLUDGES **SOME GENERAL ANALYSES**

Local Body		Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
			Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
		Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No	**UNITS**	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
Dry solids	%	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
Volatile fatty acids	g/m^3 (note 1)	4800	-	<50	-	-		-	-		3710
Volatile fatty acids	mg/kg (note 2)	-	5760	-	6760	2260		5490	3830		-
Total nitrogen	g/100g (note 3)						2.28			2.74	
Total kjeldahl N	g/100mL (note 4)						-			-	
Total phosphorous	g/100g (note 5)						0.43			0.40	
Potassium	g/100g						0.15			0.16	
N:P (for K = 1)							15/2.9			17/2.5	
	Note 1: ‘thin’ samples were tested as water (ppm w/v)										
	Note 2: ‘thick’ samples were tested as dry matter (ppm w/w)										
	Note 3: tested as dry matter (% w/w)										
	Note 4: tested as liquid (% w/v)										
	Note 5: tested as dry matter (% w/w)										

RAW SLUDGES **SOME GENERAL ANALYSES**

Local Body	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare					
		Fielding	Rosedale	Bay – Mech.		Mangere					
	Wool Scour	Raw Slg	Raw Slg	Dewatered Slg	Primary Slg	Raw Slg					
Lab No	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**MEDIAN**	**NUMBER**
Dry solids	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	4.8	
Volatile fatty acids	6590	-	4050		1840	3130		6590	<50	4050	7
Volatile fatty acids	-	103	-		-	-		6760	103	4660	6
Total nitrogen				1.56				2.74	1.56	2.28	3
Total kjeldahl N				-				-	-	-	0
Total phosphorous				0.62				0.62	0.40	0.43	3
Potassium				0.07				0.16	0.07	1.15	3
N:P (for K = 1)				22/8.8						15/2.9	3

ANAEROBIC SLUDGES **SOME GENERAL ANALYSES**

Local Body:		Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua
		Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin
		Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds
Lab No	**UNITS**	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4
Dry solids	%	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8
Volatile fatty acids	g/m^3 (note 1)	<50		<50			566		
Volatile fatty acids	mg/kg (note 2)	-		-			-		
Total nitrogen	g/100g (note 3)		3.11	3.14	3.13	0.17		3.07	3.10
Total kjeldahl N	g/100mL (note 4)		-	-	-	-		-	-
Total phosphorous	g/100g (note 5)		2.22	1.59	1.63	0.18		1.23	0.81
Potassium	g/100g		0.40	0.12	0.12	0.16		0.13	0.13
N:P (for K = 1)			7.8/5.6	26/13	26/14	1.1/1.1		24/9.5	24/6.2
	Note 1: ‘thin’ samples were tested as water (ppm w/v)								
	Note 2: ‘thick’ samples were tested as dry matter (ppm w/w)								
	Note 3: tested as dry matter (% w/w)								
	Note 4: tested as liquid (% w/v)								
	Note 5: tested as dry matter (% w/w)								

ANAEROBIC SLUDGES **SOME GENERAL ANALYSES**

Local Body	Hutt	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth Waikato	Sth Waikato
	Wainuiomata	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa
	Digester Slg	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth Lagoon	Sth Lagoon
Lab No	116891/2	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	006224/2	116224/1
Dry solids	4.0	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7
Volatile fatty acids	722		667		<50		<50			
Volatile fatty acids	-		-		-		-			
Total nitrogen		2.35		1.28		4.04		3.88	1.03	3.22
Total kjeldahl N		-		-		-		-	-	-
Total phosphorous		0.97		0.42		0.91		1.24	0.72	1.32
Potassium		0.14		0.93		0.20		0.15	0.34	0.10
N:P (for K = 1)		17/6.9		1.4/0.5		20/4.6		26/8.3	3.0/2.1	32/13

ANAEROBIC SLUDGES **SOME GENERAL ANALYSES**

Local Body	Watercare	Watercare	Watercare	Watercare					
	Mangere	Mangere	Mangere	Mangere					
	Digester Slg	Dewatered Slg	Lime Stanilised	Air Dried Slg					
Lab No	116306/2	116306/4	116306/5	116306/6		**MAX.**	**MIN.**	**MEDIAN**	**NUMBER**
Dry solids	0.9	33.8	44.6	43.3		93.9	0.9	17.5	
Volatile fatty acids	103					722	<50	75	8
Volatile fatty acids	-					-	-	-	0
Total nitrogen		2.93	1.89	1.60		4.04	0.17	3.07	15
Total kjeldahl N		-	-	-		-	-	-	0
Total phosphorous		1.12	0.81	1.34		2.22	0.18	1.12	15
Potassium		0.11	0.10	0.15		0.93	0.10	0.14	15
N:P (for K = 1)		27/10.2	19/8.1	11/8.9				22/8.0	15

AEROBIC SLUDGES **SOME GENERAL ANALYSES**

Local Body		Carterton	Carterton	Christchurch	Central Otago	Kapati Coast	Kapati Coast	Kapati Coast	New Plymouth
				Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth
		Digesters 1/2	Digesters 3/4	Secondary Slg	Biological Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg
Lab No	**UNITS**	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2
Dry solids	%	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5
Volatile fatty acids	g/m^3 (note 1)	200	-	4580	300	1790		-	
Volatile fatty acids	mg/kg (note 2)	-	<50	-	-	-		1470	
Total nitrogen	g/100g (note 3)						4.81		5.09
Total kjeldahl N	g/100mL (note 4)						-		-
Total phosphorous	g/100g (note 5)						2.65		3.46
Potassium	g/100g						0.58		0.30
N:P (for K = 1)							8.3/4.6		17/11.5
	Note 1: 'thin' samples were tested as water (ppm w/v)								
	Note 2: 'thick' samples were tested as dry matter (ppm w/w)								
	Note 3: tested as dry matter (% w/w)								
	Note 4: tested as liquid (% w/v)								
	Note 5: tested as dry matter (% w/w)								

AEROBIC SLUDGES **SOME GENERAL ANALYSES**

Local Body	Porirua	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP					
	Mechanically	Warkworth	Waste		Thames	Tepuke					
	Dewatered	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS					
Lab No	116149/1	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**MEDIAN**	**NUMBER**
Dry solids	11.3	14.9	4.2	29.6	0.9	1.4		29.6	0.9	4.3	
Volatile fatty acids			-		<50	No result		4580	<50	300	5
Volatile fatty acids			3110		-	No result		3110	<50	1470	3
Total nitrogen	6.70	4.70		2.50				6.70	2.50	4.81	5
Total kjeldahl N	-	-		-	Insufficient			-	-	-	0
Total phosphorous	1.66	1.62		0.94	sample			3.46	0.94	1.66	5
Potassium	0.53	0.29		0.11				0.58	0.11	0.30	5
N:P (for K = 1)	12.6/3.1	16/5.6		23/8.5						16/5.5	5

POND SEDIMENT/COMPOST **SOME GENERAL ANALYSES**

Local Body		Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore
		Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale
		Pond Sed. Entry	Pond Sed. (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed
Lab No	**UNITS**	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5
Dry solids	%	25.9	2.4	0.9	4.6	7.2	1.8	1.5
Volatile fatty acids	g/m^3 (note 1)							
Volatile fatty acids	mg/kg (note 2)							
Total nitrogen	g/100g (note 3)	0.26	-	-	-	2.59	-	2.15
Total kjeldahl N	g/100mL (note 4)	-	2.70	1.74	0.70	-	2.35	-
Total phosphorous	g/100g (note 5)	0.14	1.52	1.14	0.16	0.85	2.34	0.95
Potassium	g/100g	0.15	0.48	0.86	0.19	0.19	0.49	0.28
N:P (for K = 1)		1.7/0.9	7.3/4.1	2.0/1.3	3.7/0.8	13.6/4.5	4.8/4.8	7.7/3.4
	Note 1: ‘thin’ samples were tested as water (ppm w/v)							
	Note 2: ‘thick’ samples were tested as dry matter (ppm w/w)							
	Note 3: tested as dry matter (% w/w)							
	Note 4: tested as liquid (% w/v)							
	Note 5: tested as dry matter (% w/w)							

POND SEDIMENT/COMPOST **SOME GENERAL ANALYSES**

Local Body	S. Wairarapa	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua					
	Featherston	Greytown	Martinborough	Pleasant Point	Mangere		Bromley						
	Pond Sediment	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost					
Lab No	116452/1	116452/2	116452/3	115887/2	116306/3		115742/1	116021/4		**MAX.**	**MIN.**	**MEDIAN**	**NUMBER**
Dry solids	1.3	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	3.5	
Volatile fatty acids	<50	51	<50							51	<50	51	3
Volatile fatty acids	-	-	-							-	-	-	0
Total nitrogen				2.03	2.35		1.67	5.43		5.43	0.26	2.15	7
Total kjeldahl N				-	-		-	-		2.70	0.70	2.05.	4
Total phosphorous				1.20	1.20		0.70	0.82		2.34	0.14	0.95	11
Potassium				0.21	0.21		0.38	0.36		0.86	0.08	0.28	11
N:P (for K = 1)				11.1/5.7	11.1/5.7		4.4/1.8	15/2.3				7.5/3.4	11

SECTION 3

HALOGENATED HYDROCARBONS

ANALYTICAL METHODOLOGY

Extraction: Solids - VOCs

Based on US-EPA methods 8260 and 624. A representative sub-sample of the samples was obtained using several cores. Samples were extracted into methanol using sonication. The methanol was poured off into a vial, and stored at 4°C until extraction/analysis. A methanol extraction blank was included with every worksheet, or twenty samples.

An aliquot of the methanol extract was added to an aliquot of water immediately prior to analysis. Final extraction/analysis was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous/methanol phase on to a VOCARB4000 trap. Surrogates of approximately 0.25 mg/kg equivalent in the solid (assuming 100% dry matter) were added prior to extraction.

Extraction: Liquids - VOCs

Based on US-EPA methods 8260 and 624. Extraction was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous phase on to a VOCARB4000 trap. Surrogates of 10 µg/L equivalent in the liquid were added prior to extraction.

Instrumental Analysis - VOCs

VOC compounds were determined by full scan GC-MS (based on US-EPA method 8260). Quantitation was performed using internal standardisation and a continuing calibration curve for all target compounds.

Extraction: Solids - SVOCs

Based on USEPA method 3545. Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 333 and 667 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction: Liquids - SVOCs

Based on USEPA method 3520A. Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 12.5 and 25 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup - SVOCs

An aliquot of each extract was cleaned up by gel permeation chromatography (USEPA method 3640).

Instrumental Analysis - SVOCs

SVOC compounds were determined by full scan GC-MS (based on USEPA method 8270). Quantitation was performed using internal standardisation and a 4 point calibration curve for all target compounds.

Quality Control

For SVOC and VOC compounds, an extraction blank was run with every worksheet, or twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples have surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

Results for the volatile organic (VOC) halogenated hydrocarbons appear in Tables B3.1 - B3.4. Results for the semivolatile organic (SVOC) halogenated hydrocarbons appear in Tables B3.5 -B3.8. Some previous New Zealand results appear in Table 6.4 in Part A. Some results from an Eastern Canadian survey appear in Table 7.2 and a US survey in Table 7.15.

Hydrocarbons (or aliphatic hydrocarbons) in the context of this report are organic chemicals where carbon atoms are joined in a chain, as opposed to a ring. Given time, the VOCs are likely to disperse to the atmosphere, so their main interest will probably be whether their concentrations are likely to affect the treatment process.

Some common synonyms or tradenames have been included in the tables where space allowed. Chemicals ending in -ethene or -propene are still sometimes referred to as chemicals ending in -ethylene and -propylene.

Some chemicals beginning with bis- can alternatively start with di-. Some chemicals starting with mono- can be written without mono-, the prefix being considered superfluous.

The VOC 1,2-dibromo-3-chloropropane is also called DBPC, a pesticide banned in USA in 1979. It is sometimes written as 3-chloro-1,2-dibromo-propane.

Vinyl chloride is also called chloroethene, and 1,2-dibromoethane is ethylene dibromide.

The VOCs bromodichloromethane (also known as dichlorobromomethane), bromoform, dibromochloromethane (also known as chlorodibromomethane), and chloroform are commonly tested for in drinking waters – they are known collectively as trihalomethanes.

Halogenated hydrocarbons were included in this survey because some can inhibit biological treatment processes, and because some of the more persistent chemicals may cause undesirable environmental effects when the sludge is disposed of.

The USEPA priority pollutants list includes bromomethane, carbon tetrachloride, chloroform, chlorodibromomethane, chloroethane, chloromethane, dichlorobromomethane, dichloromethane, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloroethane, tribromomethane,1,1,1- trichloroethane, 1,1,2-trichloroethane, trichlorofluoro-methane,1,1,2,2-tetrachloroethane, hexachloroethane, vinyl chloride, 1,1-dichloroethene, 1,2-trans-dichloroethene, trichloroethene, tetrachloroethene, 1,2-dichloropropane, 1,3-dichloropropane, hexachlorobutadiene, hexachlorocyclopentadiene. Plus bis(chloromethyl)ether, bis(chloroethyl)ether, bis(chloroisopropyl)ether, bis(chloroethyl)vinylether, bis(2-chloroethoxy)methane.

Discussion

(a) VOCs

A total of 35 VOC halogenated hydrocarbons were reported - only six were detected above their limit of detection.

Chloroform (trichloromethane) was found in the Invercargill woolscour wastewater sample at a very low level (< 0.1 mg/kg). Chloroform is used as a solvent for oils, fats, greases, waxes, resins, and alkaloids, and as a cleansing agent. Chloroform was used in some cough mixtures, and can be found up to about 0.1 mg/L in some chlorinated water supplies.

Chloromethane (or methyl chloride) was found at 1.3 mg/kg in the sediment sample composited from the Pleasant Point oxidation pond. Methyl chloride is a gas so it is unlikely to be present in pond sediments unless it had only very recently been placed there or if it is generated in situ. It is used as a soil fumigant and was used as a local anaesthetic.

Cis-1,2-dichloroethene (also known as acetylene dichloride and vinylidene chloride) was found in five samples, three at the Bromley plant in Christchurch and in the raw sludge and dewatered sludge at the Tahuna plant in Dunedin. The concentrations were below 10 mg/kg. The concentrations reduced as the sludge passed through the Bromley plant. Dichloroethene is used as solvent for fats, phenol, camphor etc. It is used in the polymer formulation industry overseas.

Dichloromethane (methylene chloride) was found in the Tahuna raw sludge, at less than 1 mg/kg. Dichloromethane is used as a solvent in industry and in chemical laboratories, and as a degreasing and cleansing fluid. It is also found in some paint strippers and is used as a solvent for some pesticides.

Tetrachloroethene (also called tetrachloroethylene and perchlorethylene) was found in 13 of 66 samples, at a maximum of 14 mg/kg in the Levin raw sludge. Tetrachloroethene was found in more than one sample in sludges from Levin, Invercargill, Dunedin and Rotorua, where the highest concentrations were in the raw sludges. It was also found in the Seaview milliscreenings (2.9 mg/kg). Tetrachloroethene is used commonly in the drycleaning industry and for metal degreasing.

Trichloroethene (trichloroethylene) was found in three samples, at a maximum of 1 mg/kg in Levin raw sludge. Trichloroethene is used as a solvent for oils, fats, greases, waxes, resins, rubber, paint, and varnishes, and in the drycleaning and degreasing industry. It has also been used as an analgesic and anaesthetic.

No halogenated hydrocarbons were detected in the compost samples, and apart from chloromethane, none were found in the pond sediments either.

Cis-1,2-dichloroethene, dichloromethane, tetrachloroethene, and trichloroethene had been found in the earlier New Zealand samples too, all at less than 0.25 mg/kg. Likewise, chloroform, cis-1,2-dichloroethene, dichloromethane, tetrachloroethene, and trichloroethene were found commonly in the Eastern Canada study, but at very low concentrations. Maxima were generally less than 0.05 mg/kg and means were about 0.005 mg/kg dry weight.

(b) SVOCs

Results for a total of 6 SVOC halogenated hydrocarbons were reported - only one was detected above the limit of detection - bis(2-chloroethyl)ether, and in only 1 of the 66 samples.

Bis(2-chloroethyl)ether (or sym-dichloroethyl ether) was found at 1.8 mg/kg in Bromley digested sludge (but in no other Bromley samples). Bis(2-chloroethyl)ether has been used as a soil fumigant, and as a scouring agent for textiles. It is also used as a solvent.

No SVOC halogenated hydrocarbons were detected in previous New Zealand samples or in the Eastern Canada study.

Halogenated hydrocarbons in sewage sludges do not appear to be regulated in any national standards, etc.

RAW SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4
VOCs % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5
bromodichloromethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
bromoform (tribromomethane)	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
bromomethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
carbon tetrachloride	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
chloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
chloroform (trichloromethane)	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
chloromethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
dibromochloromethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,2-dibromo-3-chloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,2-dibromomethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
dibeomomethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
Dichlorodifluoromethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,1-dichloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,2-dichloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,1-dichloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
cis-1,2-dichloroethane	<0.25	**6.7**	<0.29	**1.64**	<0.4	**0.06**	<1	<0.6	<0.2
trans-1,2-dichloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
tichloromethane (methylene chloride)	<5.0	<4	<5.9	**0.8**	<4	<0.6	<10	<6	<2
1,2-dichloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,3-dichloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
2,2-dichloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,1-dichloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
cis-1,3-dichloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
trans-1,3-dichloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
hexachlorobutadiene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,1,1,2-tetrachloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,1,2,2- tetrachloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
tetrachloroethane	<0.25	<0.4	<0.29	<0.03	**2.8**	**1.63**	**14**	<0.6	**2.9**
1,1,1-tetrachloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,1,2-tetrachloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
trichloroethane	<0.25	<0.4	<0.29	<0.03	<0.4	**0.65**	**1**	<0.6	**0.3**
trichloroflouromethane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,2,3-trichloropropane	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2
1,1,2-trichlorotriflouroethane	<2.5	<2	<2.9	<0.3	<2	<0.3	<6	<3	<0.9
vinyl chloride	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2

RAW SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Invercargill	Invercargill	Manawatu	North Shore	Rodney: Army	Rotarua	Watercare				
			Fielding	Rosedale	Bay - Mech		Mangere				**Number**
mg/kg dry weight	Raw Slg	Wool Scour	Raw Slg	Raw Slg	Dewatered Slg	Primary Slg	Raw Slg				**(from 16)**
Lab No:	116836/1	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	3.7	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
bromodichloromethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
bromoform (tribromomethane)	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
bromomethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
carbon tetrachloride	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
chloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
chloroform (trichloromethane)	<0.27	**0.08**	<0.8	<0.30	<0.1	<0.29	<0.05		0.08	<0.03	1
chloromethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
dibromochloromethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,2-dibromo-3-chloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,2-dibromomethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
dibeomomethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
Dichlorodifluoromethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,1-dichloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,2-dichloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,1-dichloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
cis-1,2-dichloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		6.7	<0.05	3
trans-1,2-dichloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
tichloromethane (methylene chloride)	<5.4	<0.82	<8	<6.67	<1	<6.5	<0.50		0.8	<0.5	1
1,2-dichloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,3-dichloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
2,2-dichloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,1-dichloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
cis-1,3-dichloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
trans-1,3-dichloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
hexachlorobutadiene	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,1,1,2-tetrachloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,1,2,2- tetrachloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
tetrachloroethane	**4.6**	<0.08	<0.8	**0.50**	<0.1	**0.81**	**0.13**		14	<0.03	8
1,1,1-tetrachloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,1,2-tetrachloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
trichloroethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		1.0	<0.03	0
trichloroflouromethane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,2,3-trichloropropane	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0
1,1,2-trichlorotriflouroethane	<2.7	<0.41	<4	<3.0	<0.5	<2.9	<0.2		-	<0.3	0
vinyl chloride	<0.27	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		-	<0.03	0

RAW SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4
SVOCs % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5
bis(2-chloroethoxy)methane	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4
bis(2-chloroethyl)ether	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4
bis(2-chloroisopropyl)ether	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4
hexachlorobutadiene	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4
hexachlorocyclopentadiene	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4
hexachloroethane	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4

RAW SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Invercargill	Invercargill	Manawatu	North Shore	Rodney: Army	Rotarua	Watercare				
			Fielding	Rosedale	Bay - Mech		Mangere				**Number**
mg/kg dry weight	Raw Slg	Wool Scour	Raw Slg	Raw Slg	Dewatered Slg	Primary Slg	Raw Slg				**(from 16)**
Lab No:	116836/1	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	3.7	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
bis(2-chloroethoxy)methane	<1.6	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
bis(2-chloroethyl)ether	<1.6	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
bis(2-chloroisopropyl)ether	<1.6	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
hexachlorobutadiene	<1.6	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
hexachlorocyclopentadiene	<1.6	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
hexachloroethane	<1.6	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0

ANAEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua
	Bromley	Bromley	Bromley 17/3	Bromley 17/4	Bromley	Levin	Levin	Levin
mg/kg dry weight	Digester Slg	Slg lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digested Slg	Slg Lagoon	Air Dries ex Beds
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4
VOCs % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8
bromodichloromethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
bromoform (tribromomethane)	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
bromomethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
carbon tetrachloride	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
chloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
chloroform (trichloromethane)	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
chloromethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
dibromochloromethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,2-dibromo-3-chloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,2-dibromomethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
dibeomomethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
Dichlorodifluoromethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,1-dichloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,2-dichloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,1-dichloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
cis-1,2-dichloroethane	**2.35**	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
trans-1,2-dichloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
tichloromethane (methylene chloride)	<11.8	<10	<2	<4	<0.1	<2.4	<2	<6
1,2-dichloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,3-dichloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
2,2-dichloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,1-dichloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
cis-1,3-dichloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
trans-1,3-dichloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
hexachlorobutadiene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,1,1,2-tetrachloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,1,2,2- tetrachloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
tetrachloroethane	<0.59	<1	<0.2	<0.4	<0.01	**0.88**	<0.2	<0.6
1,1,1-tetrachloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,1,2-tetrachloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
trichloroethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
trichloroflouromethane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,2,3-trichloropropane	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6
1,1,2-trichlorotriflouroethane	<5.9	<5	<0.9	<2	<0.06	<1.18	<1	<3
vinyl chloride	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6

ANAEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Hutt	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore
	Wainuiomata	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale
mg/kg dry weight	Digester Slg	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered
Lab No:	116891/2	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4
VOCs % Dry Solids	4.0	30.9	4.1	34.8	1.5	74.9	1.7	20.1
bromodichloromethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
bromoform (tribromomethane)	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
bromomethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
carbon tetrachloride	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
chloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
chloroform (trichloromethane)	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
chloromethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
dibromochloromethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,2-dibromo-3-chloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,2-dibromomethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
dibeomomethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
Dichlorodifluoromethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,1-dichloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,2-dichloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,1-dichloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
cis-1,2-dichloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
trans-1,2-dichloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
tichloromethane (methylene chloride)	<10	<1	<1.0	<0.4	<2.7	<0.4	<2.4	<1
1,2-dichloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,3-dichloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
2,2-dichloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,1-dichloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
cis-1,3-dichloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
trans-1,3-dichloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
hexachlorobutadiene	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,1,1,2-tetrachloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,1,2,2- tetrachloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
tetrachloroethane	<0.5	<0.1	**0.27**	**0.04**	<0.27	<0.04	<0.24	<0.1
1,1,1-tetrachloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,1,2-tetrachloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
trichloroethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
trichloroflouromethane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,2,3-trichloropropane	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1
1,1,2-trichlorotriflouroethane	<5	<0.5	<0.5	<0.2	<1.3	<0.2	<1.18	<0.5
vinyl chloride	<0.5	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1

ANAEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Sth. Waikato	Sth. Waikato	Watercare	Watercare	Watercare	Watercare				
	Tokoroa	Tokoroa	Mangere	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Nth. Lagoon	Sth. Lagoon	Digester Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 22)**
Lab No:	116224/2	116224/1	116306/2	116306/4	116306/5	116306/6		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	23.6	13.7	0.9	33.8	44.6	43.3		93.9	0.9	
bromodichloromethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
bromoform (tribromomethane)	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
bromomethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
carbon tetrachloride	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
chloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
chloroform (trichloromethane)	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
chloromethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
dibromochloromethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,2-dibromo-3-chloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,2-dibromomethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
dibeomomethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
Dichlorodifluoromethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,1-dichloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,2-dichloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,1-dichloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
cis-1,2-dichloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		2.35	<0.01	1
trans-1,2-dichloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
tichloromethane (methylene chloride)	<0.8	<1	<2.2	<6	<4	<0.4		--	<0.1	0
1,2-dichloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,3-dichloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
2,2-dichloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,1-dichloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
cis-1,3-dichloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
trans-1,3-dichloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
hexachlorobutadiene	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,1,1,2-tetrachloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,1,2,2- tetrachloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
tetrachloroethane	<0.08	**0.2**	<0.22	<0.6	<0.4	<0.4		0.88	<0.01	4
1,1,1-tetrachloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,1,2-tetrachloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
trichloroethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
trichloroflouromethane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,2,3-trichloropropane	<0.08	<0.1	<0.22	<0.6	<0.4	<0.4		-	<0.01	0
1,1,2-trichlorotriflouroethane	<0.4	<0.7	<0.89	<3	<2	<0.2		-	<0.06	0
vinyl chloride	<0.08	<0.1	<0.22	<0.6	<0.4	<0.04		-	<0.01	0

ANAEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua
	Bromley	Bromley	Bromley 17/3	Bromley 17/4	Bromley	Levin	Levin	Levin
mg/kg dry weight	Digester Slg	Slg lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digested Slg	Slg Lagoon	Air Dries ex Beds
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4
SVOCs % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8
bis(2-chloroethoxy)methane	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5
bis(2-chloroethyl)ether	**1.8**	<20	<4	<4	<0.8	<1.2	<9	<5
bis(2-chloroisopropyl)ether	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5
hexachlorobutadiene	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5
hexachlorocyclopentadiene	<1.2	<20	<4	<4	<0.8	<2.4	<9	<5
hexachloroethane	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5

ANAEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Hutt	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore
	Wainuiomata	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale
mg/kg dry weight	Digester Slg	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered
Lab No:	116891/2	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4
SVOCs % Dry Solids	4.0	30.9	4.1	34.8	1.5	74.9	1.7	20.1
bis(2-chloroethoxy)methane	<0.5	<3	<1.5	<2	<0.67	<2	<1.2	<4
bis(2-chloroethyl)ether	<0.5	<3	<1.5	<2	<0.67	<2	<1.2	<4
bis(2-chloroisopropyl)ether	<0.5	<3	<1.5	<2	<0.67	<2	<1.2	<4
hexachlorobutadiene	<0.5	<3	<1.5	<2	<0.67	<2	<1.2	<4
hexachlorocyclopentadiene	<0.5	<3	<1.5	<2	<0.67	<2	<1.2	<4
hexachloroethane	<0.5	<3	<1.5	<2	<0.67	<2	<1.2	<4

ANAEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Sth. Waikato	Sth. Waikato	Watercare	Watercare	Watercare	Watercare				
	Tokoroa	Tokoroa	Mangere	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Nth. Lagoon	Sth. Lagoon	Digester Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 22)**
Lab No:	116224/2	116224/1	116306/2	116306/4	116306/5	116306/6		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	23.6	13.7	0.9	33.8	44.6	43.3		93.9	0.9	
bis(2-chloroethoxy)methane	<3	<6	<1	<2	<2	<2		-	<0.5	0
bis(2-chloroethyl)ether	<3	<6	<1	<2	<2	<2		1.8	<0.5	1
bis(2-chloroisopropyl)ether	<3	<6	<1	<2	<2	<2		-	<0.5	0
hexachlorobutadiene	<3	<6	<1	<2	<2	<2		-	<0.5	0
hexachlorocyclopentadiene	<3	<6	<1	<2	<2	<2		-	<0.5	0
hexachloroethane	<3	<6	<1	<2	<2	<2		-	<0.5	0

AEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR?DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
VOCs % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
bromodichloromethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
bromoform (tribromomethane)	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
bromomethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
carbon tetrachloride	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
chloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
chloroform (trichloromethane)	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
chloromethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
dibromochloromethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,2-dibromo-3-chloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,2-dibromomethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
dibeomomethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
Dichlorodifluoromethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1-dichloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,2-dichloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1-dichloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
cis-1,2-dichloroethane	<0.23	<0.2	**0.91**	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
trans-1,2-dichloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
tichloromethane (methylene chloride)	<4.7	<2	<8.7	<11.8	<2.7	<2	<6	<1	<2
1,2-dichloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,3-dichloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
2,2-dichloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1-dichloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
cis-1,3-dichloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
trans-1,3-dichloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
hexachlorobutadiene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1,1,2-tetrachloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1,2,2- tetrachloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
tetrachloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1,1-tetrachloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1,2-tetrachloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
trichloroethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
trichloroflouromethane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,2,3-trichloropropane	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,1,2-trichlorotriflouroethane	<2.3	<1	<3.9	<5.9	<1.33	<0.8	<3	<0.7	<0.8
vinyl chloride	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2

AEROBIC SLUDGES HALOGENATED HYDROCARBONS

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	14.9	4.2	29.6	0.9	1.4				
bromodichloromethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
bromoform (tribromomethane)	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
bromomethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
carbon tetrachloride	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
chloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
chloroform (trichloromethane)	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
chloromethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
dibromochloromethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,2-dibromo-3-chloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,2-dibromomethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
dibeomomethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
Dichlorodifluoromethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,1-dichloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,2-dichloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,1-dichloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
cis-1,2-dichloroethane	<0.1	<0.4	<0.06	<2.2	<1		0.91	<0.06	1
trans-1,2-dichloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
tichloromethane (methylene chloride)	<1	<4	<0.6	<44	<10		-	<0.6	0
1,2-dichloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,3-dichloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
2,2-dichloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,1-dichloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
cis-1,3-dichloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
trans-1,3-dichloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
hexachlorobutadiene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,1,1,2-tetrachloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,1,2,2- tetrachloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
tetrachloroethane	<0.1	<0.4	<0.06	<2.2	<1		0.08	<0.1	10
1,1,1-tetrachloroethane	<0.1	<0.4	**0.08**	<2.2	<1		-	<0.06	0
1,1,2-tetrachloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
trichloroethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
trichloroflouromethane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,2,3-trichloropropane	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,1,2-trichlorotriflouroethane	<0.6	<2	<0.3	<22	<7		-	<0.3	0
vinyl chloride	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0

AEROBIC SLUDGES HALOGENATED HYDROCARBONS

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
SVOCs % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
bis(2-chloroethoxy)methane	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
bis(2-chloroethyl)ether	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
bis(2-chloroisopropyl)ether	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
hexachlorobutadiene	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
hexachlorocyclopentadiene	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
hexachloroethane	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7

AEROBIC SLUDGES **HALOGENATED HYDROCARBONS**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
bis(2-chloroethoxy)methane	<6	<20	<3	<5	<60		-	<0.5	0
bis(2-chloroethyl)ether	<6	<20	<3	<5	<60		-	<0.5	0
bis(2-chloroisopropyl)ether	<6	<20	<3	<5	<60		-	<0.5	0
hexachlorobutadiene	<6	<20	<3	<5	<60		-	<0.5	0
hexachlorocyclopentadiene	<6	<20	<3	<5	<60		-	<0.5	0
hexachloroethane	<6	<20	<3	<5	<60		-	<0.5	0

POND SEDIMENT/COMPOST **HALOGENATED HYDROCARBONS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
VOCs % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
bromodichloromethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
bromoform (tribromomethane)	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
bromomethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
carbon tetrachloride	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
chloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
chloroform (trichloromethane)	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
chloromethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
dibromochloromethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,2-dibromo-3-chloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,2-dibromomethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
dibeomomethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
Dichlorodifluoromethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1-dichloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,2-dichloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1-dichloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
cis-1,2-dichloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
trans-1,2-dichloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
tichloromethane (methylene chloride)	<0.6	<8.3	<2.2	<0.43	<2	<11	<10	<1.5
1,2-dichloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,3-dichloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
2,2-dichloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1-dichloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
cis-1,3-dichloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
trans-1,3-dichloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
hexachlorobutadiene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1,1,2-tetrachloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1,2,2- tetrachloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
tetrachloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1,1-tetrachloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1,2-tetrachloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
trichloroethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
trichloroflouromethane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,2,3-trichloropropane	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,1,2-trichlorotriflouroethane	<0.3	<4.2	<0.89	<0.17	<1	<5.6	<7	<0.62
vinyl chloride	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15

POND SEDIMENT/COMPOST **HALOGENATED HYDROCARBONS**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
bromodichloromethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
bromoform (tribromomethane)	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
bromomethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
carbon tetrachloride	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
chloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
chloroform (trichloromethane)	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
chloromethane	<0.22	<0.2	**1.3**	<0.2		<0.04	<0.1		1.3	<0.04	1
dibromochloromethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,2-dibromo-3-chloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,2-dibromomethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
dibeomomethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
Dichlorodifluoromethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1-dichloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,2-dichloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1-dichloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
cis-1,2-dichloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
trans-1,2-dichloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
tichloromethane (methylene chloride)	<2.2	<2	<1	<2		<0.4	<1		-	<0.4	0
1,2-dichloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,3-dichloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
2,2-dichloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1-dichloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
cis-1,3-dichloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
trans-1,3-dichloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
hexachlorobutadiene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1,1,2-tetrachloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1,2,2- tetrachloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
tetrachloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1,1-tetrachloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1,2-tetrachloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
trichloroethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
trichloroflouromethane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,2,3-trichloropropane	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,1,2-trichlorotriflouroethane	<0.9	<0.8	<0.5	<1		<0.2	<0.6		-	<0.17	0
vinyl chloride	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0

POND SEDIMENT/COMPOST **HALOGENATED HYDROCARBONS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
SVOCs % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
bis(2-chloroethoxy)methane	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
bis(2-chloroethyl)ether	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
bis(2-chloroisopropyl)ether	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
hexachlorobutadiene	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
hexachlorocyclopentadiene	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
hexachloroethane	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8

POND SEDIMENT/COMPOST **HALOGENATED HYDROCARBONS**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
bis(2-chloroethoxy)methane	<2	<2	<4	<9		<2	<5		-	<0.4	0
bis(2-chloroethyl)ether	<2	<2	<4	<9		<2	<5		-	<0.4	0
bis(2-chloroisopropyl)ether	<2	<2	<4	<9		<2	<5		-	<0.4	0
hexachlorobutadiene	<2	<2	<4	<9		<2	<5		-	<0.4	0
hexachlorocyclopentadiene	<2	<2	<4	<9		<2	<5		-	<0.4	0
hexachloroethane	<2	<2	<4	<9		<2	<5		-	<0.4	0

SECTION 4

HALOGENATED AROMATICS

ANALYTICAL METHODOLOGY

Extraction: Solids - VOCs

Based on US-EPA methods 8260 and 624. A representative sub-sample of the samples was obtained using several cores. Samples were extracted into methanol using sonication. The methanol was poured off into a vial, and stored at 4°C until extraction/analysis. A methanol extraction blank was included with every worksheet, or twenty samples.

An aliquot of the methanol extract was added to an aliquot of water immediately prior to analysis. Final extraction/analysis was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous/methanol phase on to a VOCARB4000 trap. Surrogates of approximately 0.25 mg/kg equivalent in the solid (assuming 100% dry matter) were added prior to extraction.

Extraction: Liquids - VOCs

Based on US-EPA methods 8260 and 624. Extraction was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous phase on to a VOCARB4000 trap. Surrogates of 10 µg/L equivalent in the liquid were added prior to extraction.

Instrumental Analysis - VOCs

VOC compounds were determined by full scan GC-MS (based on US-EPA method 8260). Quantitation was performed using internal standardisation and a continuing calibration curve for all target compounds.

Extraction: Solids - SVOCs

Based on USEPA method 3545. Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 333 and 667 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction: Liquids - SVOCs

Based on USEPA method 3520A. Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 12.5 and 25 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup - SVOCs

An aliquot of each extract was cleaned up by gel permeation chromatography (USEPA method 3640).

Instrumental Analysis - SVOCs

SVOC compounds were determined by full scan GC-MS (based on USEPA method 8270). Quantitation was performed using internal standardisation and a 4 point calibration curve for all target compounds

Quality Control

For SVOC and VOC compounds, an extraction blank was run with every worksheet, or twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples had surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

Results of both the volatile and semivolatile (VOC and SVOC) halogenated aromatic chemicals appear in Tables B4.1 - B4.4. Some previous New Zealand results appear in Table 6.5 in Part A. Some results from an Eastern Canadian survey appear in Table 7.3.

In this report, aromatic chemicals are derivatives of benzene which is a ring comprising six carbon atoms sharing double bonds. Halogenated means substitution of a hydrogen atom by chloride or bromide atoms. Sometimes the benzene base is called phenyl.

The halogenated aromatics were included in this survey because some can interfere in biological treatment processes and because some are fairly stable in the environment. Given time, the VOCs are likely to disperse to the atmosphere, so their main interest will probably be whether their concentrations are likely to affect the treatment process.

The USEPA priority pollutants list includes: 4-bromophenylphenylether, chlorobenzene, 4-chlorophenylphenylether, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene.

Discussion

Only 3 of the 11 halogenated aromatics reported were found at concentrations above their limit of detection in this survey: they were 1,4-dichlorobenzene, 1,2-dichlorobenzene and 2- chlorotoluene.

The chemical that was found most frequently was 1,4-dichlorobenzene, which is also called paradichlorobenzene or p-dichlorobenzene. It was found in 12 of 16 raw sludges (at a maximum of 2 mg/kg in Levin raw sludge, median 0.50); in 18 of 22 anaerobic sludges (maximum 1.8 mg/kg in Bromley digested sludge, median 0.55); in 2 of 14 aerobic sludges (maximum 0.9 mg/kg in Carterton aerobic sludge); and 3 of 14 pond sediments (but in neither of the composts) at a maximum of 0.56 mg/kg in Belfast pond sediments.

The maximum values of 1,4-dichlorobenzene fell and the frequency of finding it reduced along the sequence of raw sludge to pond sediments, implying that 1,4-dichlorobenzene is slowly broken down in sewage sludge. 1,4-Dichlorobenzene is a sweet smelling chemical used widely for odour control in public toilets. It has also been used as an insect fumigant and to protect clothes against moths.

1,2-Dichlorobenzene, which is also called orthodichlorobenzene or o-dichlorobenzene, was found in 3 of 22 anaerobic sludges, with a maximum of 0.9 mg/kg in one of the Tokoroa ponds; sludge from the other Tokoroa pond also contained some 1,4-dichlorobenzene. The mean concentration was 0.6 mg/kg. It has been used as a solvent for waxes, gums, resins, oils, tars, asphalts, and rubbers. It can be used as an insect fumigant, and as a degreasing agent for metals, leather and wool.

2-Chlorotoluene, also known as meta-chlorotoluene or m-chlorotoluene, was found in one of the 14 aerobic sludges, at 0.3 mg/kg in sludge from the Paraparaumu lagoon.

1,4-Dichlorobenzene (in 3 of 3 samples) and 1,2-dichlorobenzene (in 1 of 3 samples) were found in New Zealand sludge samples tested earlier - refer Table 6.5 in Part A.

1,2-Dichlorobenzene, 1,3-dichlorobenzene and 1,4-dichlorobenzene were found in most sludge samples tested in the Eastern Canada survey, although at very low levels - for example 1,4- dichlorobenzene was at about a tenth the concentration found in the New Zealand survey. The Canadian study also found chlorobenzene in most samples, but at a maximum of only 0.005 mg/kg - the limit of detection in the New Zealand study was at least 10 times higher than this. Chlorobenzene can be used as a solvent in paints.

Halogenated aromatics in sewage sludges do not appear to be regulated in any national standards etc

RAW SLUDGES **HALOGENATED AROMATICS**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
Mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
VOCs % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
Bromobenzene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
Chlorobenzene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
2-chlorotoluene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
4-chlorotoluene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
1,2-dichlorobenzene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
1,3-dichlorobenzene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
1,4-dichlorobenzene	<0.25	**0.5**	**0.9**	**0.27**	**0.7**	**0.82**	**2**	<0.6	**0.7**	**1.62**
1,2,3-trichlorobenzene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
1,2,4-trichlorobenzene	<0.25	<0.4	<0.29	<0.03	<0.4	<0.06	<1	<0.6	<0.2	<0.27
SVOCs										
4-chlorophenylphenylether	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
hexachlorobenzene	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6

RAW SLUDGES **HALOGENATED AROMATICS**

Local Body	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
		Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
Mg/kg dry weight	Wool Scour	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 14)**
Lab No:	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
Bromobenzene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
Chlorobenzene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
2-chlorotoluene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
4-chlorotoluene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
1,2-dichlorobenzene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
1,3-dichlorobenzene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
1,4-dichlorobenzene	<0.08	<0.8	**0.50**	**0.2**	**0.52**	**0.13**		2	<0.08	12
1,2,3-trichlorobenzene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
1,2,4-trichlorobenzene	<0.08	<0.8	<0.30	<1.0	<0.29	<0.05		-	<0.03	0
SVOCs										
4-chlorophenylphenylether	<0.6	<30	<0.67	<0.4	<0.65	<0.5		-	<0.5	0
hexachlorobenzene	<0.6	<30	<0.67	<0.4	<0.65	<0.5		-	<0.5	0

ANAEROBIC SLUDGES **HALOGENATED AROMATICS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
Mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
VOCs % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
Bromobenzene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
Chlorobenzene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
2-chlorotoluene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
4-chlorotoluene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
1,2-dichlorobenzene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
1,3-dichlorobenzene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
1,4-dichlorobenzene	**1.76**	<1	**0.8**	**0.4**	<0.01	**1.06**	**0.3**	**0.8**	<0.5
1,2,3-trichlorobenzene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
1,2,4-trichlorobenzene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.5
SVOCs									
4-chlorophenylphenylether	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<05
hexachlorobenzene	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<05

ANAEROBIC SLUDGES **HALOGENATED AROMATICS**

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa
Mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1
VOCs % Dry Solids	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7
Bromobenzene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
Chlorobenzene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
2-chlorotoluene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
4-chlorotoluene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
1,2-dichlorobenzene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	**0.12**	<0.1
1,3-dichlorobenzene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
1,4-dichlorobenzene	<0.1	**0.9**	**0.90**	**0.33**	**0.04**	**0.41**	**0.3**	**0.28**	**1.5**
1,2,3-trichlorobenzene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
1,2,4-trichlorobenzene	<0.1	<0.1	<0.04	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
SVOCs									
4-chlorophenylphenylether	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
hexachlorobenzene	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6

ANAEROBIC SLUDGES **HALOGENATED AROMATICS**

Local Body	Watercare	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere	Mangere				**Number**
Mg/kg dry weight	Digester Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 14)**
Lab No:	116306/2	116306/4	116306/5	116306/6		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	0.9	33.8	44.6	43.3		93.9	0.9	
Bromobenzene	<0.22	<0.6	<0.4	<0.04		-	<0.01	0
Chlorobenzene	<0.22	<0.6	<0.4	<0.04		-	<0.01	0
2-chlorotoluene	<0.22	<0.6	<0.4	<0.04		-	<0.01	0
4-chlorotoluene	<0.22	<0.6	<0.4	<0.04		-	<0.01	0
1,2-dichlorobenzene	<0.22	<0.6	<0.4	<0.04		0.9	<0.01	0
1,3-dichlorobenzene	<0.22	<0.6	<0.4	<0.04		-	<0.01	0
1,4-dichlorobenzene	**1.11**	**0.6**	<0.4	**0.04**		1.76	<0.01	17
1,2,3-trichlorobenzene	<0.22	<0.6	<0.4	<0.04		-	<0.01	0
1,2,4-trichlorobenzene	<0.22	<0.6	<0.4	<0.04		-	<0.01	0
SVOCs								
4-chlorophenylphenylether	<1	<2	<2	<2		-	<0.5	0
hexachlorobenzene	<1	<2	<2	<2		-	<0.5	0

AEROBIC SLUDGES HALOGENATED AROMATICS

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
Mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
VOCs % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
Bromobenzene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
Chlorobenzene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
2-chlorotoluene	<0.23	<0.2	<0.39	<0.59	<0.27	**0.3**	<0.6	<0.1	<0.2
4-chlorotoluene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,2-dichlorobenzene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,3-dichlorobenzene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,4-dichlorobenzene	**0.93**	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,2,3-trichlorobenzene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
1,2,4-trichlorobenzene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
SVOCs									
4-chlorophenylphenylether	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
hexachlorobenzene	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7

AEROBIC SLUDGES **HALOGENATED AROMATICS**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
Mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
Bromobenzene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
Chlorobenzene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
2-chlorotoluene	<0.1	<0.4	<0.06	<2.2	<1		0.3	<0.06	1
4-chlorotoluene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,2-dichlorobenzene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,3-dichlorobenzene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,4-dichlorobenzene	<0.1	<0.4	**0.13**	<2.2	<1		0.93	<0.1	2
1,2,3-trichlorobenzene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
1,2,4-trichlorobenzene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
SVOCs									
4-chlorophenylphenylether	<6	<20	<3	<5	<60		-	<0.5	0
hexachlorobenzene	<6	<20	<3	<5	<60		-	<0.5	0

POND SEDIMENTS/COMPOST **HALOGENATED AROMATICS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
Mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
VOCs % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
Bromobenzene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
Chlorobenzene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
2-chlorotoluene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
4-chlorotoluene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,2-dichlorobenzene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,3-dichlorobenzene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,4-dichlorobenzene	<0.06	<0.42	**0.56**	**0.09**	<0.2	<0.56	<1	<0.15
1,2,3-trichlorobenzene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
1,2,4-trichlorobenzene	<0.06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
SVOCs								
4-chlorophenylphenylether	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
hexachlorobenzene	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8

POND SEDIMENTS/COMPOST **HALOGENATED AROMATICS**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
Mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
Bromobenzene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
Chlorobenzene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
2-chlorotoluene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
4-chlorotoluene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,2-dichlorobenzene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,3-dichlorobenzene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,4-dichlorobenzene	<0.22	<0.2	**0.17**	<0.2		<0.04	<0.1		0.56	<0.04	3
1,2,3-trichlorobenzene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
1,2,4-trichlorobenzene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
SVOCs											
4-chlorophenylphenylether	<2	<2	<4	<9		<2	<5		-	<0.4	0
hexachlorobenzene	<2	<2	<4	<9		<2	<5		-	<0.4	0

SECTION 5

AROMATICS

ANALYTICAL METHODOLOGY

Extraction: Solids - VOCs

Based on US-EPA methods 8260 and 624. A representative sub-sample of the samples was obtained using several cores. Samples were extracted into methanol using sonication. The methanol was poured off into a vial, and stored at 4°C until extraction/analysis. A methanol extraction blank was included every worksheet, or 20 samples.

An aliquot of the methanol extract was added to an aliquot of water immediately prior to analysis. Final extraction/analysis was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous/methanol phase on to a VOCARB4000 trap. Surrogates of approximately 0.25 mg/kg equivalent in the solid (assuming 100% dry matter) were added prior to extraction.

Extraction: Liquids - VOCs

Based on US-EPA methods 8260 and 624. Extraction was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous phase on to a VOCARB4000 trap. Surrogates of 10 µg/L equivalent in the liquid were added prior to extraction.

Instrumental Analysis - VOCs

VOC compounds were determined by full scan GC-MS (based on US-EPA method 8260). Quantitation was performed using internal standardisation and a continuing calibration curve for all target compounds.

Extraction: Solids - SVOCs

Based on USEPA method 3545. Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 333 and 667 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction: Liquids - SVOCs

Based on USEPA method 3520A. Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 12.5 and 25 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup - SVOCs

An aliquot of each extract was cleaned up by gel permeation chromatography (USEPA method 3640).

Instrumental Analysis - SVOCs

SVOC compounds were determined by full scan GC-MS (based on USEPA method 8270). Quantitation was performed using internal standardisation and a 4 point calibration curve for all target compounds.

Quality Control

For SVOC and VOC compounds, an extraction blank is run with every worksheet, or twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples have surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

Results of both the volatile and semivolatile (VOC and SVOC) aromatic chemicals appear in Tables B5.1 - B5.4. Some previous New Zealand results appear in Table 6.6 in Part A. Some results from an Eastern Canadian survey appear in Table 7.4.

In this report, aromatic chemicals are derivatives of benzene which is a ring comprising six carbon atoms sharing double bonds.

The aromatics include the four chemicals often referred to as BTEX: benzene, toluene, ethylbenzene and xylene.

The aromatics were included in this survey because some can interfere in biological treatment processes and because some are fairly stable in the environment. Given time, the VOCs are likely to disperse to the atmosphere, so their main interest will probably be whether their concentrations are likely to affect the treatment process.

The USEPA priority pollutants list includes benzene, ethylbenzene, nitrobenzene, toluene, 2,4-dinitrotoluene and 2,6-dinitrotoluene.

Discussion

The 4 SVOC aromatics were below their limit of detection (LOD) in all 66 sludge samples. The benzyl alcohol results are indicative only, due to some problems with interferences.

Results for 13 VOC aromatics were reported. Tertiary butylbenzene was the only one not found above its LOD. Some others were found in very high concentrations. All those detected are common components of petroleum, crude or refined oils, or vehicle exhausts. Some may also be used as solvents in industry, for paints etc.

Benzene was found in 2 of 16 raw sludges, 6 of 22 anaerobic sludges, 1 of 14 aerobic sludges (Otaki clarifier), and 1 of 14 pond sediments (North Shore), all near or below 1 mg/kg. The highest raw sludge concentration was in the Hutt Milliscreenings. The anaerobic sample with the highest concentration was digested sludge from Mangere.

N-butylbenzene was found in 6 of 16 raw sludges, 12 of 22 anaerobic sludges, 2 of 14 aerobic sludges, and 2 of 14 pond sediments, all near or below 3 mg/kg. The highest raw sludge concentrations were in the Invercargill raw sludge and Hutt milliscreenings. The anaerobic sample with the highest concentration was from the Bromley lagoon. The pond sediments from Pleasant Point and North Shore contained some n-butylbenzene.

Sec-butylbenzene was found in 5 of 16 raw sludges, 6 of 22 anaerobic sludges, but in none of the aerobic sludges or pond sediments; concentrations were near or below 0.5 mg/kg. The highest raw sludge concentrations were in the Invercargill and North Shore raw sludges. The anaerobic samples with the highest concentrations were the Bromley dewatered sludge and Mangere digested sludge.

Ethylbenzene was found in 7 of 16 raw sludges, 7 of 22 anaerobic sludges, 2 of 14 aerobic sludges, but none of the 14 pond sediments, all near or below 3 mg/kg. The highest raw sludge concentrations were in the Invercargill raw sludge and Hutt milliscreenings. The anaerobic samples with the highest concentrations were Mangere digested sludge and Invercargill airdried sludge. Aerobic sludges contained less than 0.1 mg/kg.

Isopropylbenzene (or cumene) was found in 5 of 16 raw sludges, in 4 of 22 anaerobic sludges, but in none of the aerobic sludges or pond sediments; concentrations were near or below 0.5 mg/kg. The highest raw sludge concentrations were in the Invercargill raw sludge and Hutt milliscreenings. The anaerobic sample with the highest concentration was Mangere digested sludge.

N-propylbenzene was found in 8 of 16 raw sludges, 11 of 22 anaerobic sludges, but in none of the aerobic sludges or pond sediments; concentrations in all except one sample were near or below 0.9 mg/kg. The highest raw sludge concentrations were in the Invercargill raw sludge (3.5 mg/kg) and Hutt milliscreenings. The anaerobic samples with the highest concentrations were Mangere and Bromley digested sludges.

4-Isopropyltoluene (or cymene) was found in 13 of 16 raw sludges (median 1.08 mg/kg), 17 of 22 anaerobic sludges (median 1.02 mg/kg), 4 of 14 aerobic sludges, and 3 of 14 pond sediments. Five of the samples contained more than 10 mg/kg. The highest raw sludge concentrations were in the Rotorua raw sludge (25.5) and the Templeton Imhoff sample (19 mg/kg). The anaerobic samples with the highest levels were the North Shore digested (18.5) and North Shore dewatered (17.3 mg/kg) samples. One of the Carterton aerobic sludge samples contained 18.1 mg/kg (the other contained 3 mg/kg). Some 4-isopropyl-toluene was found in the Inglewood and Pleasant Point pond sediments. A trace was detected in the Rotorua compost sample too - the only aromatic in either of the compost samples.

Toluene was found in all 16 raw sludges (median 1.74 mg/kg), 16 of 22 anaerobic sludges (median 0.54 mg/kg), 13 of 14 aerobic sludges (median 53.5 mg/kg), and in 6 of the 14 pond sediments. Eleven of the samples contained more than 75 mg/kg. The highest raw sludge concentrations were from Invercargill (524), Templeton Imhoff sample (185), Wainuiomata (91) and Carterton (78 mg/kg). The anaerobic samples with the highest levels were Levin lagoon (41.2), Invercargill digested (38.5) and Wainuiomata airdried (26.4 mg/kg). Seven of the aerobic sludge samples contained more than 100 mg/kg of toluene! They were Te Puke WAS (758), Bromley secondary sludge (670), Alexandra (272), Porirua (217), Paraparaumu lagoon (138), Rotorua WAS (125) and Paraparaumu ex DAF (103 mg/kg). The North Shore pond sediment contained 1.1 mg/kg. Toluene was not detected in either compost.

1,2,4-Trimethylbenzene (also known as pseudocumene) was found in 12 of 16 raw sludges (median 1.0 mg/kg), 18 of 22 anaerobic sludges (median 1.9 mg/kg), 6 of 14 aerobic sludges, and 5 of 14 pond sediments. Only one sample contained more than 10 mg/kg. The highest raw sludge concentrations were from Invercargill (28.9), Hutt milliscreenings (6.7) and Wainuiomata (4.8 mg/kg). The anaerobic samples with the highest levels were Bromley lagoon (6.1), Bromley dewatered (3.9 and 3.4) and Bromley digested (2.9 mg/kg). The aerobic sludge samples containing the highest concentrations of 1,2,4-trimethylbenzene were from Alexandra (5.9) and Carterton (4.4 mg/kg). The pond sediments and composts contained less than 0.6 mg/kg.

1,3,5-Trimethylbenzene (also known as mesitylene) was found in 10 of 16 raw sludges (median 0.5 mg/kg), 18 of 22 anaerobic sludges (median 0.65 mg/kg), 3 of 14 aerobic sludges, and 3 of 14 pond sediments. Only two samples contained more than 5 mg/kg. The highest raw sludge concentrations were in the Invercargill raw sludge (9.2) and Hutt milliscreenings (2.2 mg/kg). The anaerobic samples with the highest levels were Bromley digested (2.4), Bromley lagoon (1.9), Mangere digested (1.9) and Bromley dewatered (1.3 and 1.0 mg/kg). The aerobic sludge sample containing the highest concentration of 1,3,5-trimethylbenzene was from Carterton (1.2 mg/kg). The sediments and composts contained less than 0.2 mg/kg.

M-xylene plus p-xylene (also known as 1,3-dimethylbenzene and 1,4-dimethylbenzene) were found in 9 of 16 raw sludges, 9 of 22 anaerobic sludges, 3 of 14 aerobic sludges, but in none of the 14 pond sediments. Only one sample contained more than 5 mg/kg. The highest raw sludge concentrations were from Invercargill (15.9), Hutt milliscreenings (4.2) and Wainuiomata (2.8 mg/kg). The anaerobic samples with the highest levels were Mangere digested (1.6) and North Shore digested (1.0 mg/kg). The aerobic sludge sample containing the highest concentration of m-xylene plus p-xylene was Carterton (2.1 mg/kg).

O-xylene (or 1,2-dimethylbenzene) was found in 9 of 16 raw sludges, 9 of 22 anaerobic sludges, 1 of 14 aerobic sludges, but in none of the 14 pond sediments. Only one sample contained more than 5 mg/kg. The highest raw sludge concentrations were from Invercargill (8.4) and Hutt milliscreenings (2.0 mg/kg). The anaerobic sample with the highest level was Mangere digested (1.1 mg/kg). The only aerobic sludge sample containing o-xylene was Rotorua dewatered largely due to the very low limit of detection obtained for that sample.

The three earlier results from testing New Zealand sludges (Table 6.6 in Part A) also reported aromatics frequently, although at somewhat lower concentrations than in this survey.

The Eastern Canadian study found the SVOC nitrobenzene at the 2-3 mg/kg level which was about the limit of detection in the New Zealand survey; they found one outlier with 127 mg/kg. The Eastern Canadian study found most of the same VOCs that were detected in the New Zealand study although generally at about a half to a tenth the concentrations. They reported results for 1,2-diethylbenzene, 1,3-diethylbenzene and 1,4-diethylbenzene; plus 2-ethyltoluene, 3- ethyltoluene and 4-ethyltoluene as well; 3- and 4-ethyltoluene were reported together. They gave the third highest results and 1,4-diethylbenzene gave the fourth or fifth highest results after toluene and 1,2,4-trimethylbenzene. Presumably if these had been measured in the New Zealand survey they would have reached some quite high concentrations too.

Aromatics in sewage sludges do not appear to be regulated in any national standards etc. RJ Hill Laboratories analysed some digested sludge from the North Shore plant in March 1996, using GC/MS. They reported concentrations for some unofficial (or unconfirmed) identifications of a variety of aromatic hydrocarbons, including a result of 2.3 mg/kg for 1-methy1-3- propylbenzene. Some other aromatic hydrocarbons were tentatively identified as well: 1-methyl2-(1-methylethyl)benzene, 1-ethyl-2-methylbenzene, 1-ethyl-4-methyl-benzene, 1-ethy1-3- methylbenzene, 2-ethyl-1,2-dimethylbenzene, 4-ethyl-1,2-dimethyl-benzene, 1,2,3,4- tetramethylbenzene, 1,2,3,5-tetramethylbenzene and 1,4-diethylbenzene, ranging in concentrations from 1-2 mg/kg. These chemicals originate from the petroleum and oil industry, so they are quite likely to be present in many sludges.

RAW SLUDGES **AROMATICS**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
VOCs % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
benzene	<0.13	<0.2	<0.15	**0.07**	<0.2	<0.03	<0.6	<0.3	**0.13**	<0.14
n-butylbenzene	<0.13	<0.2	<0.15	**0.05**	<0.2	**0.29**	<0.6	**0.6**	**1.10**	**2.43**
sec-butylbenzene	<0.13	<0.2	<0.15	<0.03	<0.2	**0.15**	<0.6	<0.3	**0.22**	**0.54**
tert-butylbenzene	<0.13	<0.2	<0.15	<0.03	<0.2	<0.03	<0.6	<0.3	<0.09	<0.14
ethylbenzene	<0.13	<0.2	<0.15	**0.05**	<0.2	**0.18**	**0.7**	**0.5**	**1.10**	**2.70**
isopropylbenzene	<0.13	<0.2	<0.15	**0.03**	<0.2	**0.10**	<0.6	<0.3	**0.30**	**0.54**
n-propyltoluene	<0.13	**0.3**	<0.15	**0.10**	<0.2	**0.39**	<0.6	**0.5**	**0.92**	**3.51**
4-isopropyltoluenen	<0.13	**0.3**	**19.4**	**0.14**	**0.3**	**0.65**	**2.1**	**1.5**	**4.47**	**2.16**
toluene	**77.5**	**0.5**	**185**	**1.51**	**0.4**	**0.80**	**1.5**	**91.4**	**1.96**	**524**
1,2,4-trimethylbenzene	**0.50**	**0.9**	<0.15	**0.80**	**0.5**	**2.57**	**3.6**	**4.8**	**6.73**	**28.9**
1,3,5-trimethylbenzene	<0.13	**0.6**	<0.15	**0.34**	**0.6**	**1.06**	**1.3**	**1.5**	**2.18**	**9.2**
m & p-xylene	**0.50**	<0.4	<0.15	**0.32**	<0.4	**0.99**	<1	**2.8**	**4.20**	**15.9**
o-xylene	<0.13	**0.3**	<0.15	**0.19**	**0.3**	**0.51**	<0.6	**1.1**	**2.01**	**8.4**
SVOCs										
benzyl alcohol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
Nitrobenzene	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
2,4-dinitroroluene	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
2,6-dinitrotoluene	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6

RAW SLUDGES **AROMATICS**

Local Body	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
		Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry weight	Wool Scour	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 14)**
Lab No:	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
benzene	<0.04	<0.4	<0.15	<0.05	<0.15	<0.02		0.13	<0.02	2
n-butylbenzene	<0.04	<0.4	<0.15	<0.05	<0.15	**0.07**		2.43	<0.04	6
sec-butylbenzene	<0.04	<0.4	**0.40**	<0.05	<0.15	**0.04**		0.54	<0.03	5
tert-butylbenzene	<0.04	<0.4	<0.15	<0.05	<0.15	<0.02		-	<0.02	0
ethylbenzene	<0.04	<0.4	<0.15	<0.05	<0.15	**0.11**		2.7	<0.04	7
isopropylbenzene	<0.04	<0.4	<0.15	<0.05	<0.15	**0.03**		0.54	<0.04	5
n-propyltoluene	<0.04	<0.4	**0.50**	<0.05	<0.15	**0.15**		3.51	<0.04	8
4-isopropyltoluenen	<0.04	<0.4	**4.2**	**0.28**	**25.5**	**0.14**		25.5	<0.04	13
toluene	**0.06**	**0.4**	**2.1**	**0.25**	**15.2**	**0.48**		524	0.06	16
1,2,4-trimethylbenzene	<0.04	<0.4	**1.2**	**0.10**	<0.15	**1.07**		28.9	<0.04	12
1,3,5-trimethylbenzene	<0.04	<0.4	**1.6**	<0.05	<0.15	**0.37**		9.2	<0.04	10
m & p-xylene	**0.09**	<0.4	**0.60**	<0.05	<0.15	**0.48**		15.9	<0.1	9
o-xylene	<0.04	<0.4	**0.40**	<0.05	<0.15	**0.32**		8.4	<0.04	9
SVOCs										
benzyl alcohol	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
Nitrobenzene	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
2,4-dinitroroluene	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
2,6-dinitrotoluene	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0

ANAEROBIC SLUDGES **AROMATICS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
VOCs % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
benzene	<0.3	<0.5	<0.09	<0.2	<0.006	**0.18**	<0.1	<0.3	<0.25
n-butylbenzene	<0.3	**1.7**	**0.72**	**0.4**	<0.006	<0.12	**0.2**	<0.3	<0.25
sec-butylbenzene	<0.3	<0.3	**0.21**	<0.2	<0.006	<0.12	<0.1	<0.3	<0.25
tert-butylbenzene	<0.3	<0.3	<0.09	<0.2	<0.006	<0.12	<0.1	<0.3	<0.25
ethylbenzene	<0.3	<0.3	<0.09	<0.2	<0.006	<0.12	<0.1	<0.3	<0.25
isopropylbenzene	<0.3	<0.3	<0.09	<0.2	<0.006	<0.12	<0.1	<0.3	<0.25
n-propyltoluene	**0.59**	<0.3	**0.40**	**0.3**	<0.006	**0.18**	**0.1**	<0.3	<0.25
4-isopropyltoluenen	**3.53**	**1.2**	**0.76**	**0.6**	<0.006	**2.06**	**3.9**	**3.1**	<0.25
toluene	**0.59**	<0.3	**0.37**	**0.4**	<0.006	**0.41**	**41.2**	**6.5**	**7.8**
1,2,4-trimethylbenzene	**2.94**	**6.1**	**3.87**	**3.4**	<0.006	**2.00**	**0.7**	**2.0**	**1.5**
1,3,5-trimethylbenzene	**2.35**	**1.9**	**1.28**	**1.0**	<0.006	**0.65**	**0.2**	**0.7**	**0.5**
m & p-xylene	<0.3	<1	**0.30**	<0.4	<0.01	<0.24	<0.2	<0.6	<0.25
o-xylene	<0.3	<0.3	**0.24**	<0.2	<0.006	**0.12**	<0.1	<0.3	<0.25
SVOCs									
benzyl alcohol	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5
Nitrobenzene	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5
2,4-dinitroroluene	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5
2,6-dinitrotoluene	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5

ANAEROBIC SLUDGES **AROMATICS**

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa
mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1
VOCs % Dry Solids	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7
benzene	**0.08**	**0.17**	<0.02	<0.27	<0.02	**0.24**	<0.05	<0.04	<0.07
n-butylbenzene	<0.05	**0.39**	**0.34**	<0.13	<0.02	**0.18**	**0.22**	**0.04**	**0.39**
sec-butylbenzene	<0.05	**0.15**	**0.12**	<0.13	<0.02	<0.12	**0.07**	<0.04	**0.17**
tert-butylbenzene	<0.05	<0.05	<0.02	<0.13	<0.02	<0.12	<0.05	<0.04	<0.07
ethylbenzene	**0.12**	**0.15**	**0.30**	<0.13	<0.02	**0.18**	**0.10**	<0.04	**0.08**
isopropylbenzene	<0.05	**0.05**	**0.04**	<0.13	<0.02	<0.12	<0.05	<0.04	<0.07
n-propyltoluene	<0.05	**0.32**	**0.25**	<0.13	<0.02	**0.18**	**0.15**	<0.04	<0.07
4-isopropyltoluenen	<0.05	**3.41**	**1.24**	<0.13	<0.02	**18.5**	**17.3**	**0.13**	**1.14**
toluene	**26.4**	**38.5**	**2.24**	<0.13	<0.02	**0.59**	**0.29**	**0.47**	**3.61**
1,2,4-trimethylbenzene	**0.11**	**2.51**	**1.86**	<0.13	<0.02	**2.12**	**1.22**	**0.41**	**2.98**
1,3,5-trimethylbenzene	**0.06**	**1.00**	**0.79**	<0.13	<0.02	**0.65**	**0.44**	**0.17**	**1.07**
m & p-xylene	<0.1	**0.46**	**0.58**	<0.27	<0.04	**1.00**	**0.30**	**0.08**	**0.04**
o-xylene	<0.05	**0.29**	**0.36**	<0.13	<0.02	**0.53**	**0.16**	<0.04	**0.27**
SVOCs									
benzyl alcohol	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
Nitrobenzene	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
2,4-dinitroroluene	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
2,6-dinitrotoluene	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6

ANAEROBIC SLUDGES **AROMATICS**

Local Body	Watercare	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Digester Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 14)**
Lab No:	116306/2	116306/4	116306/5	116306/6		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	0.9	33.8	44.6	43.3		93.9	0.9	
benzene	**0.10**	<0.3	<0.2	**0.56**		0.56	<0.06	6
n-butylbenzene	**0.53**	**0.3**	<0.2	<0.02		1.7	<0.06	12
sec-butylbenzene	**0.20**	<0.3	<0.2	<0.02		0.21	<0.06	6
tert-butylbenzene	<0.09	<0.3	<0.2	<0.02		-	<0.06	0
ethylbenzene	**0.31**	<0.3	<0.2	<0.02		0.31	<0.06	7
isopropylbenzene	**0.11**	<0.3	<0.2	**0.03**		0.11	<0.06	4
n-propyltoluene	**0.62**	**0.3**	<0.2	<0.02		0.62	<0.06	11
4-isopropyltoluenen	**1.70**	**0.9**	**0.3**	**0.04**		18.5	<0.06	17
toluene	**0.89**	<0.3	<0.2	**0.07**		41.2	<0.06	16
1,2,4-trimethylbenzene	**6.0**	**3.0**	<0.2	**0.08**		6.1	<0.06	18
1,3,5-trimethylbenzene	**1.92**	**1.0**	<0.2	**0.03**		2.35	<0.06	18
m & p-xylene	**1.56**	<0.3	<0.2	**0.06**		1.56	<0.01	9
o-xylene	**1.08**	<0.3	<0.2	**0.02**		1.08	<0.06	9
SVOCs								
benzyl alcohol	<1	<2	<2	<2		-	<0.5	0
Nitrobenzene	<1	<2	<2	<2		-	<0.5	0
2,4-dinitroroluene	<1	<2	<2	<2		-	<0.5	0
2,6-dinitrotoluene	<1	<2	<2	<2		-	<0.5	0

AEROBIC SLUDGES **AROMATICS**

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
VOCs % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
benzene	<0.12	<0.1	<0.2	<0.3	**0.20**	<0.08	<0.3	<0.07	<0.08
n-butylbenzene	<0.12	<0.1	<0.2	<0.3	**0.67**	<0.08	<0.3	<0.07	<0.08
sec-butylbenzene	<0.12	<0.1	<0.2	<0.3	<0.13	<0.08	<0.3	<0.07	<0.08
tert-butylbenzene	<0.12	<0.1	<0.2	<0.3	<0.13	<0.08	<0.3	<0.07	<0.08
ethylbenzene	<0.12	<0.1	<0.2	<0.3	<0.13	**0.09**	<0.3	<0.07	<0.08
isopropylbenzene	<0.12	<0.1	<0.2	<0.3	<0.13	<0.08	<0.3	<0.07	<0.08
n-propyltoluene	<0.12	<0.1	<0.2	<0.3	<0.13	<0.08	<0.3	<0.07	<0.08
4-isopropyltoluenen	**18.1**	**3.2**	<0.2	<0.3	**0.33**	**1.44**	<0.3	<0.07	<0.08
toluene	**3.72**	**0.9**	**670**	**272**	**3.6**	**138**	**103**	**0.11**	**217**
1,2,4-trimethylbenzene	**4.4**	**0.6**	<0.2	**5.9**	**1.00**	**0.12**	<0.3	<0.07	<0.08
1,3,5-trimethylbenzene	**1.16**	**0.2**	<0.2	<0.3	<0.13	<0.08	<0.3	<0.07	<0.08
m & p-xylene	**2.09**	**0.3**	<0.2	<0.3	<0.27	<0.2	<0.6	<0.1	<0.2
o-xylene	<0.12	<0.1	<0.2	<0.3	<0.13	<0.08	<0.3	<0.07	<0.08
SVOCs									
benzyl alcohol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
Nitrobenzene	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
2,4-dinitroroluene	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
2,6-dinitrotoluene	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7

AEROBIC SLUDGES **AROMATICS**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
benzene	<0.06	<0.2	<0.03	<1	<0.7		0.2	<0.03	1
n-butylbenzene	<0.06	<0.2	**0.05**	<1	<0.7		0.67	<0.06	2
sec-butylbenzene	<0.06	<0.2	<0.03	<1	<0.7		-	<0.03	0
tert-butylbenzene	<0.06	<0.2	<0.03	<1	<0.7		-	<0.03	0
ethylbenzene	<0.06	<0.2	**0.04**	<1	<0.7		0.09	<0.06	2
isopropylbenzene	<0.06	<0.2	<0.03	<1	<0.7		-	<0.03	0
n-propyltoluene	<0.06	<0.2	<0.03	<1	<0.7		-	<0.03	0
4-isopropyltoluenen	<0.06	<0.2	<0.03	<1	<0.7		18.1	<0.03	4
toluene	**0.12**	125	**0.18**	<1	**758**		758	0.11	13
1,2,4-trimethylbenzene	<0.06	<0.2	**0.22**	<1	<0.7		5.9	<0.06	6
1,3,5-trimethylbenzene	<0.06	<0.2	**0.09**	<1	<0.7		1.16	<0.06	3
m & p-xylene	<0.1	<0.4	**0.10**	<1	<1		2.09	<0.1	3
o-xylene	<0.06	<0.2	**0.05**	<1	<0.7		0.05	<0.06	1
SVOCs									
benzyl alcohol	<6	<20	<3	<5	<60		-	<0.5	0
Nitrobenzene	<6	<20	<3	<5	<60		-	<0.5	0
2,4-dinitroroluene	<6	<20	<3	<5	<60		-	<0.5	0
2,6-dinitrotoluene	<6	<20	<3	<5	<60		-	<0.5	0

POND SEDIMENT/COMPOST **AROMATICS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
VOCs % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
benzene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	**1.1**	<0.06
n-butylbenzene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	**0.7**	<0.06
sec-butylbenzene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	<0.7	<0.06
tert-butylbenzene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	<0.7	<0.06
ethylbenzene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	<0.7	<0.06
isopropylbenzene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	<0.7	<0.06
n-propyltoluene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	<0.7	<0.06
4-isopropyltoluenen	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	<0.7	<0.06
toluene	<0.03	<0.2	<0.09	<0.02	<0.1	**0.56**	<0.7	<0.06
1,2,4-trimethylbenzene	**0.08**	<0.2	**0.19**	<0.02	<0.1	**0.56**	**1.1**	**0.11**
1,3,5-trimethylbenzene	**0.04**	<0.2	**0.14**	<0.02	<0.1	**0.56**	<0.7	<0.06
m & p-xylene	<0.06	<0.2	<0.22	<0.04	<0.2	<0.3	<1	<0.15
o-xylene	<0.03	<0.2	<0.09	<0.02	<0.1	<0.3	<0.7	<0.06
SVOCs								
benzyl alcohol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
Nitrobenzene	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2,4-dinitroroluene	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2,6-dinitrotoluene	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8

POND SEDIMENT/COMPOST **AROMATICS**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**>LOD**
VOCs % Dry Solids	0.9	1.0	19.9	8.3		50	15.8		50	0.9	
benzene	<0.10	<0.08	<0.05	<0.2		<0.02	<0.06		1.1	<0.02	1
n-butylbenzene	<0.10	<0.08	**0.08**	<0.1		<0.02	<0.06		0.7	<0.02	2
sec-butylbenzene	<0.10	<0.08	<0.05	<0.1		<0.02	<0.06		-	<0.02	0
tert-butylbenzene	<0.10	<0.08	<0.05	<0.1		<0.02	<0.06		-	<0.02	0
ethylbenzene	<0.10	<0.08	<0.05	<0.1		<0.02	<0.06		-	<0.02	0
isopropylbenzene	<0.10	<0.08	<0.05	<0.1		<0.02	<0.06		-	<0.02	0
n-propyltoluene	<0.10	<0.08	<0.05	<0.1		<0.02	<0.06		-	<0.02	0
4-isopropyltoluenen	<0.10	<0.08	**0.10**	<0.1		<0.02	**0.07**		0.56	<0.02	3
toluene	**0.10**	**0.09**	**0.08**	<0.1		<0.02	<0.06		1.1	<0.02	6
1,2,4-trimethylbenzene	<0.10	<0.08	**0.33**	**0.2**		<0.02	<0.06		0.56	<0.02	5
1,3,5-trimethylbenzene	<0.10	<0.08	**0.10**	<0.1		<0.02	<0.06		1.4	<0.02	3
m & p-xylene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
o-xylene	<0.10	<0.08	<0.05	<0.1		<0.02	<0.06		-	<0.02	0
SVOCs											
benzyl alcohol	<2	<2	<5	<9		<2	<5		-	<0.4	0
Nitrobenzene	<2	<2	<5	<9		<2	<5		-	<0.4	0
2,4-dinitroroluene	<2	<2	<5	<9		<2	<5		-	<0.4	0
2,6-dinitrotoluene	<2	<2	<5	<9		<2	<5		-	<0.4	0

SECTION 6

HALOGENATED AND SOME OTHER PHENOLS

ANALYTICAL METHODOLOGY

Extraction - Solids

Based on USEPA method 3545 (SVOCs). Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 333 and 667 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction - Liquids

Based on USEPA method 3520A (SVOCs). Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 12.5 and 25 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup

An aliquot of each extract was cleaned up by gel permeation chromatography (USEPA method 3640).

Instrumental Analysis

The phenolic compounds were determined by full scan GC-MS (based on USEPA method 8270 -SVOCs). Quantitation was performed using internal standardisation and a 4 point calibration curve for all target compounds.

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

Results for the 11 halogenated and other phenols appear in Tables B6.1 - B6.4. Some previous New Zealand results appear in Table 6.9 in Part A. Some results from an Eastern Canadian survey appear in Table 7.7. The pentachlorophenol (PCP) results also appear in the tables for acid herbicides.

The phenolic compounds were included in this survey because many are disinfectants so may interfere in biological treatment processes. Some halogenated phenols are fairly stable in the environment.

The USEPA priority pollutants list includes phenol, 2-chlorophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol, pentachlorophenol, 2-nitrophenol, 4-nitrophenol, 2,4-dinitrophenol, 2,4- dimethylphenol, 4-chloro-3-cresol and 4,6-dinitro-2-cresol.

Discussion

Six of the 11 phenolic compounds reported were below their detection limit in all 66 samples. They were 4-chloro-3-cresol (or 4-chloro-3-methylphenol), 2-chlorophenol, 2,4-dichlorophenol, 2-nitrophenol, 2,4,5-trichlorophenol and 2,4,6-trichlorophenol.

0-cresol (2-methylphenol) was found in 2 of 16 raw sludges, 2 of 22 anaerobic sludges, but in none of 14 aerobic sludges or 14 pond sediments. The two raw sludge samples above the LOD were from the Templeton

Imhoff tank (2.6) and the Invercargill woolscour waste (1.1 mg/kg). The two anaerobic samples were the Mangere lime stabilised sludge (4) and Invercargill digested (2 mg/kg). Cresols are often a component of disinfectants and cleaning fluids.

M-cresol (3-methylphenol) plus p-cresol (4-methylphenol) were found in 15 of 16 raw sludges (median 300 mg/kg), 14 of 22 anaerobic sludges (median 37 mg/kg), 9 of 14 aerobic sludges (median 251 mg/kg), and 2 of 14 pond sediments. Fourteen samples contained more than 500 mg/kg. The highest raw sludge concentrations were from Invercargill (1675), Invercargill woolscour wastes (980), Mangere raw (588), Wainuiomata (570), Bromley raw (541) and Carterton (540 mg/kg). The anaerobic samples with the highest levels were North Shore dewatered (780), Mangere digested (200), North Shore digested (141), Mangere dewatered (131) and Levin airdried (107 mg/kg). The aerobic sludge samples containing the highest levels of m-cresol plus p-cresol were Bromley secondary sludge (2130), Rotorua WAS (1360), Paraparaumu BNR (1010), Rotorua dewatered (910) and Te Puke (800 mg/kg). The pond sediments containing m-cresol plus p-cresol were from Templeton and Bromley; none were found in the compost samples. Cresols are often a component of disinfectants and cleaning fluids.

Phenol (once called carbolic acid) was found in 9 of 16 raw sludges (2 above 10 mg/kg), 13 of 22 anaerobic sludges (9 above 10 mg/kg), 7 of 14 aerobic sludges (all above 10 mg/kg), but in none of the 14 pond sediments or composts. Eighteen of the 66 samples contained more than 10 mg/kg of phenol. The highest raw sludge concentrations were from Army Bay (190 mg/kg) and the Invercargill woolscour wastes (135 mg/kg). The anaerobic samples with the highest levels were Mangere digested (144) and Mangere dewatered (106 mg/kg). The aerobic sludge samples containing the highest levels of phenol were Bromley secondary sludge (161) and New Plymouth dewatered (55 mg/kg). Phenol is frequently used as a component of disinfectants and cleaning fluids.

Only 3 samples contained 2,4-dimethylphenol (also called m-xylenol): the Invercargill woolscour waste (24 mg/kg), Mangere digested (4.4) and Wainuiomata digested sludge (0.8 mg/kg). It is used in some cleaning fluids.

Only 2 samples contained pentachlorophenol (PCP): the Mangere raw sludge (0.06 mg/kg) and Mangere digested sludge (0.04 mg/kg). Refer to the acid herbicides section for further discussion.

Table 6.9 in Part A shows that the only phenol detected above its LOD in other New Zealand sludges was p-cresol, at 380 mg/kg in North Shore digested sludge.

The Canadian study (Table 7.7) shows only 4 phenols were detected above their LODs, but note that they did not report any results for the cresols. They found phenol in sludges at all 5 sites, usually around 3 mg/kg with a maximum of 19 mg/kg, Significantly lower than the New Zealand sludges. They found 2-chlorophenol at 2 sites, at a maximum of 0.2 mg/kg (this was less than the New Zealand LODs). They found 2,4-dimethylphenol at one site, at about 0.03 mg/kg with a maximum value of 0.4 mg/kg, again less than the New Zealand LODs. They found 2,4,6- trichlorophenol in one site, at a mean of about 0.01 mg/kg with a maximum value of 0.2 mg/kg (the New Zealand LOD was about 0.5 mg/kg).

Phenolic compounds (including PCP) in sewage sludges do not appear to be regulated in any national standards etc.

RAW SLUDGES **PHENOLS**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
SVOCs % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
4-chloro-3-cresol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
o-cresol (2-methylphenol)	<0.5	<10	**2.6**	<10	<10	<3	<50	<10	<4	<1.6
m- + p-cresol (3- + 4-methylphenol)	**540**	**541**	**312**	**111**	**114**	**240**	**290**	**570**	<4	**1675**
phenol	**6.5**	<10	**8.8**	<10	<10	3.0	<50	<10	<4	**2.4**
2-chlorophenol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
2,4-dichlorophenol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
2,4-dimethylphenol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
2-nitrophenol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
pentachlorophenol *	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.08	<0.1	<0.04	<0.03
2,4,5-trichlorophenol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
2,4,6-trichlorophenol	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
	* measured with the acidic herbicide suite									

RAW SLUDGES **PHENOLS**

Local Body	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
		Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry weight	Wool Scour	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 14)**
Lab No:	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
4-chloro-3-cresol	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
o-cresol (2-methylphenol)	**1.1**	<30	<0.67	<4	<0.65	<0.5		2.6	<0.5	2
m- + p-cresol (3- + 4-methylphenol)	**980**	**172**	**400**	**230**	**165**	**588**		1675	<4	15
phenol	**135**	<30	**5.0**	**190**	**3.5**	**6.8**		190	<4	9
2-chlorophenol	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
2,4-dichlorophenol	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
2,4-dimethylphenol	**24**	<30	<0.67	<4	<0.65	<0.5		24	<0.5	1
2-nitrophenol	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
pentachlorophenol *	<0.01	<0.3	<0.01	<0.04	<0.006	**0.06**		0.06	<0.006	1
2,4,5-trichlorophenol	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
2,4,6-trichlorophenol	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0

ANAEROBIC SLUDGES **PHENOLS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin
mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4
SVOCs % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8
4-chloro-3-cresol	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5
o-cresol (2-methylphenol)	<1.2	<20	<4	<4	<0.8	<1.2	<255	13<5
m- + p-cresol (3- + 4-methylphenol)	**39**	<20	**53**	**88**	<0.8	**55**	**13**	**1073**
phenol	**4.7**	<20	**48**	**52**	<0.8	**48**	**3**	**5.0**
2-chlorophenol	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5
2,4-dichlorophenol	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5
2,4-dimethylphenol	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5
2-nitrophenol	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5
pentachlorophenol *	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06
2,4,5-trichlorophenol	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5
2,4,6-trichlorophenol	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5
	* measured with the acidic herbicide suite							

ANAEROBIC SLUDGES PHENOLS

Local Body	Hutt	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato
	Wainuiomata	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa
mg/kg dry weight	Digester Slg	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon
Lab No:	116891/2	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2
SVOCs % Dry Solids	4.0	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6
23.64-chloro-3-cresol	<0.05	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3
o-cresol (2-methylphenol)	<0.05	<3	**2**	<2	<0.67	<2	<1.2	<4	<3
m- + p-cresol (3- + 4-methylphenol)	**35**	<3	**82**	<2	<0.67	<2	**141**	**780**	**50**
phenol	**6.3**	<3	**26**	<2	<0.67	<2	<1.2	**27**	**10**
2-chlorophenol	<0.05	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3
2,4-dichlorophenol	<0.05	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3
2,4-dimethylphenol	**0.8**	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3
2-nitrophenol	<0.05	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3
pentachlorophenol *	<0.01	<0.03	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03
2,4,5-trichlorophenol	<0.05	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3
2,4,6-trichlorophenol	<0.05	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3
	* measured with the acidic herbicide suite								

ANAEROBIC SLUDGES **PHENOLS**

Local Body	Sth. Waikato	Watercare	Watercare	Watercare	Watercare				
	Tokoroa	Mangere	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Sth. Lagoon	Digester Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 14)**
Lab No:	116224/1	116306/2	116306/4	116306/5	116306/6		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	13.7	0.9	33.8	44.6	43.3		93.9	0.9	
4-chloro-3-cresol	<6	<1	<2	<2	<2		-	<0.5	0
o-cresol (2-methylphenol)	<6	<1	<2	**4**	<2		4	<0.5	2
m- + p-cresol (3- + 4-methylphenol)	**29**	**200**	**131**	<2	<2		780	<0.67	14
phenol	**27**	**144**	**106**	<2	<2		144	<0.67	13
2-chlorophenol	<6	<1	<2	<2	<2		-	<0.5	0
2,4-dichlorophenol	<6	<1	<2	<2	<2		-	<0.5	0
2,4-dimethylphenol	<6	**4.4**	<2	<2	<2		4.4	<0.67	2
2-nitrophenol	<6	<1	<2	<2	<2		-	<0.5	0
pentachlorophenol *	<0.05	**0.04**	<0.02	<0.02	<0.02		0.04	<0.005	1
2,4,5-trichlorophenol	<6	<1	<2	<2	<2		-	<0.5	0
2,4,6-trichlorophenol	<6	<1	<2	<2	<2		-	<0.5	0

AEROBIC SLUDGES PHENOLS

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
SVOCs % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
4-chloro-3-cresol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
o-cresol (2-methylphenol)	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
m- + p-cresol (3- + 4-methylphenol)	**0.7**	<10	**2130**	**212**	**500**	<7	**1010**	**290**	<7
phenol	<0.5	<10	**161**	**16**	**23**	<7	**40**	**55**	<7
2-chlorophenol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
2,4-dichlorophenol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
2,4-dimethylphenol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
2-nitrophenol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
pentachlorophenol *	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07
2,4,5-trichlorophenol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
2,4,6-trichlorophenol	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
	* measured with the acidic herbicide suite								

AEROBIC SLUDGES **PHENOLS**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
4-chloro-3-cresol	<6	<20	<3	<5	<60		-	<0.5	0
o-cresol (2-methylphenol)	<6	<20	<3	<5	<60		-	<0.5	0
m- + p-cresol (3- + 4-methylphenol)	<6	**1360**	**910**	<5	**800**		2130	0.7	9
phenol	<6	**29**	**45**	<5	<60		161	<0.5	7
2-chlorophenol	<6	<20	<3	<5	<60		-	<0.5	0
2,4-dichlorophenol	<6	<20	<3	<5	<60		-	<0.5	0
2,4-dimethylphenol	<6	<20	<3	<5	<60		-	<0.5	0
2-nitrophenol	<6	<20	<3	<5	<60		-	<0.5	0
pentachlorophenol *	<0.05	<0.2	<0.03	<0.1	<0.6		-	<0.009	0
2,4,5-trichlorophenol	<6	<20	<3	<5	<60		-	<0.5	0
2,4,6-trichlorophenol	<6	<20	<3	<5	<60		-	<0.5	0

POND SEDIMENT/COMPOST **PHENOLS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
SVOCs % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
4-chloro-3-cresol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
o-cresol (2-methylphenol)	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
m- + p-cresol (3- + 4-methylphenol)	<3	**1.3**	<5.5	**4.3**	<10	<1	<50	<0.8
phenol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2-chlorophenol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2,4-dichlorophenol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2,4-dimethylphenol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2-nitrophenol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
pentachlorophenol *	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02
2,4,5-trichlorophenol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2,4,6-trichlorophenol	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
	* measured with the acidic herbicide suite							

POND SEDIMENT/COMPOST **PHENOLS**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
4-chloro-3-cresol	<2	<2	<4	<9		<2	<5		-	<0.4	0
o-cresol (2-methylphenol)	<2	<2	<4	<9		<2	<5		-	<0.4	0
m- + p-cresol (3- + 4-methylphenol)	<2	<2	<4	<9		<2	<5		4.3	<0.8	2
phenol	<2	<2	<4	<9		<2	<5		-	<0.4	0
2-chlorophenol	<2	<2	<4	<9		<2	<5		-	<0.4	0
2,4-dichlorophenol	<2	<2	<4	<9		<2	<5		-	<0.4	0
2,4-dimethylphenol	<2	<2	<4	<9		<2	<5		-	<0.4	0
2-nitrophenol	<2	<2	<4	<9		<2	<5		-	<0.4	0
pentachlorophenol *	<0.04	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.08	0
2,4,5-trichlorophenol	<2	<2	<4	<9		<2	<5		-	<0.4	0
2,4,6-trichlorophenol	<2	<2	<4	<9		<2	<5		-	<0.4	0

SECTION 7

PHTHALATES

ANALYTICAL METHODOLGY

Extraction - Solids

Based on USEPA method 3545 (SVOC). Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 333 and 667 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction - Liquids

Based on USEPA method 3520A (SVOC). Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 12.5 and 25 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup

An aliquot of each extract was cleaned up by gel permeation chromatography (USEPA method 3640 SVOC).

Instrumental Analysis

Phthalate compounds were determined by full scan GC-MS (based on USEPA method 8270 SVOC). Quantitation was performed using internal standardisation and a 4 point calibration curve for all target compounds.

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

The phthalate results from this survey appear in Tables B7.1, 7.2, 7.3 and 7.4. Phthalates are derivatives of phthalic acid - a benzene ring with two adjacent acid groups. Some previous New Zealand results appear in Table 6.7 in Part A. Some results from an Eastern Canadian survey appear in Table 7.5 and a US survey in Table 7.14.

Phthalates were included in this survey because 6 of them [dimethyl, diethyl, di-n-butyl, di-noctyl, bis(2-ethylhexyl), and butylbenzyl] are USEPA priority pollutants and their concentrations therefore seem to be requested quite often in environmental samples by some regulating authorities.

Di-(2-ethylhexyl)adipate is a plasticiser in many synthetic resins and PVC and is readily included with the phthalate analytical suite. It is a determinand of health Significance in the Drinking-Water Standards for New Zealand 1995.

Bis(2-ethylhexyl)phthalate is also called di(2-ethylhexyl)phthalate; and is a determinand of health significance in the Drinking-Water Standards for New Zealand 1995.

Discussion

Bis(2-ethylhexyl)phthalate was found in almost every sample. It was found in 14 of 16 raw sludge samples (median 42 mg/kg), 21 of 22 anaerobic sludges (median 65 mg/kg), 10 of 14 aerobic sludges (median 29 mg/kg), and in 10 of the 14 pond sediments or composts (median 13). Of the 66 samples, 13 contained more than 50 mg/kg of bis(2-ethylhexyl) phthalate. The highest raw sludge concentrations were found in the Tahuna scum (120 mg/kg), Wainuiomata (70), Bromley raw (60) and Tahuna dewatered raw sludge (70 mg/kg). The anaerobic samples with the highest levels were Mangere airdried and Mangere dewatered (150 mg/kg), the two Bromley dewatered sludges 124 and 115 mg/kg) and North Shore dewatered (99). The aerobic sludge samples containing the highest levels of bis(2-ethylhexyl)phthalate were Thames aerated lagoon sludge (67), Rotorua dewatered (46) and Rotorua WAS (40 mg/kg). It was found in both composts.

Bis(2-ethylhexyl)phthalate is used in vacuum pumps. It is also used as a plasticiser in synthetic resins and PVC products. It has been used as a replacement for PCBs in low voltage electrical capacitors.

Di-n-butylphthalate (or n-butylphthalate) was found in 5 samples: in 3 of 16 raw sludges and in 2 of 22 anaerobic sludges. The highest raw sludge concentration was found in Mangere raw sludge (4.5 mg/kg). The anaerobic samples with the highest levels were Mangere dewatered (16 mg/kg and Mangere digested (5.6 mg/kg). Di-n-butylphthalate has been used as an insect repellant in clothing.

Dimethylphthalate was found in 2 samples: in Carterton raw sludge (1 mg/kg) and in Carterton aerobic sludge (1.9 mg/kg). Dimethylphthalate is used in some insect repellant creams. It is also used as a solvent or plasticiser for cellulose acetate and cellulose acetate/butyrate compositions.

Butylbenzylphthalate was found in Mangere raw sludge, at 1 mg/kg. However, the LOD for most other samples was higher than this.

Table 6.7 in Part A shows that bis(2-ethylhexyl)phthalate was found in one of the earlier New Zealand sludge analyses, at 16 mg/kg, which is less than the median values in the present survey.

Table 7.14 shows that bis(2-ethylhexyl)phthalate was found in 92% of sludge samples in a US study, with a maximum of 75 mg/kg.

Phthalates (except dimethylphthalate) were found to be quite common in the Eastern Canadian study (Table 7.5). Bis(2-ethylhexyl)phthalate concentrations appeared to be higher than in the New Zealand samples, averaging about 50-250 mg/kg in the five towns sampled, with a maximum of 450 mg/kg. Butylbenzylphthalate and diethylphthalate were found in most of their samples but at very low levels - lower in fact than their LODs in the New Zealand study. In the Canadian samples di-n-butylphthalate and di-n-octylphthalate averaged about 11 mg/kg and with maxima of about 70 mg/kg, whereas the maximum concentration in the New Zealand study was 16 mg/kg (although the LOD was higher than this for many samples).

Phthalate compounds in sludges do not appear to be regulated in any national standards etc.

RAW SLUDGES **PHTHALATES**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
SVOCS % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
bis(2-ethylhexyl)phthalate	**13**	**60**	**44**	**40**	**120**	**59**	<100	**70**	**13**	**43**
butylbenzylphthalate	<1.0	<20	<1.2	<20	<20	<6	<100	<20	<8	<2.7
di-n-butylphthalate	<1.0	<20	<1.2	<20	<20	<6	<100	<20	<8	<2.7
di-(2-ethylhexyl)adipate	<0.5	<10	<0.6	<10	<20	<3	<50	<10	<4	<1.6
diethylphthalate	<1.0	<20	<1.2	<20	<20	<6	<100	<20	<8	<2.7
dimethylphthalate	<1.0	<20	<1.2	<20	<20	<6	<100	<20	<8	<2.7
di-n-octylphthalate	<1.0	<20	<1.2	<20	<20	<6	<100	<20	<8	<2.7

RAW SLUDGES **PHTHALATES**

Local Body	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
		Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry weight	Wool Scour	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 16)**
Lab No:	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**>LOD**
SVOCS % Dry Solids	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
bis(2-ethylhexyl)phthalate	**1.0**	<60	**20**	**30**	**10**	**35**		120	1	14
butylbenzylphthalate	<1	<60	<1.3	<8	<1.3	1.0		1.0	<1.0	1
di-n-butylphthalate	<1	<60	**2.7**	<8	**1.9**	**4.5**		4.5	<1	3
di-(2-ethylhexyl)adipate	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
diethylphthalate	<1	<60	<1.3	<8	<1.3	<1.0		-	<1	0
dimethylphthalate	<1	<60	<1.3	<8	<1.3	<1.0		1.0	<1	1
di-n-octylphthalate	<1	<60	<1.3	<8	<1.3	<1.0		-	<1	0

ANAEROBIC SLUDGES **PHTHALATES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
SVOCS % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
bis(2-ethylhexyl)phthalate	**24**	**90**	**115**	**124**	<2	**8**	**37**	**90**	**8**
butylbenzylphthalate	<2.4	<40	<8	<8	<2	<2.4	<4	<10	<1
di-n-butylphthalate	<2.4	<40	<8	<8	<2	<2.4	<4	<10	<1
di-(2-ethylhexyl)adipate	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5	<0.5
diethylphthalate	<2.4	<40	<8	<8	<2	<2.4	<4	<10	<1
dimethylphthalate	<2.4	<40	<8	<8	<2	<2.4	<4	<10	<1
di-n-octylphthalate	<2.4	<40	<8	<8	<2	<2.4	<4	<10	<1

ANAEROBIC SLUDGES **PHTHALATES**

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa
mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1
SVOCS % Dry Solids	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7
bis(2-ethylhexyl)phthalate	**42**	**22**	**30**	**2**	**19**	**25**	**99**	**80**	**98**
butylbenzylphthalate	<6	<2.4	<4	<1.3	<4	<2.4	<8	<6	<10
di-n-butylphthalate	<6	<2.4	<4	<1.3	<4	<2.4	<8	<6	<10
di-(2-ethylhexyl)adipate	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
diethylphthalate	<6	<2.4	<4	<1.3	<4	<2.4	<8	<6	<10
dimethylphthalate	<6	<2.4	<4	<1.3	<4	<2.4	<8	<6	<10
di-n-octylphthalate	<6	<2.4	<4	<1.3	<4	<2.4	<8	<6	<10

ANAEROBIC SLUDGES **PHTHALATES**

Local Body	Watercare	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Digester Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 22)**
Lab No:	116306/2	116306/4	116306/5	116306/6		**MAX**	**MIN**	**>LOD**
SVOCS % Dry Solids	0.9	33.8	44.6	43.3		93.9	0.9	
bis(2-ethylhexyl)phthalate	**89**	**150**	**50**	**150**		150	<2	21
butylbenzylphthalate	<2	<4	<4	<4		-	<1	0
di-n-butylphthalate	**5.6**	**16**	<4	<4		16	<1	2
di-(2-ethylhexyl)adipate	<1	<2	<2	<2		-	<1	0
diethylphthalate	<2	<4	<4	<4		-	<1	0
dimethylphthalate	<2	<4	<4	<4		-	<1	0
di-n-octylphthalate	<2	<4	<4	<4		-	<1	0

AERCOBIC SLUDGES **PHTHALATES**

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
SVOCS % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
bis(2-ethylhexyl)phthalate	**6.5**	**40**	**26**	<2.4	**4.7**	**16**	<40	**29**	**19**
butylbenzylphthalate	<0.9	<20	<17	<2.4	<1.3	<10	<40	<10	<10
di-n-butylphthalate	<0.9	<20	<17	<2.4	<1.3	<10	<40	<10	<10
di-(2-ethylhexyl)adipate	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
diethylphthalate	<0.9	<20	<17	<2.4	<1.3	<10	<40	<10	<10
dimethylphthalate	**1.9**	<20	<17	<2.4	<1.3	<10	<40	<10	<10
di-n-octylphthalate	<0.9	<20	<17	<2.4	<1.3	<10	<40	<10	<10

AEROBIC SLUDGES **PHTHALATES**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**>LOD**
SVOCS % Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
bis(2-ethylhexyl)phthalate	<10	**40**	**46**	**67**	<100		67	<2.4	10
butylbenzylphthalate	<10	<40	<6	<11	<100		-	<0.9	10
di-n-butylphthalate	<10	<40	<6	<11	<100		-	<0.9	0
di-(2-ethylhexyl)adipate	<6	<20	<3	<5	<60		-	<0.9	0
diethylphthalate	<10	<40	<6	<11	<100		-	<0.9	0
dimethylphthalate	<10	<40	<6	<11	<100		1.9	<1.3	1
di-n-octylphthalate	<10	<40	<6	<11	<100		-	<0.9	0

POND SEDIMENT/COMPOST **PHTHALATES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
SVOCS % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
bis(2-ethylhexyl)phthalate	**11**	**13**	**67**	<0.9	<20	**17**	<100	<1.5
butylbenzylphthalate	<6	<1.6	<5.5	<0.9	<20	<2	<100	<1.5
di-n-butylphthalate	<6	<1.6	<4.4	<0.9	<20	<2	<100	<1.5
di-(2-ethylhexyl)adipate	<3	<0.8	<2.2	<0.4	<10	<1	<50	<0.8
diethylphthalate	<6	<1.6	<4.4	<0.9	<20	<2	<100	<1.5
dimethylphthalate	<6	<1.6	<11	<0.9	<20	<2	<100	<1.5
di-n-octylphthalate	<6	<1.6	<4.4	<0.9	<20	<2	<100	<1.5

POND SEDIMENT/COMPOST **PHTHALATES**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**>LOD**
SVOCS % Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	<0.9	
bis(2-ethylhexyl)phthalate	**4.4**	**4.0**	**9**	**80**		**24**	**21**		80	<0.9	10
butylbenzylphthalate	<4	<4	<8	<20		<4	<10		-	<0.9	0
di-n-butylphthalate	<4	<4	<8	<20		<4	<10		-	<0.9	0
di-(2-ethylhexyl)adipate	<2	<2	<4	<10		<2	<5		-	<0.4	0
diethylphthalate	<4	<4	<8	<20		<4	<10		-	<0.9	0
dimethylphthalate	<4	<4	<8	<20		<4	<10		-	<0.9	0
di-n-octylphthalate	<4	<4	<8	<20		<4	<10		-	<0.9	0

SECTION 8

POLYAROMATIC HYDROCARBONS (PAHs)

ANALYTICAL METHODOLOGY

Extraction - Solids

Based on USEPA method 3545 (SVOC). Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 333 and 667 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction - Liquids

Based on USEPA method 3520A (SVOC). Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 12.5 and 25 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup

An aliquot of each extract was cleaned up by gel permeation chromatography (USEPA method 3640 SVOC).

Instrumental Analysis

SVOC compounds were determined by full scan GC-MS (based on USEPA method 8270). Quantitation was performed using internal standardisation and a 4 point calibration curve for all target compounds.

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

The polyaromatic hydrocarbon (also called polynuclear aromatic hydrocarbon) results from this survey appear in Tables B8.1, 8.2, 8.3 and 8.4. Polyaromatic hydrocarbons are organic chemicals comprising two or more benzene rings where the adjacent rings share two carbon atoms. Some previous New Zealand results appear in Table 6.8 in Part A. Some results from an Eastern Canadian survey appear in Table 7.6 and a US survey in Table 7.12.

Tables B8.1, 8.2, 8.3 and 8.4 indicate with an asterisk the PAHs which are considered to be carcinogenic. Table B8.5 indicates the PAHs which are shown to be carcinogenic in the Ministry for the Environment Draft Guidelines (December 1996). The table also shows how carcinogenic the PAHs are relative to benzo[a]pyrene, ie benzo[a]pyrene is attributed a toxic equivalence factor (TEF) of 1; benzo[a]anthracene has a factor of 0.1 so it has a tenth the carcinogenicity of benzo[a]pyrene.

PAH	Carcinogenic	TEF
acenaphthene	no	-
acenaphthylene	no	-
anthracene	no	-
benzo[a]anthracene	yes	0.1
benzo[a]pyrene	yes	1.0
benzo[b]fluoranthene	yes	0.1
benzo[g,h,i]perylene	possibly	-
benzo[k]fluoranthene	yes	0.1
chrysene	yes	0.01
dibenzo[a,h]anthracene	yes	1.0
fluoranthene	no	-
fluorene	no	-
indeno(1,2,3-c,d)pyrene	yes	0.1
naphthalene	no	-
phenanthrene	no	-
pyrene	no	-

Table B8.5: Carcinogenicity of individual PAHs

The above 16 PAHs are also USEPA priority pollutants; so is 2-chloronaphthalene which appears in some EPA lists amongst the PCBs. Benzo[a]pyrene is a determinand of health significance in the Drinking-Water Standards for New Zealand 1995.

Discussion

The PAHs are mostly combustion products from the burning of wood, coal and petroleum products. Naphthalene is the only PAH that has been manufactured in significant volume, and has been used as a moth and insect repellent.

Naphthalene was the only PAH detected on a fairly regular basis (in 27 of the 66 samples), being above its limit of detection in half the raw sludge samples, and in about two-thirds of the anaerobic sludges. It was found in only one of the pond sediments and in just 20% of the aerobic sludges, which confirms that naphthalene is amenable to breakdown by aerobic processes, or over long periods in anaerobic sediments. The maximum concentration of naphthalene was quite high in raw sludge (Tahuna scum and Bromley raw 10 mg/kg), also quite high in the anaerobic sludges (Mangere dewatered 34.6 and Mangere digested 21.4 mg/kg); but only 3 mg/kg in the aerobic sludges (Otaki clarifier), and 0.7 mg/kg in the pond sediments (at Bromley). It was below its LOD in the two composts. Although naphthalene is by far the most soluble PAH and therefore perhaps less likely to be found in sewage sludge, it is usually the commonest PAH in the environment.

The seven carcinogenic PAHs were not found very often. In the raw sludges, aerobic sludges and pond sediments, the carcinogenic PAHs were present at less than 2 mg/kg. They were a little more prevalent in the anaerobic sludges, with the maximum values generally falling in the 2-5 mg/kg range.

Benzo[a]anthracene was found in 6 of the 22 anaerobic samples, 1 raw sludge and 2 pond sediments; its highest concentration was in the Invercargill lagoon sludge (5.4 mg/kg), and it was detected in 3 of the Bromley samples. Benzo[a]pyrene was found five samples with a maximum of 3.9 mg/kg; again three of the samples were from the Bromley plant.

Dibenzo[a,h]anthracene was only found above its LOD once and then at only 0.2 mg/kg.

Phenanthrene was also quite concentrated in the Invercargill lagoon sludge (7.3 mg/kg); it was detected in 12 of the 66 samples, as was pyrene.

The PAH 2-methylnaphthalene is not one of the 'usual 16' analysed, but it is detected quite frequently (in 17 of the samples). It would appear to concentrate in the scum (oils and fats) because it was found to be 19 mg/kg in the Tahuna scum; the next highest concentration was only 4.2 mg/kg.

Comparing different samples is difficult due to the variations in their respective LODs. However, it was interesting to note some of the fairly high concentrations in the Dunedin scum sample where the PAHs were probably associated with oils, fats and greases. This was the only scum sample tested; it is probably little different from the scum collected from the primary sedimentation tanks at most wastewater treatment plants in the country.

The results from the present survey are similar to those found in samples tested earlier in New Zealand. They are also similar to the Eastern Canadian survey except that the naphthalene levels were higher in New Zealand sludges.

There do not appear to be any national standards or 'upper levels' established for PAHs in sludges or biosolids.

RAW SLUDGES **POLYAROMATIC HYDROCARBONS**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview		
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg	Wool Scour
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2
SVOCs % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7	9.8
The 'usual 16'											
acenaphthene	<0.1	<2	<0.12	<2	<2	<0.6	<10	<2	<0.8	<0.3	<0.1
acenaphthylene	<0.1	<2	<0.12	<2	<2	**0.6**	<10	<2	<0.8	<0.3	<0.1
anthracene	<0.1	<2	<0.12	<2	<2	<0.6	<10	<2	<0.8	<0.3	<0.1
benzo[a]anthracene *	<0.1	<2	<0.12	<2	<2	**0.8**	<10	<2	<0.8	<0.3	<0.1
benzo[a]pyrene *	<0.1	<2	<0.12	<2	<2	**1.4**	<10	<2	<0.8	<0.3	<0.1
benzo[b]fluoranthene *	<0.1	<2	<0.12	<2	<2	**1.5**	<10	<2	<0.8	**0.3**	<0.1
benzo[g,h,i]perylene	**0.1**	<2	**0.3**	<2	<2	**0.7**	<10	<2	<0.8	<0.3	<0.1
benzo[k]fluoranthene *	<0.1	<2	<0.12	<2	<2	**0.6**	<10	<2	<0.8	<0.3	<0.1
chrysene *	<0.1	<2	<0.12	<2	<2	**0.7**	<10	<2	<0.8	<0.3	<0.1
dibenzo[a,h]anthracene *	<0.1	<2	<0.12	<2	<2	<0.6	<10	<2	<0.8	<0.3	<0.1
fluoranthene	<0.1	<2	<0.12	<2	<2	**2.0**	<10	<2	<0.8	<0.3	<0.1
fluorene	<0.1	<2	<0.12	<2	<2	<0.6	<10	<2	<0.8	<0.3	<0.1
indeno(1,2,3-c,d)pyrene *	<0.1	<2	<0.12	<2	<2	**1.0**	<10	<2	<0.8	<0.3	<0.1
naphthalene	<0.1	**10**	<0.12	<2	**10**	**1.7**	<10	<2	**1.1**	**0.5**	<0.1
phenanthrene	<0.1	<2	<0.12	<2	**6**	**1.3**	<10	<2	<0.8	<0.3	<0.1
pyrene	<0.1	<2	<0.12	<2	<2	**1.7**	<10	<2	<0.8	<0.3	<0.1
Some other PAHs											
carbazole (dibenzopyrrole)	<0.5	<2	<0.6	<10	<10	<0.6	<50	<10	<4	<1.6	<0.6
2-chloronaphthalene	<0.1	<2	<0.12	<2	<2	<0.6	<10	<2	<0.8	<0.3	<0.1
2-methylnaphthalene	<0.1	**3**	<0.12	<2	**19**	**2.1**	<10	**3**	**3**	**0.3**	<0.1

RAW SLUDGES **POLYAROMATIC HYDROCARBONS**

Local Body	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
	Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry weight	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 16)**
Lab No:	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
The 'usual 16'									
acenaphthene	<6	<0.13	<0.8	<0.13	<0.1		-	<0.1	0
acenaphthylene	<6	<0.13	<0.8	<0.13	<0.1		0.6	<0.1	1
anthracene	<6	<0.13	<0.8	<0.13	<0.1		-	<0.1	0
benzo[a]anthracene *	<6	<0.13	<0.8	<0.13	<0.1		0.8	<0.1	1
benzo[a]pyrene *	<6	<0.13	<0.8	<0.13	<0.1		1.4	<0.1	1
benzo[b]fluoranthene *	<6	<0.13	<0.8	<0.13	<0.1		1.5	<0.1	2
benzo[g,h,i]perylene	<6	<0.13	<0.8	<0.13	<0.1		0.7	<0.1	3
benzo[k]fluoranthene *	<6	<0.13	<0.8	<0.13	<0.1		0.6	<0.1	1
chrysene *	<6	<0.13	<0.8	<0.13	<0.1		0.7	<0.1	1
dibenzo[a,h]anthracene *	<6	<0.13	<0.8	<0.13	<0.1		-	<0.1	0
fluoranthene	<6	<0.13	<0.8	<0.13	<0.1		2.0	<0.1	1
fluorene	<6	<0.13	<0.8	<0.13	<0.1		-	<0.1	0
indeno(1,2,3-c,d)pyrene *	<6	<0.13	<0.8	<0.13	<0.1		1.0	<0.1	1
naphthalene	<6	0.30	<0.8	0.16	<02.8		10	<0.1	8
phenanthrene	<6	<0.13	<0.8	<0.13	<0.1		6	<0.1	2
pyrene	<6	<0.13	<0.8	<0.13	<0.1		1.7	<0.1	1
Some other PAHs									
carbazole (dibenzopyrrole)	<30	<0.67	<0.4	<0.65	<0.5		-	<0.5	0
2-chloronaphthalene	<6	<0.13	<0.8	<0.13	<0.1		-	<0.1	0
2-methylnaphthalene	<6	<0.13	<0.8	<0.13	<0.1		19	<0.1	6

ANAEROBIC SLUDGES POLYAROMATIC HYDROCARBONS

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
SVOCs % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
The 'usual 16'									
acenaphthene	<0.24	<4	<0.8	<0.8	<0.2	<0.24	1.3	<1	<0.1
acenaphthylene	<0.24	<4	<0.8	<0.8	<0.2	<0.24	<0.4	<1	<0.1
anthracene	<0.24	<4	<0.8	<0.8	**1.6**	<0.24	<0.4	<1	<0.1
benzo[a]anthracene *	<0.24	<4	<0.8	<0.8	**3.6**	<0.24	<0.4	<1	<0.1
benzo[a]pyrene *	<0.24	<4	<0.8	<0.8	**3.9**	<0.24	<0.4	<1	<0.1
benzo[b]fluoranthene *	<0.24	<4	<0.8	<0.8	**4.0**	<0.24	<0.4	<1	<0.1
benzo[g,h,i]perylene	<0.24	<4	<0.8	<0.8	**2.3**	<0.24	<0.4	<1	<0.1
benzo[k]fluoranthene *	<0.24	<4	<0.8	<0.8	**1.6**	<0.24	<0.4	<1	<0.1
chrysene *	<0.24	<4	<0.8	<0.8	**4.0**	<0.24	<0.4	<1	<0.1
dibenzo[a,h]anthracene *	<0.24	<4	<0.8	<0.8	**0.2**	<0.24	<0.4	<1	<0.1
fluoranthene	<0.24	<4	<0.8	**0.8**	**8.7**	<0.24	**0.4**	<1	<0.1
fluorene	<0.24	<4	<0.8	<0.8	**0.2**	<0.24	**0.9**	<1	<0.1
indeno(1,2,3-c,d)pyrene *	<0.24	<4	<0.8	<0.8	**3.0**	<0.24	<0.4	<1	<0.1
naphthalene	**4.2**	**10**	**11.0**	**12.3**	**0.3**	**0.35**	**1.3**	**1.0**	<0.1
phenanthrene	<0.24	<4	**1.4**	**1.8**	**5.2**	<0.24	**0.9**	<1	<0.1
pyrene	<0.24	<4	<0.8	**1.0**	**8.3**	<0.24	**0.9**	<1	<0.1
Some other PAHs									
carbazole (dibenzopyrrole)	<1.2	<20	<4	<4	<0.8	<1.2	<2	<5	<0.5
2-chloronaphthalene	<0.24	<4	<0.8	<0.8	<0.2	<0.24	<0.4	<1	<0.1
2-methylnaphthalene	**1.4**	**4.0**	**3.6**	**4.2**	<0.2	<0.24	**0.9**	<1	<0.1

ANAEROBIC SLUDGES POLYAROMATIC HYDROCARBONS

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere
mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Digester Slg
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2
SVOCs % Dry Solids	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7	0.9
The 'usual 16'										
acenaphthene	<0.6	<0.2	**0.9**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
acenaphthylene	<0.6	<0.2	**0.7**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
anthracene	<0.6	<0.2	**2.5**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
benzo[a]anthracene *	**0.9**	<0.2	**5.4**	<0.13	<0.4	<0.24	<0.8	**0.6**	<1	<0.2
benzo[a]pyrene *	<0.6	<0.2	**1.5**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
benzo[b]fluoranthene *	<0.6	<0.2	**4.2**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
benzo[g,h,i]perylene	<0.6	<0.2	<0.4	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
benzo[k]fluoranthene *	<0.6	<0.2	**1.3**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
chrysene *	<0.6	<0.2	**3.8**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
dibenzo[a,h]anthracene *	<0.6	<0.2	<0.4	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
fluoranthene	**0.7**	**0.2**	**8.3**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
fluorene	<0.6	<0.2	**1.5**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
indeno(1,2,3-c,d)pyrene *	<0.6	**2.0**	<0.4	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
naphthalene	<0.6	**0.5**	**0.7**	<0.13	<0.4	**0.35**	<0.8	<0.6	<1	**21.4**
phenanthrene	<0.6	<0.2	**7.3**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	**0.3**
pyrene	**0.6**	<0.2	**7.6**	<0.13	<0.4	<0.24	<0.8	<0.6	<1	**0.2**
Some other PAHs										
carbazole (dibenzopyrrole)	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6	<1
2-chloronaphthalene	<0.6	<0.2	<0.4	<0.13	<0.4	<0.24	<0.8	<0.6	<1	<0.2
2-methylnaphthalene	<0.6	<0.2	**1.4**	<0.13	<0.4	**0.35**	<0.8	<0.6	<1	**1.9**

ANAEROBIC SLUDGES POLYAROMATIC HYDROCARBONS

Local Body	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 22)**
Lab No:	116306/4	116306/5	116306/6		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	33.8	44.6	43.3		93.9	0.9	
The 'usual 16'							
acenaphthene	<0.4	<0.4	<0.4		1.3	<0.1	2
acenaphthylene	<0.4	<0.4	<0.4		0.7	<0.1	1
anthracene	<0.4	<0.4	<0.4		2.5	<0.1	2
benzo[a]anthracene *	<0.4	**0.4**	**0.5**		5.4	<0.1	6
benzo[a]pyrene *	<0.4	<0.4	<0.4		3.9	<0.1	2
benzo[b]fluoranthene *	<0.4	<0.4	<0.4		4.2	<0.1	2
benzo[g,h,i]perylene	<0.4	<0.4	<0.4		2.3	<0.1	1
benzo[k]fluoranthene *	<0.4	<0.4	<0.4		1.6	<0.1	2
chrysene *	<0.4	<0.4	<0.4		4.0	<0.1	2
dibenzo[a,h]anthracene *	<0.4	<0.4	<0.4		0.2	<0.1	1
fluoranthene	<0.4	<0.4	<0.4		8.7	<0.1	6
fluorene	<0.4	<0.4	<0.4		1.5	<0.1	3
indeno(1,2,3-c,d)pyrene *	<0.4	<0.4	<0.4		3.0	<0.1	1
naphthalene	**34.6**	**13.3**	**1.9**		34.6	<0.1	15
phenanthrene	**1.0**	**0.8**	<0.4		7.3	<0.1	8
pyrene	**0.6**	**0.5**	**0.6**		8.3	<0.1	9
Some other PAHs							
carbazole (dibenzopyrrole)	<2	<2	<2		-	<0.5	0
2-chloronaphthalene	<0.4	<0.4	<0.4		-	<0.1	0
2-methylnaphthalene	<0.4	2.5	**0.8**		4.2	<0.1	9

AEROBIC SLUDGES POLYAROMATIC HYDROCARBONS

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
SVOCs % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
The 'usual 16'									
acenaphthene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
acenaphthylene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
anthracene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
benzo[a]anthracene *	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
benzo[a]pyrene *	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
benzo[b]fluoranthene *	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
benzo[g,h,i]perylene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
benzo[k]fluoranthene *	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
chrysene *	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
dibenzo[a,h]anthracene *	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
fluoranthene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
fluorene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
indeno(1,2,3-c,d)pyrene *	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
naphthalene	**0.12**	<2	<1.7	**2.7**	**3.1**	<1	<4	<1	<1
phenanthrene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
pyrene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
Some other PAHs									
carbazole (dibenzopyrrole)	<0.45	<10	<8.7	<1.2	<0.67	<7	<20	<6	<7
2-chloronaphthalene	<0.09	<2	<1.7	<0.24	<0.13	<1	<4	<1	<1
2-methylnaphthalene	<0.09	<2	<1.7	**0.4**	<0.13	<1	<4	<1	<1

AEROBIC SLUDGES **POLYAROMATIC HYDROCARBONS**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
The 'usual 16'									
acenaphthene	<1	<4	<0.6	<1	<10		-	<0.09	0
acenaphthylene	<1	<4	<0.6	<1	<10		-	<0.09	0
anthracene	<1	<4	<0.6	<1	<10		-	<0.09	0
benzo[a]anthracene *	<1	<4	<0.6	<1	<10		-	<0.09	0
benzo[a]pyrene *	<1	<4	<0.6	<1	<10		-	<0.09	0
benzo[b]fluoranthene *	<1	<4	<0.6	<1	<10		-	<0.09	0
benzo[g,h,i]perylene	<1	<4	<0.6	<1	<10		-	<0.09	0
benzo[k]fluoranthene *	<1	<4	<0.6	<1	<10		-	<0.09	0
chrysene *	<1	<4	<0.6	<1	<10		-	<0.09	0
dibenzo[a,h]anthracene *	<1	<4	<0.6	<1	<10		-	<0.09	0
fluoranthene	<1	<4	<0.6	<1	<10		-	<0.09	0
fluorene	<1	<4	<0.6	<1	<10		-	<0.09	0
indeno(1,2,3-c,d)pyrene *	<1	<4	<0.6	**1.0**	<10		1.0	<0.09	1
naphthalene	<1	<4	<0.6	<1	<10		3.1	0.12	3
phenanthrene	<1	<4	<0.6	<1	<10		-	<0.09	0
pyrene	<1	<4	<0.6	<1	<10		-	<0.09	0
Some other PAHs									
carbazole (dibenzopyrrole)	<6	<20	<3	<5	<60		-	<0.45	0
2-chloronaphthalene	<1	<4	<0.6	<1	<10		-	<0.09	0
2-methylnaphthalene	<1	<4	<0.6	<1	<10		-	<0.09	1

POND SEDIMENTS/COMPOST **POLYAROMATIC HYDROCARBONS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
SVOCs % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
The 'usual 16'								
acenaphthene	<0.6	<0.16	<1	<0.07	<2	<0.2	<10	<0.15
acenaphthylene	<0.6	<0.16	<1	<0.07	<2	<0.2	<10	<0.15
anthracene	<0.6	<0.16	<1	<0.07	<2	<0.2	<10	<0.15
benzo[a]anthracene *	**1.7**	**0.5**	<1	<0.07	<2	<0.2	<10	<0.15
benzo[a]pyrene *	**1.0**	**0.6**	<1	<0.07	<2	<0.2	<10	<0.15
benzo[b]fluoranthene *	**1.6**	**0.7**	<1	<0.07	<2	<0.2	<10	<0.15
benzo[g,h,i]perylene	**0.7**	**0.3**	<1	<0.07	<2	<0.2	<10	<0.15
benzo[k]fluoranthene *	<0.6	**0.3**	<1	<0.07	<2	<0.2	<10	<0.15
chrysene *	**1.2**	**0.7**	<1	<0.07	<2	<0.2	<10	<0.15
dibenzo[a,h]anthracene *	<0.6	<0.16	<1	<0.07	<2	<0.2	<10	<0.15
fluoranthene	**2.2**	**1.0**	<1	<0.07	<2	<0.2	<10	<0.15
fluorene	<0.6	<0.16	<1	<0.07	<2	<0.2	<10	<0.15
indeno(1,2,3-c,d)pyrene *	**0.6**	**0.4**	<1	<0.07	<2	<0.2	<10	<0.15
naphthalene	**0.7**	<0.16	<1	<0.07	<2	<0.2	<10	<0.15
phenanthrene	**1.6**	**0.6**	<1	<0.07	<2	<0.2	<10	<0.15
pyrene	**2.4**	**1.0**	<1	<0.07	<2	<0.2	<10	<0.15
Some other PAHs								
carbazole (dibenzopyrrole)	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
2-chloronaphthalene	<0.6	<0.16	<1	<0.07	<2	<0.2	<10	<0.15
2-methylnaphthalene	**0.6**	<0.16	<1	<0.07	<2	<0.2	<10	<0.15

POND SEDIMENTS/COMPOST **POLYAROMATIC HYDROCARBONS**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**>LOD**
SVOCs % Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
The 'usual 16'											
acenaphthene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		-	<0.07	0
acenaphthylene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		-	<0.07	0
anthracene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		-	<0.07	0
benzo[a]anthracene *	<0.4	<0.4	<0.8	<0.2		<0.4	<1		1.7	<0.07	2
benzo[a]pyrene *	<0.4	<0.4	<0.8	<0.2		<0.4	<1		1.0	<0.07	2
benzo[b]fluoranthene *	<0.4	<0.4	<0.8	<0.2		<0.4	<1		1.6	<0.07	2
benzo[g,h,i]perylene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		0.7	<0.07	2
benzo[k]fluoranthene *	<0.4	<0.4	<0.8	<0.2		<0.4	<1		0.25	<0.07	1
chrysene *	<0.4	<0.4	<0.8	<0.2		<0.4	<1		1.2	<0.07	2
dibenzo[a,h]anthracene *	<0.4	<0.4	<0.8	<0.2		<0.4	<1		-	<0.07	0
fluoranthene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		2.2	<0.07	2
fluorene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		-	<0.07	0
indeno(1,2,3-c,d)pyrene *	<0.4	<0.4	<0.8	<0.2		<0.4	<1		0.6	<0.07	2
naphthalene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		0.7	<0.07	1
phenanthrene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		1.6	<0.07	2
pyrene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		2.4	<0.07	2
Some other PAHs											
carbazole (dibenzopyrrole)	<2	<2	<4	<9		<2	<5		-	<0.4	0
2-chloronaphthalene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		-	<0.07	0
2-methylnaphthalene	<0.4	<0.4	<0.8	<0.2		<0.4	<1		0.6	<0.07	1

SECTION 9

TOTAL PETROLEUM HYDROCARBONS

ANALYTICAL METHODOLOGY

Extraction: Solids

Based on an in-house method. A representative sub-sample is taken from the samples after homogenisation using a corer or spatula as appropriate. Samples were shaken with sodium sulphate and dichloromethane, and then extracted using sonication. After settling, an aliquot of solvent was removed and treated with silica. An aliquot was then removed for analysis.

Extraction: Liquids

Based on an in-house method. A representative sub-sample was taken from the sample after homogenisation. Samples were shaken with hexane. After extraction and settling, an aliquot of hexane was removed for analysis.

Instrumental Analysis

TPH compounds were analysed using GC-FID, based on a method from the NZ Oil Industry Environmental Working Group (OIEWG). Quantitation was by three point calibration using a multi-component n-alkane standard. Calibration was confirmed using an independent diesel QC standard.

The standard method used for screening contaminated sites for hydrocarbon contamination used to be by Freon Extraction/Infrared Spectroscopy as defined by US-EPA Method 418.1 and APHA 5520C. The manufacture of Freon 112 has been banned so these methods are no longer used.

The method used is aimed as a replacement, for use in the investigation of contaminated sites, particularly those which may be contaminated with petrol, diesel, other petroleum fuels, and petroleum based solvents. Very volatile (eg pentanes: C5) or heavy petroleum products will not be determined using this method. The method is designed to be rapid and economical, providing a guide to the relative levels of hydrocarbon contamination, as well as information as to the likely source of the hydrocarbons.

The method is not designed to produce data which can be used in risk assessment calculations, ie specific data for benzene, toluene, benzo[a]pyrene, etc - these were measured by other techniques and have been reported elsewhere in this report.

Most of the proposed methods for sample preparation will give rise to the loss of the most volatile components in the sample, mainly during the weighing and chemical drying steps.

Any organic compounds which are soluble in the extracting solvent and which elute from the GC under the conditions used will interfere. These may include vegetable and animal oils and fats, chlorinated and other solvents, plasticisers, etc. The use of silica to adsorb oxygenated compounds may reduce these interferences.

Quality Control

For TPH, an extraction blank was run with every worksheet, or every twenty samples. A duplicate sample was run approximately every thirtieth sample.

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as or where covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally the limits of detection (in a few samples only) are apparent when referring to the Tables.

ANALYTICAL RESULTS

Total petroleum hydrocarbon results (TPH) from this survey appear in Tables B9.1, B9.2, B9.3 and B9.4. TPHs are grouped together by the number of carbon atoms in the hydrocarbon chain. As a generalisation, the lighter components are gases (up to C4 - CNG, LPG etc) or volatile liquids (C5 – C9) which probably do not remain in the liquid phase very long. Therefore the first group that is classified is usually the C7-C9 group. As the number of carbon atoms increases the substances become more solid, so by C30 and above they are becoming waxy.

There are no TPH results in Part A.

Discussion

This rather empirical test is described above. The procedure is commonly used to measure contamination of soil and water by petroleum products. TPHs include fuels and industrial chemicals used as reagents, solvents and cleaning products. They include substances such as petrol, diesel and oil components, BTEX, limonene, mineral turpentine and detergents. With respect to sewage, higher than normal levels of TPH can indicate an explosion risk, a spill or unusual discharge; some of the individual products may inhibit biological treatment processes. For this reason TPHs were determined on the 'operational' suite only.

Petrol generally falls into the C4 – C11 range; kerosene, diesel and aviation fuel into the C8 – C17 range, fuel oil Cll – C20 and transformer oil C15 – C20.

The highest total TPH concentrations in the raw sludges overall were found in the Dunedin scum (100,000 mg/kg or 10% of the dry weight!), Levin (8.1%), Invercargill (7.3%), and Wainuiomata (6.2%). The C30 – C44 fraction varied between a quarter and two thirds of the total THP. It was not unexpected to find the highest TPH concentrations in the scum phase of raw sludge.

The highest total TPH concentrations in the anaerobic sludges overall were found in the Invercargill digested (6.0%) and Mangere digested sample (3.3%). The C30 – C44 fraction varied between 50-85% of the total THP.

The highest total TPH concentrations in the aerobic sludges overall were found in the Otaki sludge (3.0% of the dry weight), Bromley secondary sludge (2.4%), and Thames (1.7%). The C30 – C44 fraction varied between a half and three quarters of the total THP.

Only three pond sediments were tested, and concentrations were much lower – see Table B9.5. Median TPH concentrations fell as the sludges were treated.

TPH Fraction	Raw Sludges	Anaerobic	Aerobic	Sediments
C7 – C9	853	<60	173	<100
C10 –C11	413	176	222	<100
C12 – C14	338	176	250	<100
C15 – C20	15335	1353	967	<100
C21 – C25	17753	1471	983	<111
C26 – C29	2431	1118	1142	222
C30 – C44	15011	15059	8260	4444
TOT. C7-C44	56411	18059	11600	4478

Table B9.5: Median TPH concentrations by sludge grouping (mg/kg)

Total petroleum hydrocarbons in sewage sludges do not appear to have been analysed previously. There do not appear to be any national standards or guidelines for TPH in sewage sludges.

RAW SLUDGES **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview		
mg/kg dry wt	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg	Wool Scour
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2
% DS	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7	9.8
C7 – C9	1275	1630	853	833	373		4690	296		1189	<10
C10 – C11	400	1600	353	279	324		752	413		1541	184
C12 – C14	225	507	294	122	370		414	338		514	286
C15 – C20	14700	18900	15971	4730	13050		6870	12700		18324	1031
C21 – C25	17925	8750	13853	5590	17580		9490	23700		18838	1041
C26 – C29	1750	2100	2529	1570	2820		3640	5570		3622	622
C30 – C44	8700	13400	13382	23500	65475		55400	19200		29189	4765
Total H/C (C7 – C44)	45000	46900	47353	36700	100000		81000	62100		73243	7929
	NOTE: Total H/C is total hydrocarbon										

RAW SLUDGES **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare		*Not including the*		
	Fielding	Rosedale	Bay – Mech.		Mangere		*Woolscour sample:*		
mg/kg dry wt	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				
Lab No:	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX**	**MIN**	**MEDIAN**
% DS	2.7	3.0	18.1	3.1	4.0		29.0	1.6	4.8
C7 – C9	<200	1000		452	775		4690	<200	853
C10 – C11	<200	567		323	650		1600	<200	413
C12 – C14	<200	500		194	325		514	122	338
C15 – C20	646	21267		19129	16350		21267	646	15335
C21 – C25	935	21100		22226	18550		23700	935	17753
C26 – C29	1610	2333		2774	2050		5570	1570	2431
C30 – C44	5770	14700		15323	13700		65475	5770	15011
Total H/C (C7 – C44)	9000	61333		60323	52500		100000	9000	56411

ANAEROBIC SLUDGES **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry wt	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
% DS	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
C7 – C9	<60					<60			<25
C10 – C11	235					176			50
C12 – C14	294					176			125
C15 – C20	1353					1235			475
C21 – C25	1118					1471			975
C26 – C29	1000					1765			925
C30 – C44	15059					12294			7075
Total H/C (C7 – C44)	19000					17118			9575
	NOTE: Total H/C is total hydrocarbon								

ANAEROBIC SLUDGES **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere
mg/kg dry wt	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Dewatered Slg
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2
% DS	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7	0.9
C7 – C9		73		69		<59				<111
C10 – C11		146		69		353				333
C12 – C14		195		<69		176				444
C15 – C20		3317		1586		529				1556
C21 – C25		1927		2069		588				1778
C26 – C29		1854		621		1118				2111
C30 – C44		52439		4138		15235				26444
Total H/C (C7 – C44)		60000		8621		18059				32667

ANAEROBIC SLUDGES **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere				
mg/kg dry wt	Dewatered Slg	Lime stabilised	Air Dried Slg				
Lab No:	116306/4	116306/5	116306/6		**MAX**	**MIN**	**MEDIAN**
% DS	33.8	44.6	43.3		93.9	0.9	17
C7 – C9					73	<25	-
C10 – C11					353	50	176
C12 – C14					444	<69	176
C15 – C20					3317	475	1353
C21 – C25					2069	588	1471
C26 – C29					2111	621	1118
C30 – C44					52439	4138	15059
Total H/C (C7 – C44)					60000	8621	18059

AERObic SLUDGES **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua	Rodney
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically	Warkworth
mg/kg dry wt	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered	Air Dried Slg
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1	115840/2
% DS	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3	14.9
C7 – C9	47	<70	87	235	<67		1440			
C10 – C11	116	<70	522	176	267		489			
C12 – C14	47	<70	609	235	333		265			
C15 – C20	581	346	4391	1353	5600		322			
C21 – C25	907	842	3304	1059	6467		551			
C26 – C29	1093	1190	1348	588	1333		640			
C30 – C44	7279	7590	13696	1529	16133		8930			
Total H/C (C7 – C44)	10023	10000	23913	5176	30067		12600			
	NOTE: Total H/C is total hydrocarbon									

AEROBIC SLUDGES **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Waste		Thames	Te Puke				
mg/kg dry wt	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				
Lab No:	116021/5	116021/3	116736/1	115739/1		**MAX**	**MIN**	**MEDIAN**
% DS	4.2	29.6	0.9	1.4		29.6	0.9	4.3
C7 – C9	2320		<111	no result		2320	47	173
C10 – C11	839		<111	no result		839	<70	222
C12 – C14	297		<111	no result		609	47	250
C15 – C20	475		1444	no result		5600	322	967
C21 – C25	844		1556	no result		6467	551	983
C26 – C29	935		1778	no result		1778	588	1142
C30 – C44	4910		12444	no result		16133	1529	8260
Total H/C (C7 – C44)	10600		17111	no result		30067	5176	11600

POND SEDIMENTS/COMPOST **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry wt	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
% DS	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
C7 – C9								<77
C10 – C11								<77
C12 – C14								<77
C15 – C20								<77
C21 – C25								<77
C26 – C29								<77
C30 – C44								<77
Total H/C (C7 – C44)								<540
	NOTE: Total H/C is total hydrocarbon							

POND SEDIMENTS/COMPOST **TOTAL PETROLEUM HYDROCARBONS**

Local Body:	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					
mg/kg dry wt	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX**	**MIN**	**MEDIAN**
% DS	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	4
C7 – C9	<111	<100							-	-	-
C10 – C11	<111	<100							-	-	-
C12 – C14	<111	<100							-	-	-
C15 – C20	111	300							300	<77	-
C21 – C25	<111	400							400	<77	-
C26 – C29	222	900							900	<77	222
C30 – C44	4444	5800							5800	<77	4444
Total H/C (C7 – C44)	4778	7400							7400	<540	4778

SECTION 10

SOME OTHER ORGANICS

ANALYTICAL METHODOLOGY

Extraction: Solids - VOCs

Based on US-EPA methods 8260 and 624. A representative sub-sample of the samples was obtained using several cores. Samples were extracted into methanol using sonication. The methanol was poured off into a vial, and stored at 4°C until extraction/analysis. A methanol extraction blank was included with every worksheet, or twenty samples.

An aliquot of the methanol extract was added to an aliquot of water immediately prior to analysis. Final extraction/analysis was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous/methanol phase on to a VOCARB4000 trap. Surrogates of approximately 0.25 mg/kg equivalent in the solid (assuming 100% dry matter) were added prior to extraction.

Extraction: Liquids - VOCs

Based on US-EPA methods 8260 and 624. Extraction was by automated Purge and Trap, using a stream of helium to purge the volatile compounds from the aqueous phase on to a VOCARB4000 trap. Surrogates of 10 µg/L equivalent in the liquid were added prior to extraction.

Instrumental Analysis - VOCs

VOC compounds were determined by full scan GC-MS (based on US-EPA method 8260). Quantitation was performed using internal standardisation and a continuing calibration curve for all target compounds.

Extraction: Solids - SVOCs

Based on USEPA method 3545. Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 333 and 667 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction: Liquids - SVOCs

Based on USEPA method 3520A. Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 12.5 and 25 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup - SVOCs

An aliquot of each extract was cleaned up by gel permeation chromatography (USEPA method 3640).

Instrumental Analysis - SVOCs

SVOC compounds were determined by full scan GC-MS (based on USEPA method 8270). Quantitation was performed using internal standardisation and a 4 point calibration curve for all target compounds.

Quality Control

For SVOC and VOC compounds, an extraction blank was run with every worksheet, or twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples had surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

The 'other organics' results from this survey appear in Tables B10.1, B10.2, B10.3 and B10.4. These 'other organic chemicals' are simply those that do not logically fit into the other groupings. They include some solvents, hydrocarbons and nitrosamines. Some previous New Zealand results appear in Table 6.10 in Part A. Some results from an Eastern Canadian survey appear in Table 7.8.

Four of the chemicals in Tables B10.1 - B10.4 are USEPA priority pollutants, these are: 3,3'-dichlorobenzidine, isophorone (which appears in some EPA lists with the pesticides), N-nitrosodiphenylamine and N-nitrosodi-n-propylamine. Some related or sundry chemicals in their list (but not tested in this survey) are: N-nitrosodimethylamine, benzidine, 1,2-diphenylhydrazine and acrylonitrile.

Discussion

Three of these 'other organic chemicals' were detected above their limits of detection (LOD). Methylethyl ketone or 2-butanone was detected in 13 of 66 samples, 6 of 16 raw sludges, 7 of 22 anaerobic sludges and 1 aerobic sludge.

Carbon disulphide was found in 8 samples; 4 raw sludges, 3 anaerobic sludges and 1 aerobic sludge.

Styrene was found in 6 sludges; 3 raw and 3 anaerobic.

The highest concentration of 2-butanone in the raw sludges was 29 mg/kg in the Hutt milliscreenings. In anaerobic sludges it reached 16.1 mg/kg (North Shore dewatered), and 12.7 mg/kg in both the Invercargill and Wainuiomata digested sludges. Methylethyl ketone (2- butanone) is a common solvent in the paint and surface coating industry. In the Eastern Canada study, 2-butanone was detected at a maximum level of 450 mg/kg, but averaged about 50-250 mg/kg (Table 7.8), significantly higher than in New Zealand.

Carbon disulphide was found at 8.3 mg/kg in Mangere raw sludge, 5.9 in Mangere digested sludge, and 8.0 mg/kg in Otaki aerobic sludge. Carbon disulphide is used as a specialist solvent in many industries, including rubber and resins. Carbon disulphide was the only 'other organic chemical' detected above its LOD in earlier New Zealand analyses (Table 6.10 in Part A). Carbon disulphide results were not reported in the Canadian study.

Styrene was detected at 0.27 mg/kg in Invercargill raw and 0.25 mg/kg in Carterton raw sludge. It was less than 0.1 mg/kg in the anaerobic sludges. Styrene is used in New Zealand in the production of resins for the fibreglassing industry. Styrene is thought to result from the degradation of polystyrene. In the Canadian study, styrene was detected in sludge from all 5 towns at about their LOD of 0.004 mg/kg.

The Canadian study also reported results for cyclohexane, hexane, nonane and octane. These were not reported in this or earlier New Zealand studies. They found quite high concentrations of nonane (up to 0.3 mg/kg). Hexane and octane were near their LODs of about 0.01 mg/kg.

RJ Hill Laboratories analysed some digested sludge from the North Shore plant in March 1996, using GC/MS. They reported concentrations for some unofficial (or unconfirmed) identifications, including a result for nonane of 1.3 mg/kg. Some other aliphatic hydrocarbons were tentatively identified as well: undecane, decane, dodecane, and 1-methyl-4-(1-methylethyl)cyclohexane in concentrations from 1-4 mg/kg. These chemicals originate from the petroleum and oil industry, so they are quite likely to be present in many sludges, particularly those chemicals that are less volatile.

RAW SLUDGES **OTHER ORGANICS**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
VOCs % Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
2-butanone (MEK)	<2.5	**3**	<2.9	<0.3	**4.2**	<0.3	<6	<3	**28.9**	<2.7
carbon disulphide	**5.0**	<2	<2.9	**4.1**	<2	<0.3	<6	<3	<0.9	<0.9
methyl-butylether (MTBE)	<2.5	<2	<2.9	<0.3	<2	<0.3	<6	<3	<0.9	<0.9
4-methylpentan-2-one (MIBK)	<2.5	<2	<2.9	<0.3	<2	<0.3	<6	<3	<0.9	<0.9
styrene	**0.25**	<0.4	<0.29	<0.03	<0.4	**0.07**	<1	<0.6	<0.2	**0.27**
SVOCs										
dibenzofuran	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
3,3'-dichlorobenzidine	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
isophorone	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
N-nitrosodi-n-propylamine	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6
N-nitrosodiphenylamine	<0.5	<10	<0.6	<10	<10	<3	<50	<10	<4	<1.6

RAW SLUDGES **OTHER ORGANICS**

Local Body	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
		Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry weight	Wool Scour	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 16)**
Lab No:	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**
VOCs % Dry Solids	9.8	2.7	3.0	18.1	3.1	4.0		29.0	1.6	
2-butanone (MEK)	<0.41	<4	**5.3**	**4.2**	<2.9	**2.7**		28.9	<0.3	6
carbon disulphide	<0.41	<4	<3.0	<0.5	**6.1**	**8.3**		8.3	<0.3	4
methyl-butylether (MTBE)	<0.41	<4	<3.0	<0.5	<2.9	<0.20		-	<0.20	0
4-methylpentan-2-one (MIBK)	<0.41	<4	<3.0	<0.5	<2.9	<0.20		-	<0.20	0
styrene	<0.08	<0.8	<0.30	<0.1	<0.29	<0.05		0.27	<0.03	3
SVOCs										
dibenzofuran	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
3,3'-dichlorobenzidine	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
isophorone	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
N-nitrosodi-n-propylamine	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0
N-nitrosodiphenylamine	<0.6	<30	<0.67	<4	<0.65	<0.5		-	<0.5	0

ANAEROBIC SLUDGES OTHER ORGANICS

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
VOCs % Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
2-butanone (MEK)	<5.9	<5	<0.9	<2	<0.06	**2.94**	<1	<3	12.7
carbon disulphide	<5.9	<5	<0.9	<2	<0.06	**4.12**	<1	<3	<0.5
methyl-butylether (MTBE)	<5.9	<5	<0.9	<2	<0.06	<1.18	<1	<3	<0.5
4-methylpentan-2-one (MIBK)	<5.9	<5	<0.9	<2	<0.06	<1.18	<1	<3	<0.5
styrene	<0.59	<1	<0.2	<0.4	<0.01	<0.24	<0.2	<0.6	<0.1
SVOCs									
dibenzofuran	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5
3,3'-dichlorobenzidine	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5
isophorone	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5
N-nitrosodi-n-propylamine	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5
N-nitrosodiphenylamine	<1.2	<20	<4	<4	<0.8	<1.2	<9	<5	<0.5

ANAEROBIC SLUDGES **OTHER ORGANICS**

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa
mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1
VOCs % Dry Solids	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7
2-butanone (MEK)	<0.2	**12.7**	<0.2	<1.3	**1.9**	**3.53**	**16.1**	<0.4	<0.7
carbon disulphide	<0.2	<0.5	<0.2	<1.3	<0.2	**1.76**	<0.5	<0.4	<0.7
methyl-butylether (MTBE)	<0.2	<0.5	<0.2	<1.3	<0.2	<1.18	<0.5	<0.4	<0.7
4-methylpentan-2-one (MIBK)	<0.2	<0.5	<0.2	<1.3	<0.2	<1.18	<0.5	<0.4	<0.7
styrene	**0.09**	<0.1	**0.09**	<0.27	<0.04	<0.24	<0.1	<0.08	<0.1
SVOCs									
dibenzofuran	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
3,3'-dichlorobenzidine	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
isophorone	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
N-nitrosodi-n-propylamine	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6
N-nitrosodiphenylamine	<3	<1.5	<2	<0.67	<2	<1.2	<4	<3	<6

ANAEROBIC SLUDGES **OTHER ORGANICS**

Local Body	Watercare	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Dewatered Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 22)**
Lab No:	116306/2	116306/4	116306/5	116306/6		**MAX.**	**MIN.**	**>LOD**
VOCs % Dry Solids	0.9	33.8	44.6	43.3				
2-butanone (MEK)	<0.89	**8.9**	<2	<0.2		16.1	<0.06	7
carbon disulphide	**5.9**	<3	<2	<0.2		5.9	<0.06	3
methyl-butylether (MTBE)	<0.89	<3	<2	<0.2		-	<0.06	0
4-methylpentan-2-one (MIBK)	<0.89	<3	<2	<0.2		-	<0.06	0
styrene	<0.22	<0.6	<0.4	**0.04**		0.09	<0.01	3
SVOCs								
dibenzofuran	<1	<2	<2	<2		-	<0.5	0
3,3'-dichlorobenzidine	<1	<2	<2	<2		-	<0.5	0
isophorone	<1	<2	<2	<2		-	<0.5	0
N-nitrosodi-n-propylamine	<1	<2	<2	<2		-	<0.5	0
N-nitrosodiphenylamine	<1	<2	<2	<2		-	<0.5	0

AEROBIC SLUDGES OTHER ORGANICS

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
VOCs % Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
2-butanone (MEK)	<2.3	<1	<3.9	<5.9	<1.33	<0.8	<3	<0.7	<0.8
carbon disulphide	<2.3	<1	<3.9	<5.9	**8.0**	<0.8	<3	<0.7	<0.8
methyl-butylether (MTBE)	<2.3	<1	<3.9	<5.9	<1.33	<0.8	<3	<0.7	<0.8
4-methylpentan-2-one (MIBK)	<2.3	<1	<3.9	<5.9	<1.33	<0.8	<3	<0.7	<0.8
styrene	<0.23	<0.2	<0.39	<0.59	<0.27	<0.2	<0.6	<0.1	<0.2
SVOCs									
dibenzofuran	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
3,3'-dichlorobenzidine	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
isophorone	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
N-nitrosodi-n-propylamine	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7
N-nitrosodiphenylamine	<0.5	<10	<8.6	<1.2	<0.67	<7	<20	<6	<7

AEROBIC SLUDGES OTHER ORGANICS

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 16)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**>LOD**
VOCs % Dry Solids	14.9	4.2	29.6	0.9	1.4				
2-butanone (MEK)	<0.6	<2	3.6	<22	<7		3.6	<0.6	1
carbon disulphide	<0.6	<2	<0.3	<22	<7		8	<0.3	1
methyl-butylether (MTBE)	<0.6	<2	<0.3	<22	<7		-	<0.3	0
4-methylpentan-2-one (MIBK)	<0.6	<2	<0.3	<22	<7		-	<0.3	0
styrene	<0.1	<0.4	<0.06	<2.2	<1		-	<0.06	0
SVOCs									
dibenzofuran	<6	<20	<3	<5	<60		-	<0.5	0
3,3'-dichlorobenzidine	<6	<20	<3	<5	<60		-	<0.5	0
isophorone	<6	<20	<3	<5	<60		-	<0.5	0
N-nitrosodi-n-propylamine	<6	<20	<3	<5	<60		-	<0.5	0
N-nitrosodiphenylamine	<6	<20	<3	<5	<60		-	<0.5	0

POND SEDIMENT/COMPOST **OTHER ORGANICS**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
VOCs % Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
2-butanone (MEK)	<0.3	<4.2	<0.89	<0.17	<1	<5.6	<7	<0.62
carbon disulphide	<0.3	<4.2	<0.89	<0.17	<1	<5.6	<7	<0.62
methyl-butylether (MTBE)	<0.3	<4.2	<0.89	<0.17	<1	<5.6	<7	<0.62
4-methylpentan-2-one (MIBK)	<0.3	<4.2	<0.89	<0.17	<1	<5.6	<7	<0.62
styrene	<06	<0.42	<0.22	<0.04	<0.2	<0.56	<1	<0.15
SVOCs								
dibenzofuran	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
3,3'-dichlorobenzidine	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
isophorone	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
N-nitrosodi-n-propylamine	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8
N-nitrosodiphenylamine	<3	<0.8	<5.5	<0.4	<10	<1	<50	<0.8

POND SEDIMENT/COMPOST **OTHER ORGANICS**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**>LOD**
VOCs % Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
2-butanone (MEK)	<0.89	<0.8	<0.5	<1		<0.2	<0.6		-	<0.17	0
carbon disulphide	<0.89	<0.8	<0.5	<1		<0.2	<0.6		-	<0.17	0
methyl-butylether (MTBE)	<0.89	<0.8	<0.5	<1		<0.2	<0.6		-	<0.17	0
4-methylpentan-2-one (MIBK)	<0.89	<0.8	<0.5	<1		<0.2	<0.6		-	<0.17	0
styrene	<0.22	<0.2	<0.1	<0.2		<0.04	<0.1		-	<0.04	0
SVOCs											
dibenzofuran	<2	<2	<4	<9		<2	<5		-	<0.4	0
3,3'-dichlorobenzidine	<2	<2	<4	<9		<2	<5		-	<0.4	0
isophorone	<2	<2	<4	<9		<2	<5		-	<0.4	0
N-nitrosodi-n-propylamine	<2	<2	<4	<9		<2	<5		-	<0.4	0
N-nitrosodiphenylamine	<2	<2	<4	<9		<2	<5		-	<0.4	0

SECTION 11

ACID HERBICIDES

ANALYTICAL METHODOLOGY

Extraction - Solids

Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction with acidified dichloromethane/acetone (1:1). Surrogates of 67 µg/kg (equivalent in the solid) were added to the homogenised sample prior to extraction.

Extraction - Liquids

Based on USEPA method 3520A. Samples were acidified, and then extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 0.5 µg/L (equivalent in liquid) were added to samples prior to extraction.

Extract Cleanup

An aliquot of each extract was cleaned up using gel permeation chromatography and/or back extraction against water, then all samples were methylated with diazomethane.

Instrumental Analysis

Acid herbicides were determined by GC-MS using selected ion mode (SIM). Quantitation was performed using internal standardisation and a four point calibration curve for all target compounds.

Quality Control

For the acid herbicides, an extraction blank was run with every worksheet, or twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples had surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

Results of the acid herbicide analyses appear in Tables B 11.1 - B 11.4. Almost all results were below the limit of detection (LOD) for each sample, so to assist readers, results that were greater than the LOD appear in bold face. No acid herbicide results are reported in Part A, except that PCP was found to be less than 1 mg/kg in the Eastern Canadian study – Table 7.7.

RJ Hill Laboratories reported the pentachlorophenol (PCP) results with the acid herbicides. For completeness, the results have been included in the phenol tables too: see Tables B6.1 - B6.4.Acid herbicides were included in this survey because some may inhibit biological treatment processes, and because some may cause undesirable environmental effects when the sludge is disposed of or reused.

Pentachlorophenol is the only acid herbicide that appears in the USEPA priority pollutants list and is included amongst the phenols in their listings.

Discussion

Products based on 2,4,5-T are no longer used in New Zealand and 2,4,5-TP (silvex or fenoprop) never was.

The use of pentachlorophenol (PCP) in the timber industry in New Zealand ceased voluntarily in 1988 and it was withdrawn from sale as a pesticide in 1991. PCP was used in timber treatment as a fungicide to control sapstain. It was also used to control moss in lawns, and fungi, algae and `slimes' on roofs, ceilings, walls, paths etc.

The only acid herbicides found in this survey were:

(a) 0.06 mg/kg PCP in Mangere raw sludge
0.04 mg/kg PCP in Mangere digested sludge; and

(b) 0.25 mg/kg triclopyr in oxidation pond sediments at Featherston
0.32 mg/kg triclopyr in oxidation pond sediments at Greytown
0.39 mg/kg triclopyr in oxidation pond sediments at Martinborough

Triclopyr is mostly used as a weedkiller to control woody plants and many broad-leaved weeds such as nettles, docks, gorse and broom. DowElanco markets triclopyr under the Garlon tradename.

Acid herbicides are not often analysed in sewage sludges; as a result there are no acid herbicide tables in Section 6 (previous New Zealand analyses) or Section 7 (Eastern Canada and USA surveys) of Part A. Table 6.9 (phenols found in previous New Zealand analyses) has no PCP results. Table 7.7 shows that the survey in Eastern Canada found PCP did not exceed their 1 mg/kg method detection limit.

Acid herbicides and PCP do not appear to be included in any national standards or 'upper levels' established for sludges or biosolids.

RAW SLUDGES **ACIDIC HERBISIDES**

Local Body:	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview		
mg/kg dry wt	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg	Wool Scour
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2
% DS	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7	9.8
2,4,5-T	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
2,4-D	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
Dicamba	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
Fluroxypyr	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
MCPA	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
MCPB	#	<0.5^	#	<0.8^	<2*	<2*	<0.5	<3*	<0.2^	#	<0.4*
Mecoprop	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
PCP	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
Picloram	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
Silvex	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
Triclopyr	<0.01	<0.1	<0.01	<0.1	<0.1	<0.03	<0.5	<0.1	<0.04	<0.03	<0.01
	NOTE: 2,4,5-T is 2,4,5-trichlorophenoxyacetic acid; 2,4-D is 2,4-dichlorophenoxyacetic acid; PCP is pentachlorophenol; silvex is 2,4,5-TP										
		Note 1 (^): detection limit is 1-10 times higher than normal due to interference from fatty acids									
		Note 2 (*): detection limit is 10-100 times higher than normal due to interference from fatty acids									
		Note 3 (#): detection limits is meaningless due to very high interference from fatty acids									

RAW SLUDGES **ACIDIC HERBISIDES**

Local Body:	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
	Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry wt	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 16)**
Lab No:	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**
% DS	2.7	3.0	18.1	3.1	4.0		29	1.6	
2,4,5-T	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
2,4-D	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
Dicamba	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
Fluroxypyr	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
MCPA	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
MCPB	<0.3	#	<0.6*	#	#		-	<0.08	-
Mecoprop	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
PCP	<0.3	<0.01	<0.04	<0.006	**0.06**		-	<0.006	1
Picloram	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
Silvex	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-
Triclopyr	<0.3	<0.01	<0.04	<0.006	<0.01		-	<0.006	-

ANAEROBIC SLUDGES — ACIDIC HERBISIDES

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata	Wainuiomata
mg/kg dry wt	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg	Air Dried Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2	116891/3
% DS	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0	30.9
2,4,5-T	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
2,4-D	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
Dicamba	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
Fluroxypyr	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
MCPA	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
MCPB	<2*	<0.2	<0.1^	<0.2^	<0.008	<0.12^	<0.08	<0.2^	#	<0.03
Mecoprop	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
PCP	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
Picloram	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
Silvex	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03
Triclopyr	<0.02	<0.2	<0.03	<0.04	<0.008	<0.01	<0.08	<0.06	<0.01	<0.03

NOTE: 2,4,5-T is 2,4,5-trichlorophenoxyacetic acid; 2,4-D is 2,4-dichlorophenoxyacetic acid; PCP is pentachlorophenol; silvex is 2,4,5-TP

Note 1 (^): detection limit is 1-10 times higher than normal due to interference from fatty acids

Note 2 (*): detection limit is 10-100 times higher than normal due to interference from fatty acids

Note 3 (#): detection limits is meaningless due to very high interference from fatty acids

ANAEROBIC SLUDGES **ACIDIC HERBISIDES**

Local Body:	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare	Watercare
			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere	Mangere
mg/kg dry wt	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Dewatered Slg	Dewatered Slg
Lab No:	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2	116306/4
% DS	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7	0.9	33.8
2,4,5-T	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
2,4-D	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
Dicamba	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
Fluroxypyr	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
MCPA	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
MCPB	<1.7*	<0.02	<0.5*	<0.3*	<0.35*	<0.9*	<0.06^	<0.1^	<2*	<0.6*
Mecoprop	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
PCP	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	**0.04**	<0.02
Picloram	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
Silvex	<0.02	<0.02	<0.005	<0.01	<0.01	<0.04	<0.03	<0.05	<0.02	<0.02
Triclopyr										
	NOTE: 2,4,5-T is 2,4,5-trichlorophenoxyacetic acid; 2,4-D is 2,4-dichlorophenoxyacetic acid; PCP is pentachlorophenol; silvex is 2,4,5-TP									
		Note 1 (^): detection limit is 1-10 times higher than normal due to interference from fatty acids								
		Note 2 (*): detection limit is 10-100 times higher than normal due to interference from fatty acids								
		Note 3 (#): detection limits is meaningless due to very high interference from fatty acids								

ANAEROBIC SLUDGES **ACIDIC HERBISIDES**

Local Body:	Watercare	Watercare				
	Mangere	Mangere				**Number**
mg/kg dry wt	Lime stabilised	Air Dried Slg				**(from 22)**
Lab No:	116306/5	116306/6		**MAX.**	**MIN.**	**>LOD**
% DS	44.6	43.3		93.9	0.9	
2,4,5-T	<0.02	<0.02		-	<0.005	-
2,4-D	<0.02	<0.02		-	<0.005	-
Dicamba	<0.02	<0.02		-	<0.005	-
Fluroxypyr	<0.02	<0.02		-	<0.005	-
MCPA	<0.02	<0.02		-	<0.005	-
MCPB	<0.8*	<0.02		-	<0.02	-
Mecoprop	<0.02	<0.02		-	<0.005	-
PCP	<0.02	<0.02		0.04	<0.005	1
Picloram	<0.02	<0.02		-	<0.008	-
Silvex	<0.02	<0.02		-	<0.005	-
Triclopyr	<0.02	<0.02		-	<0.005	-

AEROBIC SLUDGES **ACIDIC HERBISIDES**

Local Body:	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua	Rodney
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically	Warkworth
mg/kg dry wt	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered	Air Dried Slg
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1	115840/2
% DS	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3	14.9
2,4,5-T	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
2,4-D	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
Dicamba	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
Fluroxypyr	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
MCPA	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
MCPB	<0.14*	<0.2^	#	<0.2^	#	<0.07	<0.5^	<0.05	<0.07	<0.05
Mecoprop	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
PCP	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
Picloram	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
Silvex	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
Triclopyr	<0.009	<0.1	<0.02	<0.02	<0.03	<0.07	<0.2	<0.05	<0.07	<0.05
	NOTE: 2,4,5-T is 2,4,5-trichlorophenoxyacetic acid; 2,4-D is 2,4-dichlorophenoxyacetic acid; PCP is pentachlorophenol; silvex is 2,4,5-TP									
		Note 1 (^): detection limit is 1-10 times higher than normal due to interference from fatty acids								
		Note 2 (*): detection limit is 10-100 times higher than normal due to interference from fatty acids								
		Note 3 (#): detection limits is meaningless due to very high interference from fatty acids								

AEROBIC SLUDGES **ACIDIC HERBISIDES**

Local Body:	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Waste		Thames	Te Puke				**Number**
mg/kg dry wt	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No:	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**>LOD**
% DS	4.2	29.6	0.9	1.4		29.6	0.9	
2,4,5-T	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
2,4-D	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
Dicamba	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
Fluroxypyr	<0.2	<0.03	<0.1	<0.6		-	<0.02	-
MCPA	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
MCPB	<0.2	<0.06^	<0.1	<0.6		-	<0.05	-
Mecoprop	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
PCP	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
Picloram	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
Silvex	<0.2	<0.03	<0.1	<0.6		-	<0.009	-
Triclopyr								

POND SEDIMENTS/COMPOST **ACIDIC HERBISIDES**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston	Greytown
mg/kg dry wt	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1	116452/2
% DS	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3	0.9
2,4,5-T	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
2,4-D	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
Dicamba	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
Fluroxypyr	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
MCPA	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
MCPB	<0.03	<0.008	<0.3^	<0.09^	<0.1	<1*	<0.5	<0.036	<0.09^
Mecoprop	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
PCP	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
Picloram	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
Silvex	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	<0.02	<0.04
Triclopyr	<0.03	<0.008	<0.1	<0.009	<0.1	<0.02	<0.5	**0.25**	**0.32**
	NOTE: 2,4,5-T is 2,4,5-trichlorophenoxyacetic acid; 2,4-D is 2,4-dichlorophenoxyacetic acid; PCP is pentachlorophenol; silvex is 2,4,5-TP								
		Note 1 (^): detection limit is 1-10 times higher than normal due to interference from fatty acids							
		Note 2 (*): detection limit is 10-100 times higher than normal due to interference from fatty acids							
		Note 3 (#): detection limits is meaningless due to very high interference from fatty acids							

POND SEDIMENTS/COMPOST **ACIDIC HERBISIDES**

Local Body:	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry wt	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**>LOD**
% DS	1.0	19.9	8.3		50.0	15.8		50	0.9	
2,4,5-T	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
2,4-D	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
Dicamba	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
Fluroxypyr	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
MCPA	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
MCPB	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
Mecoprop	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
PCP	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
Picloram	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
Silvex	<0.04	<0.04	<0.09		<0.02	<0.05		-	<0.008	-
Triclopyr	**0.39**	<0.04	<0.09		<0.02	<0.05		0.39	<0.008	3

SECTION 12

ORGANOCHLORINE PESTICIDES (all SVOC)

NOMENCLATURE

The naming of some of these chemicals can cause confusion. The commonest confusion seems to be between hexachlorobenzene and lindane and some of the names lindane and its isomers go by.

Hexachlorobenzene or HCB for short (which has been used as a fungicide) is as its name suggests - a benzene ring (C_6H_6) where the six hydrogen atoms have been substituted by six chlorine atoms (C_6C1_6).

Lindane (which has been used as an insecticide) is a six-carbon, single-ring, saturated hydrocarbon or cyclo-alkane It is not an aromatic. It has a chlorine atom attached to each carbon atom in place of one of the hydrogen atoms ($C_6H_6C1_6$). Its correct and formal chemical name is 1,2,3,4,5,6-hexachlorocyclohexane. Lindane is also known as gamma-BHC (γ-BHC) and gamma-HCH (γ-HCH), and less commonly by various other trade names.

Eight isomers of $C_6H_6C1_6$ exist and some are measured along with the organochlorine suite. Other than lindane, the commonest are alpha-BHC (α-BHC), beta-BHC (β-BHC) and delta-BHC (δ-BHC); once again, HCH can be used in place of BHC.

Where the word chlordane appears, it is used to include all the chemicals in that group. The cis and trans forms generally comprise 42% of the total chlordane mix. These two forms are analysed, summed, and divided by 0.42 to obtain a total chlordane concentration.

ANALYTICAL METHODOLGY

(a) RJ Hill Laboratories Ltd Method

Extraction - Solids

Based on USEPA method 3545. The samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 133 μg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction - Liquids

Samples were extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 0.5 μg/L (equivalent in water) were added to the sample prior to extraction.

Extract Cleanup

An aliquot of each extract was cleaned up by gel permeation chromatography, then passing through a triple series of solid phase extraction cartridges consisting of ENVI-Carb, florisil and SAX/aminopropyl

Instrumental Analysis

These were determined either by GC-MS using selected ion mode (SIM), or GC-ECD with all positives being confirmed using a second column. Quantitation was performed using internal standardisation and a three point calibration curve for all target compounds.

Quality Control

For OCP compounds, an extraction blank was run with every worksheet, or every twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples had surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

Samples analysed by R.J. Hill Laboratories Ltd were in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

(b) HortResearch Analytical Method

Sub-samples of the sludges/waters were taken field-moist and additions made of sodium sulphate, Celite 545, surrogate standard (oxychlordane) and phosphoric acid. The samples were extracted with acetone/hexane using sonication followed by shaking. Water was added and the upper layer removed following centrifugation. The resulting crude extract was subjected to gel permeation chromatography (GPC), followed by Florisil column chromatography.

Quantitative analysis was performed by gas chromatography with high resolution capillary column and electron capture detection (GC/ECD). Retention times were used for identification of compounds. Confirmation analyses were carried out using an alternative column. A concentrated sulphuric acid wash was used as part of the confirmation to remove some potential interferences (except for dieldrin, the OCPs are stable in this wash).

Samples analysed by HortResearch were in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as ng/g wet weight and were converted to dry weight based on their dry solids content. Recovery experiments were carried out by spiking a sample with 0.125 ng/g of most components and retesting. Recoveries were between 80-104%.

The limits of detection were 0.1 ng/g wet weight for all organochlorines.

Limits of Quantitation (LOQ) were set at three times the detection limit. Results less than the LOQ are reported but levels are in the region of uncertainty.

QA SAMPLES

Refer to Section 3 in Part A for a more detailed description of the samples. Seven samples were tested by HortResearch, principally as a quality control check on the samples tested by RJ Hill Laboratories Ltd (the % dry solids results and sample numbers are those reported by RJH):

- Rotorua compost (15.8% dry solids) ex Rotorua District Council, sample 116021/4
- Belfast oxidation pond sediment (0.9% dry solids) ex Christchurch City Council, sample 116211/3
- New Plymouth dewatered sludge (13.5% dry solids) ex New Plymouth District Council, sample 116307/2
- Tokoroa sludge lagoon north (23.6% DS) ex South Waikato District Council, sample 116224/2
- Tokoroa sludge lagoon south (13.7% DS) ex South Waikato District Council, sample 116224/1
- Levin lagooned sludge (8.8% dry solids) ex Horowhenua District Council, sample 115892/3
- Greytown oxidation pond sediment (0.9% dry solids) ex South Wairarapa District Council, sample 116452/2

QA RESULTS

The HortResearch results were reported in ng/g wet weight as received (equivalent to µg/kg wet weight). These wet weight results were converted to a dry weight basis using the results of the dry solids determinations conducted by RJ Hill Laboratories Ltd. The limits of detection were recalculated accordingly and expressed on a dry weight basis too. The HortResearch results appear in Table B 12.5, and the comparison with the RJ Hill Laboratories Ltd's results appears in Table B 12.6.

Chemical µg/kg dry weight	**Belfast**	**Greytown**	**Levin**	**New Plymouth**	**Tokoroa north**	**Tokoroa south**	**Rotorua**
Sample	pond sed	pond sed	dewatered	dewatered	lagoon	lagoon	compost
RJH Sample No.	116211/3	116452/2	115892/3	116307/2	116224/2	116224/1	116021/4
% dry solids:	0.9	0.9	8.8	13.5	23.6	13.7	15.8
aldrin + isodrin							
dieldrin	81	<10	61	52	48	83	17
endrin	<10	<10	<1	<1	<0.5	<1	<1
endrin aldehyde							
α-BHC (or ∝-HCH)	<10	<10	<1	<1	<0.5	<1	<1
β-BHC							
δ-BHC (lindane)	<10	<10	<1	4.1	<0.5	<1	<1
delta-BHC							
chlordanes: trans	<10	<10	<1	2.3	<0.5	<1	<1
chlordanes: cis	<10	<10	<1	2.1	<0.5	<1	<1
total chlordanes	<20	<20	<2	4.4	<1	<2	<2
2,4-DDE (o,p DDE)	<10	<10	<1	2.7	<0.5	<1	<1
2,4-DDD (o,p DDD)	<10	<10	7.2	2.4	<0.5	<1	<1
2,4-DDT (o,p DDT)	<10	<10	<1	<1	<0.5	<1	<1
4,4'-DDE (p,p DDE)	91	<10	<1	30	<0.5	1.2	27
4,4'-DDD (p,p DDD)	20	<10	31	8.9	2.3	<1	1.8
4,4'-DDT (p,p DDT)	<10	<10	<1	<1	<0.5	<1	<1
α-endosulfan (I)							
β-endosulfan (II)							
endosulfan sulfate							
heptachlor	<10	<10	<1	<1	<0.5	<1	<1
heptachlor epoxide	<10	<10	<1	<1	<0.5	<1	<1
hexachlorobenzene	<10	<10	<1	<1	<0.5	<1	<1

Table B 12.5: The HortResearch results for organochlorine pesticides - units in µg/kg dry weight

The two laboratories used different clean-up and analytical techniques, hence their limits of detection (LODs) varied, also depending somewhat on the nature of the sample. For one sample the RJH result was 5 times more sensitive than HortResearch's, another sample had half the LOD, but for the other five samples the RJH result was 10-40 times less sensitive. This makes a comparison rather difficult.

RJH analysed hexachlorobenzene with the general SVOC organics which is a far less sensitive technique.

Not counting the hexachlorobenzene results, Table B 12.6 compares 91 pairs of results; 69 of the pairs reported 'less than' values for each result (presumably all one can say is that these results are not in disagreement); 14 of the pairs included one 'less than' value, and only 8 pairs reported both concentrations above their respective LODs.

Of the 14 pairs where one of the results was a 'less than' value, 2 were not in agreement - that is the 'real' number was greater than the 'less than' value – they were the Levin dieldrin results of 61 and <40 µg/kg and Tokoroa north 4,4'-DDE results of <0.50 and 31 µg/kg. The difference was greater than a factor of 2 in one of these pairs.

Of the 8 pairs where both results were reported in 'real' numbers, 4 pairs agreed quite well, that is where the higher result was less than double the lower result. For low level samples like these, the agreement is considered satisfactory when one result is less than double the other result, especially when bearing in mind that different analytical techniques were used.

In conclusion, in 5.5% of the 91 paired results, one of the individual results was more than double the other; conversely, the pairs were in reasonable agreement for 94.5% of the comparisons. Neither laboratory consistently produced the higher concentration in the paired data.

Chemical µg/kg dry weight	**Belfast**		**Greytown**		**Levin**		**New Plymouth**		**Tokoroa**		**Tokoroa**		**Rotorua**	
Sample	pond sed		pond sed		dewatered		dewatered		north lagoon		south lagoon		compost	
RJH Sample Number	116211/3		116452/2		115892/3		116307/2		116224/2		116224/1		116021/4	
% dry solids	0.9		0.9		8.8		13.5		23.6		13.7		15.8	
	HR	RJH	HR	RJH	HR	RJH	HR	RJH	HR	RJH	HR	RJH	HR	RJH
aldrin + isodrin														
dieldrin	81	36	<10	<20	61	<40	52	40	48	76	83	70	17	<30
endrin	<10	<2	<10	<20	<1	<40	<1	<10	<0.5	<6	<1	<10	<1	<30
endrin aldehyde														
α-BHC	<10	<2	<10	<20	<1	<40	<1	<10	<0.5	<6	<1	<10	<1	<30
β-BHC														
γ-BHC (lindane)	<10	<2	<10	<20	<1	<40	4.1	<10	<0.5	<6	<1	<10	<1	<30
Delta-BHC														
chlordanes: trans	<10	-	<10	-	<1	-	2.3	-	<0.5	-	<1	-	<1	-
chlordanes: cis	<10	-	<10	-	<1	-	2.1	-	<0.5	-	<1	-	<1	-
total chlordanes	<20	<4	<20	<40	<2	<70	4.4	<20	<1.0	<10	<2	<20	<2	<60
2,4-DDE (o.p DDE)	<10	<2	<10	<20	<1	<40	2.7	<10	<0.5	<6	<1	<10	<1	<30
2,4-DDD (o.p DDD)	<10	<2	<10	<20	7.2	<40	2.4	<10	<0.5	<6	<1	<10	<1	<30
2,4-DDT (o.p DDT)	<10	<2	<10	<20	<1	<40	<1	<10	<0.5	<6	<1	<10	<1	<30
4,4'-DDE (p.p DDE)	91	27	<10	<20	<1	<40	30	30	<0.5	31	1.2	50	27	<30
4,4'-DDD (p.p DDD)	20	8	<10	<20	31	<40	8.9	<10	2.3	<6	<1	<10	1.8	<30
4,4'-DDT (P.p DDT)	<10	2	<10	<20	<1	<40	<1	<10	<0.5	<6	<1	<10	<1	<30
α-endosulfan (I)														
β-endosulfan (II)														
endosulfan sulfate														
heptachlor	<10	<2	<10	<20	<1	<40	<1	<10	<0.5	<6	<1	<10	<1	<30
heptachlor epoxide	<10	<2	<10	<20	<1	<40	<1	<10	<0.5	<6	<1	<10	<1	<30
hexachlorobenzene	<10	<5500	<10	<2000	<1	<9000	<1	<6000	<0.5	<3000	<1	<6000	<1	<5000

Table B12.6: Comparison of HortResearch and RJ Hill Laboratories organochlorine pesticide results – units in µg/kg dry weight

ANALYTICAL RESULTS

Results of the organochlorine pesticide (OCP) analyses appear in Tables B 12.1 - B 12.4. The 27 samples with results reported in italics were analysed in the RJ Hill Laboratories Ltd (RJH) SVOC suite - these were the 'operational' samples - none was above its LOD. The other 39 sludges (`environmental' samples) were tested by RJH using a far more sensitive technique, and most of these were below their limit of detection (LOD). Concentrations are expressed in mg/kg units, ie w/w.

The analytical design of this project was a cost effective balance between obtaining a broad screen for all samples and determining OCPs in some environmental samples at a lower LOD. The extraction methods used were chosen for their ability to efficiently extract polar and non-polar organic residues. For some samples this resulted in a very complex organic extract, too complex for the analytical step without dilution, resulting in higher limits of detection. Methods that offered lower LODs were available but are much more expensive. The analytical method needs to be chosen with care. The most sensitive techniques are needed for regulatory work, with LODs probably being needed below the 0.004 mg/kg level (or a fifth of any standards that are set).

The hexachlorobenzene results are included in the halogenated aromatic tables, Tables B4.1 -B4.4. The pentachlorophenol (PCP) results are included in the phenols section for convenience, and in the acid herbicides section where they are discussed a little more fully – see Tables B 11.1 – B11.4.

The organochlorine pesticides were included in this survey because of their persistence in the environment and their environmental effects.

Chlordane was a technical mixture of at least 11 major components and 30 or more minor ones. The cis and trans forms have frequently been found to average about 42% of the total mix, so RJ Hill multiply the sum of their concentrations by 100/42 to obtain a value for 'total' chlordanes.
All the organochlorine pesticides listed in Tables B 12.1 - B 12.4 are USEPA priority pollutants. The EPA sometimes includes in their pesticide list acrolein, isophorone, toxaphene and 2,3,7,8- TCDD. In this report isophorone is discussed in the 'Some Other Organics' section and 2,3,7,8- TCDD is discussed with the dioxins.

Discussion

The main OCPs that were used in New Zealand were dieldrin, lindane and DDT.

Dieldrin was used as an agricultural insecticide in New Zealand until it was banned in 1968. Mainly it had been used as a sheep spray and dip, and to control crickets and armyworm. Its sale for all other purposes such as spider control, timber preservation and mothproofing was effectively banned in 1989 when it was deregistered by the Pesticides Board.

The use of DDT on farmland was prohibited in New Zealand in 1970, and its sale for all other purposes such as borer bombs was banned in 1989. Some minor non-pesticide uses are still allowed. DDT and its isomers are very stable in the environment.

Lindane was used as an agricultural insecticide in New Zealand, particularly for control of cattle lice, grass grub, sheepstrike (blowflies), and insects in orchards and vegetable gardens; its use was gradually reduced until the last lindane based products were deregistered in 1990.

The main use of chlordane (a mixture of chlordane chemicals) was in the timber treatment industry for borer control. It was also used as a broad spectrum agricultural insecticide. It was deregistered as a pesticide in 1989.

Aldrin, endrin, hexachlorobenzene and heptachlor were used in New Zealand agriculture to a limited extent only. Aldrin was withdrawn from sale in New Zealand in 1985 although its use since about 1970 was not great. The withdrawal of the last endrin product was gazetted in 1976. HCB (hexachlorobenzene) was effectively banned in 1972 when it was deregistered as a horticultural pesticide. The last heptachlor product was withdrawn in 1971 (September Gazette).

Endosulfan is currently registered, and is mainly used in horticulture. Compared with DDT and dieldrin, it is of low to medium persistence in soils.

The frequency with which the organochlorine pesticides were found in the different types of sludge was very consistent, as shown in Table B 12.7.

Dieldrin and 4,4'-DDE were found in about two-thirds of all the 'environmental' suite samples, whereas 2,4'-DDD, 4,4'-DDD and 4,4'-DDT were found in about a quarter of them.

Aldrin, endrin, chlordanes, 2,4-DDE and endosulfan II were found only in 1-4 samples.

Endrin aldehyde, alpha-BHC, beta-BHC, gamma-BHC (lindane), delta-BHC, 2,4-DDT, endosulfan I, endosulfan sulphate, heptachlor, and heptachlor epoxide were not found in any of the 39 low level samples. Note however, that HortResearch detected lindane at 0.004 mg/kg in the New Plymouth dewatered sludge (the RJH LOD was 0.01 mg/kg).

Twenty of the 39 samples contained more than 0.02 mg/kg dieldrin - the limit that seems to be used quite often to determine whether the sludge may have unrestricted use – see Table 5.5 in Part A; 7 samples contained more than 0.1 mg/kg, and 3 above 0.2 mg/kg - from the Mangere airdried sludge (0.38), Bromley pond sediment (0.30) and Invercargill lagoon (0.21 mg/kg). The LOD for 4 of the 39 samples in the environmental suite was greater than 0.02 mg/kg.

Dieldrin seems to be the organochlorine pesticide that could cause the most problems regarding the reuse or disposal of sewage sludges in New Zealand. Dieldrin was not detected in the Eastern Canadian survey.

OCP	Percent of Samples Found to Contain the OCP			
	Raw Sludges	Anaerobic Sludges	Aerobic Sludges	Pond Sediments
No. of Samples Tested:	3	15	7	14
aldrin	0	7	0	7
dieldrin	67	67	57	57
endrin	0	0	0	14
endrin aldehyde	0	0	0	0
alpha-BHC	0	0	0	0
beta-BHC	0	0	0	0
gamma-BHC (lindane)	0	0	0	0
delta-BHC	0	0	0	0
chlordane (cis+trans)	0	27	0	0
2,4-DDE (o,p-DDE)	0	0	0	7
2,4-DDD (o,p-DDD)	33	13	0	14
2,4-DDT (o,p-DDT)	0	0	0	0
4,4'-DDE (p,p'-DDE)	67	67	57	64
4,4'-DDD (p,p'-DDD)	33	20	0	36
4A-DDT (p,p'-DDT)	67	13	0	21
endosulfan I	0	0	0	0
endosulfan **II**	0	7	0	0
endosulfan sulphate	0	0	0	0
heptachlor	0	0	0	0
heptachlor epoxide	0	0	0	0

Table 12.7: The percentage of low level' samples which contained organochlorine pesticides above their limits of detection (as analysed by RJH)

Nineteen of the 39 samples contained more than 0.02 mg/kg 4,4'-DDE; 3 of the samples contained more than 0.1 mg/kg, none above 0.2 mg/kg. The 3 highest levels were found in Inglewood pond sediment (0.135), Mangere airdried sludge (0.126) and Mangere pond sediment (0.11 mg/kg).

One of the 39 samples contained more than 0.02 mg/kg 2,4'-DDD; none of the samples contained more than 0.1 mg/kg.

Four of the 39 samples contained more than 0.02 mg/kg 4,4'-DDD; one of the samples contained more than 0.1 mg/kg (0.19 in Pleasant Point sediments), and none above 0.2 mg/kg.

Five of the 39 samples contained more than 0.02 mg/kg 4,4'-DDT; none were above 0.2 mg/kg and two of the samples contained more than 0.1 mg/kg: Inglewood pond (0.197) and Invercargill lagoon (0.124 mg/kg).

Some national standards etc develop an upper level for the sum of DDT and all their isomers. This is often set around the 0.5 mg/kg level – see Table 5.5 in Part A. None of the 39 samples exceeded this level; in fact, only 4 exceeded 0.2 mg/kg, these being 0.24, 0.25, 0.32 and 0.43 mg/kg, in the samples of Mangere pond sediments, Invercargill air dried sludge, Pleasant Point (Timaru) pond sediments, and New Plymouth dewatered sludge, respectively.

Aldrin, endrin, chlordanes, 2,4-DDE and endosulfan II were not found in concentrations above 0.1 mg/kg. Aldrin, endrin, and 2,4-DDE were found above 0.02 mg/kg on only one occasion each.

Very little previous data on organochlorine pesticides in New Zealand sludges seems to be available - see Table 6.11 in Part A - dieldrin and DDE were the only OCPs reported above their LODs.

Average concentrations of organochlorine pesticides in Eastern Canadian sludges (see Table 7.9 and Table 7.10) were fairly low, and the maximum values found in individual samples were quite similar to the results from this survey. Table 7.17 indicates that organochlorine pesticides are rarely found in USA sludges.

RAW SLUDGES **ORGANOCHLORINE PESTICIDES**

Local Body:	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
mg/kg dry wt	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
%DS	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
aldrin	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
dieldrin	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	**0.021**	*<50*	*<10*	**0.114**	*<1.6*
endrin	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
endrin aidehyde	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
alpha-BHC	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
beta_BHC	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
gamma-BHC (lindane)	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
delta-BHC	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
chlordane (cis+trans)	-	-	-	-	-	<0.02	-	-	<0.02	-
2,4-DDE (o.p-DDE)	-	-	-	-	-	<0.01	-	-	<0.008	-
2,4-DDD (o.p-DDD)	-	-	-	-	-	**0.018**	-	-	<0.008	-
2,4-DDT (o.p-DDT)	-	-	-	-	-	<0.01	-	-	<0.008	-
4,4'-DDE p.p'-DDE)	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	**0.018**	*<50*	*<10*	<0.008	*<1.6*
4,4'-DDD (p.p'-DDD)	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	**0.085**	*<50*	*<10*	<0.008	*<1.6*
4,4'-DDT (p.p'-DDT)	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	**0.017**	*<50*	*<10*	**0.038**	*<1.6*
endosulfan I	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
endosulfan II	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
endosulfan sulphate	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
heptachlor	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
heptachlor epoxide	*<0.5*	*<10*	*<0.6*	*<10*	*<10*	<0.01	*<50*	*<10*	<0.008	*<1.6*
	Analyses reported in italics were part of the SVOC suite, the other results were conducted by a more sensitive technique									

RAW SLUDGES **ORGANOCHLORINE PESTICIDES**

Local Body:	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
		Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry wt	Wool Scour	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 3)**
Lab No:	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**
%DS	9.8	2.7	3.0	18.1	3.1	4.0		29	1.6	
aldrin	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
dieldrin	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		0.114	<0.008	2
endrin	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
endrin aidehyde	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
alpha-BHC	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
beta_BHC	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
gamma-BHC (lindane)	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
delta-BHC	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
chlordane (cis+trans)	-	-	-	<0.02	-	-		-	<0.02	0
2,4-DDE (o.p-DDE)	-	-	-	<0.008	-	-		-	<0.008	0
2,4-DDD (o.p-DDD)	-	-	-	<0.008	-	-		0.018	<0.008	1
2,4-DDT (o.p-DDT)	-	-	-	<0.008	-	-		-	<0.008	0
4,4'-DDE p.p'-DDE)	*<0.6*	*<30*	*<0.7*	**0.013**	*<0.6*	*<0.5*		0.018	<0.008	2
4,4'-DDD (p.p'-DDD)	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		0.085	<0.008	1
4,4'-DDT (p.p'-DDT)	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		0.038	<0.008	2
endosulfan I	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
endosulfan II	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
endosulfan sulphate	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
heptachlor	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0
heptachlor epoxide	*<0.6*	*<30*	*<0.7*	<0.008	*<0.6*	*<0.5*		-	<0.008	0

ANAEROBIC SLUDGES **ORGANOCHLORINE PESTICIDES**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry wt	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
%DS	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
aldrin	*<1.2*	<0.04	<0.008	<0.007	0.004	*<1.2*	<0.04	<0.02	*<0.5*
dieldrin	*<1.2*	<0.04	**0.062**	<0.007	<0.077	*<1.2*	<0.04	**0.12**	*<0.5*
endrin	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
endrin aidehyde	*<1.2*	<0.04	<0.02	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
alpha-BHC	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
beta_BHC	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
gamma-BHC (lindane)	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
delta-BHC	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
chlordane (cis+trans)	-	<0.08	**0.04**	**0.05**	**0.04**	-	<0.07	<0.04	-
2,4-DDE (o.p-DDE)	-	<0.04	<0.008	<0.007	<0.002	-	<0.04	<0.02	-
2,4-DDD (o.p-DDD)	-	<0.04	<0.008	<0.007	**0.003**	-	<0.04	<0.02	-
2,4-DDT (o.p-DDT)	-	<0.04	<0.008	<0.007	<0.002	-	<0.04	<0.02	-
4,4’-DDE p.p’-DDE)	*<1.2*	**0.05**	**0.066**	<0.007	**0.008**	*<1.2*	<0.04	<0.02	*<0.5*
4,4’-DDD (p.p’-DDD)	*<1.2*	<0.04	<0.008	<0.007	**0.006**	*<1.2*	<0.04	<0.02	*<0.5*
4,4’-DDT (p.p’-DDT)	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
endosulfan I	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
endosulfan II	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
endosulfan sulphate	*<1.2*	<0.04	<0.008	<0.04	<0.01	*<1.2*	<0.04	<0.02	*<0.5*
heptachlor	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*
heptachlor epoxide	*<1.2*	<0.04	<0.008	<0.007	<0.002	*<1.2*	<0.04	<0.02	*<0.5*

ANAEROBIC SLUDGES **ORGANOCHLORINE PESTICIDES**

Local Body:	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere
mg/kg dry wt	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Dewatered Slg
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2
%DS	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7	0.9
aldrin	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
dieldrin	**0.03**	*<1.5*	**0.208**	*<0.7*	**0.027**	*<1.2*	**0.02**	**0.076**	**0.07**	*<1.1*
endrin	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
endrin aidehyde	<0.02	*<1.5*	<0.004	*<0.7*	<0.004	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
alpha-BHC	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
beta_BHC	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
gamma-BHC (lindane)	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
delta-BHC	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
chlordane (cis+trans)	<0.02	-	**0.057**	-	<0.004	-	<0.03	<0.01	<0.02	-
2,4-DDE (o.p-DDE)	<0.02	-	<0.004	-	<0.002	-	<0.01	<0.006	<0.01	-
2,4-DDD (o.p-DDD)	<0.02	-	**0.016**	-	<0.002	-	<0.01	<0.006	<0.01	-
2,4-DDT (o.p-DDT)	<0.02	-	<0.004	-	<0.002	-	<0.01	<0.006	<0.01	-
4,4'-DDE p.p'-DDE)	**0.03**	*<1.5*	**0.089**	*<0.7*	**0.026**	*<1.2*	<0.01	**0.031**	**0.05**	*<1.1*
4,4'-DDD (p.p'-DDD)	<0.02	*<1.5*	**0.024**	*<0.7*	**0.008**	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
4,4'-DDT (p.p'-DDT)	**0.03**	*<1.5*	**0.124**	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
endosulfan I	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
endosulfan II	<0.02	*<1.5*	**0.004**	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
endosulfan sulphate	<0.02	*<1.5*	<0.004	*<0.7*	<0.01	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
heptachlor	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*
heptachlor epoxide	<0.02	*<1.5*	<0.004	*<0.7*	<0.002	*<1.2*	<0.01	<0.006	<0.01	*<1.1*

ANAEROBIC SLUDGES **ORGANOCHLORINE PESTICIDES**

Local Body:	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere				**Number**
mg/kg dry wt	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 15)**
Lab No:	116306/4	116306/5	116306/6		**MAX.**	**MIN.**	**>LOD**
%DS	33.8	44.6	43.3		93.9	0.9	
aldrin	<0.01	<0.008	<0.004		0.004	<0.002	1
dieldrin	<0.01	<0.008	**0.379**		0.379	<0.007	10
endrin	<0.01	<0.008	<0.004		-	<0.002	0
endrin aidehyde	<0.01	<0.008	<0.004		-	<0.004	0
alpha-BHC	<0.01	<0.008	<0.004		-	<0.002	0
beta_BHC	<0.01	<0.008	<0.004		-	<0.002	0
gamma-BHC (lindane)	<0.01	<0.008	<0.004		-	<0.002	0
delta-BHC	<0.01	<0.008	<0.004		-	<0.002	0
chlordane (cis+trans)	<0.02	<0.02	<0.008		0.057	<0.004	4
2,4-DDE (o.p-DDE)	<0.01	<0.008	<0.004		-	<0.002	0
2,4-DDD (o.p-DDD)	<0.01	<0.008	<0.004		0.016	<0.002	2
2,4-DDT (o.p-DDT)	<0.01	<0.008	<0.004		-	<0.002	0
4,4'-DDE p.p'-DDE)	<0.01	**0.022**	**0.126**		0.126	<0.007	10
4,4'-DDD (p.p'-DDD)	<0.01	<0.008	<0.004		0.024	<0.004	3
4,4'-DDT (p.p'-DDT)	<0.01	<0.008	<0.004		0.124	<0.002	2
endosulfan I	<0.01	<0.008	<0.004		-	<0.002	0
endosulfan II	<0.01	<0.008	<0.004		0.004	<0.002	1
endosulfan sulphate	<0.01	<0.008	<0.004		-	<0.004	0
heptachlor	<0.01	<0.008	<0.004		-	<0.002	0
heptachlor epoxide	<0.01	<0.008	<0.004		-	<0.002	0

AEROBIC SLUDGES **ORGANOCHLORINE PESTICIDES**

Local Body:	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry wt	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
%DS	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
aldrin	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
dieldrin	**0.007**	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	**0.04**	<0.01
endrin	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
endrin aidehyde	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
alpha-BHC	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
beta_BHC	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
gamma-BHC (lindane)	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
delta-BHC	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
chlordane (cis+trans)	<0.005	-	-	-	-	<0.005	-	<0.02	<0.03
2,4-DDE (o.p-DDE)	<0.002	-	-	-	-	<0.02	-	<0.01	<0.01
2,4-DDD (o.p-DDD)	<0.002	-	-	-	-	<0.02	-	<0.01	<0.01
2,4-DDT (o.p-DDT)	<0.002	-	-	-	-	<0.02	-	<0.01	<0.01
4,4'-DDE p.p'-DDE)	**0.005**	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	**0.03**	**0.03**
4,4'-DDD (p.p'-DDD)	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
4,4'-DDT (p.p'-DDT)	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
endosulfan I	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
endosulfan II	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
endosulfan sulphate	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
heptachlor	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
heptachlor epoxide	<0.002	*<10*	*<8.5*	*<1.2*	*<0.7*	<0.02	*<20*	<0.01	<0.01
	Analyses reported in italics were part of the SVOC suite, the other results were conducted by a more sensitive technique								

AEROBIC SLUDGES ORGANOCHLORINE PESTICIDES

Local Body:	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry wt	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 7)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**>LOD**
%DS	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
aldrin	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
dieldrin	**0.04**	*<20*	**0.051**	<0.004	*<60*		0.051	<0.004	4
endrin	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
endrin aidehyde	<0.02	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
alpha-BHC	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
beta_BHC	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
gamma-BHC (lindane)	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
delta-BHC	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
chlordane (cis+trans)	<0.02	-	<0.01	<0.009	-		-	<0.005	0
2,4-DDE (o.p-DDE)	<0.01	-	<0.009	<0.004	-		-	<0.002	0
2,4-DDD (o.p-DDD)	<0.01	-	<0.009	<0.004	-		-	<0.002	0
2,4-DDT (o.p-DDT)	<0.01	-	<0.009	<0.004	-		-	<0.002	0
4,4'-DDE p.p'-DDE)	**0.02**	*<20*	<0.009	<0.004	*<60*		0.030	<0.004	4
4,4'-DDD (p.p'-DDD)	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
4,4'-DDT (p.p'-DDT)	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
endosulfan I	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
endosulfan II	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
endosulfan sulphate	<0.07	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
heptachlor	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0
heptachlor epoxide	<0.01	*<20*	<0.009	<0.004	*<60*		-	<0.002	0

POND SEDIMENTS/COMPOST **ORGANOCHLORINE PESTICIDES**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry wt	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
%DS	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
aldrin	**0.033**	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
dieldrin	**0.296**	**0.118**	**0.036**	<0.0009	<0.02	**0.135**	<0.09	**0.002**
endrin	**0.046**	**0.018**	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
endrin aidehyde	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
alpha-BHC	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
beta_BHC	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
gamma-BHC (lindane)	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
delta-BHC	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
chlordane (cis+trans)	<0.01	<0.008	<0.004	<0.0017	<0.04	<0.011	<0.2	<0.003
2,4-DDE (o.p-DDE)	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
2,4-DDD (o.p-DDD)	<0.006	<0.003	<0.002	<0.0009	<0.02	**0.009**	<0.09	<0.002
2,4-DDT (o.p-DDT)	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
4,4'-DDE p.p'-DDE)	**0.038**	**0.023**	**0.027**	**0.001**	<0.02	**0.135**	<0.09	<0.002
4,4'-DDD (p.p'-DDD)	**0.018**	<0.003	**0.008**	<0.0009	<0.02	**0.093**	<0.09	<0.002
4,4'-DDT (p.p'-DDT)	<0.006	<0.003	**0.002**	<0.0009	<0.02	**0.197**	<0.09	<0.002
endosulfan I	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
endosulfan II	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
endosulfan sulphate	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
heptachlor	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002
heptachlor epoxide	<0.006	<0.003	<0.002	<0.0009	<0.02	<0.004	<0.09	<0.002

POND SEDIMENTS/COMPOST **ORGANOCHLORINE PESTICIDES**

Local Body:	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry wt	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**>LOD**
%DS	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
aldrin	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		0.033	<0.0009	1
dieldrin	<0.02	**0.017**	**0.05**	**0.04**		<0.003	<0.03		0.296	<0.0009	8
endrin	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		0.046	<0.0009	2
endrin aidehyde	<0.02	<0.008	<0.02	<0.02		<0.006	<0.03		-	<0.0009	0
alpha-BHC	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
beta_BHC	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
gamma-BHC (lindane)	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
delta-BHC	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
chlordane (cis+trans)	<0.04	<0.02	<0.02	<0.02		<0.006	<0.06		-	<0.0017	0
2,4-DDE (o.p-DDE)	<0.02	<0.008	<0.02	**0.03**		<0.003	<0.03		0.03	<0.0009	1
2,4-DDD (o.p-DDD)	<0.02	<0.008	**0.06**	<0.02		<0.003	<0.03		0.06	<0.0009	2
2,4-DDT (o.p-DDT)	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
4,4'-DDE p.p'-DDE)	<0.02	**0.022**	**0.07**	**0.11**		**0.047**	<0.03		0.135	<0.001	9
4,4'-DDD (p.p'-DDD)	<0.02	<0.008	**0.19**	**0.02**		<0.003	<0.03		0.19	<0.0009	5
4,4'-DDT (p.p'-DDT)	<0.02	<0.008	<0.02	**0.08**		<0.003	<0.03		0.197	<0.0009	3
endosulfan I	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
endosulfan II	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
endosulfan sulphate	<0.02	<0.008	<0.02	<0.02		<0.02	<0.03		-	<0.0009	0
heptachlor	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0
heptachlor epoxide	<0.02	<0.008	<0.02	<0.02		<0.003	<0.03		-	<0.0009	0

SECTION 13

ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES (ONOPP)

ANALYTICAL METHODOLOGY

Extraction - Solids

Based on USEPA method 3545. Samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichloromethane. Surrogates of 833 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction - Liquids

Samples were extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 5 µg/L (equivalent in liquid) were added to the sample prior to extraction.

Extract Cleanup

An aliquot of the extract was cleaned up by gel permeation chromatography, then passing through a dual series of solid phase extraction cartridges consisting of ENVI-Carb and aminopropyl.

Instrumental Analysis

These were determined by full scan GC-MS. Quantitation was performed using external standardisation and a three point calibration curve for all target compounds.

Quality Control

For the ONOPP compounds, an extraction blank was run with every worksheet, or twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples had surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

ANALYTICAL RESULTS

Results of the analysis of 86 organonitrate/organophosphate pesticides (ONOPP) appear in Tables B13.1 - B13.4.
These more modern pesticides were assumed to be more readily degradable or to hydrolyse fairly rapidly in water so they were determined in the operational suite, rather than the environmental suite. The operational suite of analyses should tell wastewater treatment plant managers whether their treatment plant is receiving these pesticides in the sludge.

The herbicides which are used most commonly to control root penetration in sewers and laterals, dichlorobenyl and sodium metham, were not analysed with this group.

None of these pesticides is on the USEPA priority pollutants list.

Discussion

Diazinon was found in one of the 10 raw sludge samples, at 0.24 mg/kg, although it must be pointed out that this sample, the woolscour waste at Invercargill, was really a special trade waste; diazinon was below its limit of detection in the Invercargill raw sludge. Diazinon was also found in the digested sludge at Invercargill.

The only other pesticides from the organonitrate/organophosphate group that were found in the raw sludges were the cis and trans forms of permethrin; 7 of the 10 samples contained the cis form and 5 contained the trans form (combined median about 3 mg/kg). Quite high concentrations (cis + trans > 75 mg/kg) were found in two of the samples: the Christchurch (Bromley) and Feilding raw sludges).

Permethrin was found in all seven anaerobic sludges (median 2.0 mg/kg), but only two samples contained more than 25 mg/kg (Christchurch and Feilding digested sludges).

Permethrin was found in 3 of the 9 aerobic sludges tested, but only 1 sample contained more than 5 mg/kg (Christchurch secondary sludge). No other ONOPPs were found in the aerobic sludges.

No permethrin was found in the three pond sediment samples tested. (Sewage entering these three ponds does not receive any prior treatment). However, two of the sediments (both in the Wairarapa) contained some simazine. No other ONOPPs were found in the pond sediments.

Diazinon is a commonly used organophosphate insecticide which largely has replaced DDT for the control of grass grub and porina; it has many other agricultural applications too. Simazine is a 1,3,5-triazine herbicide and is used widely for weed control. Permethrin is a synthetic pyrethroid used as a general insecticide, often mixed with other products.

ONOPPs in sewage sludges do not appear to have been tested previously. They are not included in national standards, guidelines, etc, either.

RAW SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview		
Mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg	Wool Scour
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2
% Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7	9.8
Acephate	<1.25	<5	<1.5	<10	<6		<40	<5		<1.4	<0.5
Acetochlor	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Alachlor	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Atrazine	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Azinphos-methyl	<1.25	<5	<1.5	<10	<6		<40	<5		<1.4	<0.5
Bendiocarb	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Bifenthrin	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Bromacil	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Bromopropylate	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Bupirimate	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Buprofezin	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Captan	<0.5	<5	<0.6	<10	<6		<40	<5		<0.54	<0.2
Carbaryl	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Cabofuran	<1.25	<3	<1.5	<7	<3		<20	<3		<1.4	<0.5
Carboxin	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Chlorfenvinphos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Chlorothalonil	<0.25	<1	<0.3	<3	<1		<10	<1		<0.27	<0.1
Chlorpyrifos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Chlorpyrifos-methyl	<0.25	<1	<0.3	<3	<1		<10	<1		<0.27	<0.1
Cyanazine	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Cyfluthrin A	<0.5	<5	<0.6	<10	<6		<40	<5		<0.54	<0.2
Cyfluthrin B	<0.5	<5	<0.6	<10	<6		<40	<5		<0.54	<0.2
Cyhalothrin A	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Cyhalothrin B	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Cypermethrin A	<0.5	<5	<0.6	<10	<6		<40	<5		<0.54	<0.2
Cypermerthin B	<0.5	<5	<0.6	<10	<6		<40	<5		<0.54	<0.2
Cyproconazole	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Deltamethrin	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Demeton-S-methyl	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Diazinon	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	**0.24**
Dichlofluanid	<0.25	<1	<0.3	<3	<1		<10	<1		<0.27	<0.1

RAW SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview		
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg	Wool Scour
Lab No.	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2
Dichlorvos	<0.25	<1	<0.3	<3	<1		<10	<1		<0.27	<0.1
Dimethoate	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Diphenylamine	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Disulfoton	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Etrimfos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Fenamiphos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Fenaromol	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Fenpropathrin	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Fenpropimorph	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Fenvalerate A	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Fenvalerate B	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Flusiazole	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Fluvalinate A	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Fluvalinate B	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Hexazinone	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Hexythiazox	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Iprodione	<0.5	<5	<0.6	<10	<6		<40	<5		<0.54	<0.2
Isofenphos	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Linuron	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Malathion	<0.25	<1	<0.3	<3	<1		<10	<1		<0.27	<0.1
Methiocarb	<1.25	<1	<1.5	<3	<1		<10	<1		<1.4	<0.5
Methomyl	<1.25	<5	<1.5	<10	<6		<40	<5		<1.4	<0.5
Mevinphos	<0.25	<1	<0.3	<3	<1		<10	<1		<0.27	<0.1
Myclobutanil	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Naled	<1.25	<5	<1.5	<10	<6		<40	<5		<1.4	<0.5
Nitrothal-isopropyl	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Omethoate	<1.25	<5	<1.5	<10	<6		<40	<5		<1.4	<0.5
Oxyfluorfen	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Paclobutrazol	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Parathion (ethyl)	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Parathion-methyl	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Penconazole	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05

RAW SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview		
mg/kg dry weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg	Wool Scour
Lab No.	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2
Pendimethalin	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
cis-Permethrin	**0.15**	**101**	<0.15	**4**	<1		<10	**2**		**4.1**	<0.05
trans-Permethrin	<0.125	65	<0.15	<3	<1		<10	<1		**1.9**	<0.05
Phorate	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Phosmet	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Pirimicarb	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Pirimiphos-methyl	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Prochloraz	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Procymidone	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Prometryn	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Propazine	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Prothiofos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Pyrazophos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Simazine	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Sulfotep	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Terbacil	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Terbuthylazine	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Terbuthylazine-desethyl	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
Tetrachlorvinphos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Thiometon	<0.125	<3	<0.15	<7	<3		<20	<3		<0.14	<0.05
Triazophos	<0.25	<3	<0.3	<7	<3		<20	<3		<0.27	<0.1
Trifluralin	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05
vinclozolin	<0.125	<1	<0.15	<3	<1		<10	<1		<0.14	<0.05

RAW SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
	Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
Mg/kg dry weight	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 13)**
Lab No:	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	2.7	3.0	18.1	3.1	4.0		29	1.6	
Acephate	<30	<1.7		<16	<1.25		-	<0.5	0
Acetochlor	<8	<0.17		<1.6	<0.125		-	<0.05	0
Alachlor	<8	<0.17		<1.6	<0.125		-	<0.05	0
Atrazine	<8	<0.17		<1.6	<0.125		-	<0.05	0
Azinphos-methyl	<30	<1.7		<16	<1.25		-	<0.5	0
Bendiocarb	<20	<0.33		<3.2	<0.25		-	<0.1	0
Bifenthrin	<8	<0.17		<1.6	<0.125		-	<0.05	0
Bromacil	<20	<0.17		<1.6	<0.125		-	<0.05	0
Bromopropylate	<8	<0.17		<1.6	<0.125		-	<0.05	0
Bupirimate	<20	<0.17		<1.6	<0.125		-	<0.05	0
Buprofezin	<20	<0.17		<1.6	<0.125		-	<0.05	0
Captan	<30	<0.67		<6.4	<0.5		-	<0.2	0
Carbaryl	<20	<0.33		<3.2	<0.25		-	<0.1	0
Cabofuran	<20	<1.7		<16	<1.25		-	<0.5	0
Carboxin	<20	<0.17		<1.6	<0.125		-	<0.05	0
Chlorfenvinphos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Chlorothalonil	<8	<0.33		<3.2	<0.25		-	<0.1	0
Chlorpyrifos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Chlorpyrifos-methyl	<8	<0.33		<3.2	<0.25		-	<0.1	0
Cyanazine	<20	<0.33		<3.2	<0.25		-	<0.1	0
Cyfluthrin A	<30	<0.67		<6.4	<0.5		-	<0.2	0
Cyfluthrin B	<30	<0.67		<6.4	<0.5		-	<0.2	0
Cyhalothrin A	<20	<0.33		<3.2	<0.25		-	<0.1	0
Cyhalothrin B	<20	<0.33		<3.2	<0.25		-	<0.1	0
Cypermethrin A	<30	<0.67		<6.4	<0.5		-	<0.2	0
Cypermerthin B	<30	<0.67		<6.4	<0.5		-	<0.2	0
Cyproconazole	<20	<0.17		<1.6	<0.125		-	<0.05	0
Deltamethrin	<20	<0.33		<3.2	<0.25		-	<0.1	0
Demeton-S-methyl	<20	<0.33		<3.2	<0.25		-	<0.1	0
Diazinon	<8	<0.17		<1.6	<0.125		**0.24**	<0.125	**1**
Dichlofluanid	<8	<0.33		<3.2	<0.25		-	<0.1	0

RAW SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
	Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry weight	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 13)**
Lab No.	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**
Dichlorvos	<8	<0.33		<3.2	<0.25		-	<0.1	0
Dimethoate	<20	<0.33		<3.2	<0.25		-	<0.1	0
Diphenylamine	<8	<0.17		<1.6	<0.125		-	<0.05	0
Disulfoton	<20	<0.17		<1.6	<0.125		-	<0.05	0
Etrimfos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Fenamiphos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Fenaromol	<20	<0.17		<1.6	<0.125		-	<0.05	0
Fenpropathrin	<20	<0.17		<1.6	<0.125		-	<0.05	0
Fenpropimorph	<8	<0.17		<1.6	<0.125		-	<0.05	0
Fenvalerate A	<20	<0.33		<3.2	<0.25		-	<0.1	0
Fenvalerate B	<20	<0.33		<3.2	<0.25		-	<0.1	0
Flusiazole	<20	<0.17		<1.6	<0.125		-	<0.05	0
Fluvalinate A	<20	<0.33		<3.2	<0.25		-	<0.1	0
Fluvalinate B	<20	<0.33		<3.2	<0.25		-	<0.1	0
Hexazinone	<8	<0.17		<1.6	<0.125		-	<0.05	0
Hexythiazox	<20	<0.33		<3.2	<0.25		-	<0.1	0
Iprodione	<30	<0.67		<6.4	<0.5		-	<0.2	0
Isofenphos	<8	<0.17		<1.6	<0.125		-	<0.05	0
Linuron	<20	<0.33		<3.2	<0.25		-	<0.1	0
Malathion	<8	<0.33		<3.2	<0.25		-	<0.1	0
Methiocarb	<8	<1.7		<16	<1.25		-	<0.5	0
Methomyl	<30	<1.7		<16	<1.25		-	<0.5	0
Mevinphos	<8	<0.33		<3.2	<0.25		-	<0.1	0
Myclobutanil	<20	<0.17		<1.6	<0.125		-	<0.05	0
Naled	<30	<1.7		<16	<1.25		-	<0.5	0
Nitrothal-isopropyl	<8	<0.17		<1.6	<0.125		-	<0.05	0
Omethoate	<30	<1.7		<16	<1.25		-	<0.5	0
Oxyfluorfen	<8	<0.17		<1.6	<0.125		-	<0.05	0
Paclobutrazol	<20	<0.33		<3.2	<0.25		-	<0.1	0
Parathion (ethyl)	<20	<0.33		<3.2	<0.25		-	<0.1	0
Parathion-methyl	<8	<0.17		<1.6	<0.125		-	<0.05	0
Penconazole	<8	<0.17		<1.6	<0.125		-	<0.05	0

RAW SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
	Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry weight	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 13)**
Lab No.	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**
Pendimethalin	<8	<0.17		<1.6	<0.125		-	<0.05	0
cis-Permethrin	**59**	**0.63**		**0.65**	**1.78**		**101**	**<0.05**	**9**
trans-Permethrin	**20**	**0.57**		**0.65**	**0.85**		**65**	**<0.05**	**6**
Phorate	<20	<0.17		<1.6	<0.125		-	<0.05	0
Phosmet	<20	<0.33		<3.2	<0.25		-	<0.1	0
Pirimicarb	<20	<0.17		<1.6	<0.125		-	<0.05	0
Pirimiphos-methyl	<8	<0.17		<1.6	<0.125		-	<0.05	0
Prochloraz	<20	<0.33		<3.2	<0.25		-	<0.1	0
Procymidone	<20	<0.17		<1.6	<0.125		-	<0.05	0
Prometryn	<8	<0.17		<1.6	<0.125		-	<0.05	0
Propazine	<8	<0.17		<1.6	<0.125		-	<0.05	0
Prothiofos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Pyrazophos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Simazine	<20	<0.17		<1.6	<0.125		-	<0.05	0
Sulfotep	<8	<0.17		<1.6	<0.125		-	<0.05	0
Terbacil	<20	<0.17		<1.6	<0.125		-	<0.05	0
Terbuthylazine	<8	<0.17		<1.6	<0.125		-	<0.05	0
Terbuthylazine-desethyl	<8	<0.17		<1.6	<0.125		-	<0.05	0
Tetrachlorvinphos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Thiometon	<20	<0.17		<1.6	<0.125		-	<0.05	0
Triazophos	<20	<0.33		<3.2	<0.25		-	<0.1	0
Trifluralin	<8	<0.17		<1.6	<0.125		-	<0.05	0
vinclozolin	<8	<0.17		<1.6	<0.125		-	<0.05	0

ANAEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
Mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
% Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
Acephate	<2.9					<2.9			<1.25
Acetochlor	<0.3					<0.3			<0.13
Alachlor	<0.3					<0.3			<0.13
Atrazine	<0.3					<0.3			<0.13
Azinphos-methyl	<2.9					<2.9			<1.25
Bendiocarb	<0.6					<0.6			<0.25
Bifenthrin	<0.3					<0.3			<0.13
Bromacil	<0.3					<0.3			<0.13
Bromopropylate	<0.3					<0.3			<0.13
Bupirimate	<0.3					<0.3			<0.13
Buprofezin	<0.3					<0.3			<0.13
Captan	<1.2					<1.2			<0.5
Carbaryl	<0.6					<0.6			<0.25
Cabofuran	<2.9					<2.9			<1.25
Carboxin	<0.3					<0.3			<0.13
Chlorfenvinphos	<0.6					<0.6			<0.25
Chlorothalonil	<0.6					<0.6			<0.25
Chlorpyrifos	<0.6					<0.6			<0.25
Chlorpyrifos-methyl	<0.6					<0.6			<0.25
Cyanazine	<0.6					<0.6			<0.25
Cyfluthrin A	<1.2					<1.2			<0.5
Cyfluthrin B	<1.2					<1.2			<0.5
Cyhalothrin A	<0.6					<0.6			<0.25
Cyhalothrin B	<0.6					<0.6			<0.25
Cypermethrin A	<1.2					<1.2			<0.5
Cypermerthin B	<1.2					<1.2			<0.5
Cyproconazole	<0.3					<0.3			<0.13
Deltamethrin	<0.6					<0.6			<0.25
Demeton-S-methyl	<0.6					<0.6			<0.25
Diazinon	<0.3					<0.3			<0.13
Dichlofluanid	<0.6					<0.6			<0.25

ANAEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No.	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
Dichlorvos	<0.6					<0.6			<0.25
Dimethoate	<0.6					<0.6			<0.25
Diphenylamine	<0.3					<0.3			<0.13
Disulfoton	<0.3					<0.3			<0.13
Etrimfos	<0.6					<0.6			<0.25
Fenamiphos	<0.6					<0.6			<0.25
Fenaromol	<0.3					<0.3			<0.13
Fenpropathrin	<0.3					<0.3			<0.13
Fenpropimorph	<0.3					<0.3			<0.13
Fenvalerate A	<0.6					<0.6			<0.25
Fenvalerate B	<0.6					<0.6			<0.25
Flusiazole	<0.3					<0.3			<0.13
Fluvalinate A	<0.6					<0.6			<0.25
Fluvalinate B	<0.6					<0.6			<0.25
Hexazinone	<0.3					<0.3			<0.13
Hexythiazox	<0.6					<0.6			<0.25
Iprodione	<1.2					<1.2			<0.5
Isofenphos	<0.3					<0.3			<0.13
Linuron	<0.6					<0.6			<0.25
Malathion	<0.6					<0.6			<0.25
Methiocarb	<2.9					<2.9			<1.25
Methomyl	<2.9					<2.9			<1.25
Mevinphos	<0.6					<0.6			<0.25
Myclobutanil	<0.3					<0.3			<0.13
Naled	<2.9					<2.9			<1.25
Nitrothal-isopropyl	<0.3					<0.3			<0.13
Omethoate	<2.9					<2.9			<1.25
Oxyfluorfen	<0.3					<0.3			<0.13
Paclobutrazol	<0.6					<0.6			<0.25
Parathion (ethyl)	<0.6					<0.6			<0.25
Parathion-methyl	<0.3					<0.3			<0.13
Penconazole	<0.3					<0.3			<0.13

ANAEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No.	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
Pendimethalin	<0.3					<0.3			<0.13
cis-Permethrin	**28.2**					**0.4**			**0.68**
trans-Permethrin	**14.5**					**0.3**			**0.33**
Phorate	<0.3					<0.3			<0.13
Phosmet	<0.6					<0.6			<0.25
Pirimicarb	<0.3					<0.3			<0.13
Pirimiphos-methyl	<0.3					<0.3			<0.13
Prochloraz	<0.6					<0.6			<0.25
Procymidone	<0.3					<0.3			<0.13
Prometryn	<0.3					<0.3			<0.13
Propazine	<0.3					<0.3			<0.13
Prothiofos	<0.6					<0.6			<0.25
Pyrazophos	<0.6					<0.6			<0.25
Simazine	<0.3					<0.3			<0.13
Sulfotep	<0.3					<0.3			<0.13
Terbacil	<0.3					<0.3			<0.13
Terbuthylazine	<0.3					<0.3			<0.13
Terbuthylazine-desethyl	<0.3					<0.3			<0.13
Tetrachlorvinphos	<0.6					<0.6			<0.25
Thiometon	<0.3					<0.3			<0.13
Triazophos	<0.6					<0.6			<0.25
Trifluralin	<0.3					<0.3			<0.13
vinclozolin	<0.3					<0.3			<0.13

ANAEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere
Mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Dewatered Slg
Lab No:	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2
% Dry Solids	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7	0.9
Acephate		<1.2		<3.3		<2.9				<5.6
Acetochlor		<0.12		<0.3		<0.3				<0.6
Alachlor		<0.12		<0.3		<0.3				<0.6
Atrazine		<0.12		<0.3		<0.3				<0.6
Azinphos-methyl		<1.2		<3.3		<2.9				<5.6
Bendiocarb		<0.24		<0.7		<0.6				<1.1
Bifenthrin		<0.12		<0.3		<0.3				<0.6
Bromacil		<0.12		<0.3		<0.3				<0.6
Bromopropylate		<0.12		<0.3		<0.3				<0.6
Bupirimate		<0.12		<0.3		<0.3				<0.6
Buprofezin		<0.12		<0.3		<0.3				<0.6
Captan		<0.49		<1.3		<1.2				<2.2
Carbaryl		<0.24		<0.7		<0.6				<1.1
Cabofuran		<1.2		<3.3		<2.9				<5.6
Carboxin		<0.12		<0.3		<0.3				<0.6
Chlorfenvinphos		<0.24		<0.7		<0.6				<1.1
Chlorothalonil		<0.24		<0.7		<0.6				<1.1
Chlorpyrifos		<0.24		<0.7		<0.6				<1.1
Chlorpyrifos-methyl		<0.24		<0.7		<0.6				<1.1
Cyanazine		<0.24		<0.7		<0.6				<1.1
Cyfluthrin A		<0.49		<1.3		<1.2				<2.2
Cyfluthrin B		<0.49		<1.3		<1.2				<2.2
Cyhalothrin A		<0.24		<0.7		<0.6				<1.1
Cyhalothrin B		<0.24		<0.7		<0.6				<1.1
Cypermethrin A		<0.49		<1.3		<1.2				<2.2
Cypermerthin B		<0.49		<1.3		<1.2				<2.2
Cyproconazole		<0.12		<0.3		<0.3				<0.6
Deltamethrin		<0.24		<0.7		<0.6				<1.1
Demeton-S-methyl		<0.24		<0.7		<0.6				<1.1
Diazinon		**2.1**		<0.3		<0.3				<0.6
Dichlofluanid		<0.24		<0.7		<0.6				<1.1

ANAEROBIC SLUDGES ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere
mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Dewatered Slg
Lab No.	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2
Dichlorvos		<0.24		<0.7		<0.6				<1.1
Dimethoate		<0.24		<0.7		<0.6				<1.1
Diphenylamine		<0.12		<0.3		<0.3				<0.6
Disulfoton		<0.12		<0.3		<0.3				<0.6
Etrimfos		<0.24		<0.7		<0.6				<1.1
Fenamiphos		<0.24		<0.7		<0.6				<1.1
Fenaromol		<0.12		<0.3		<0.3				<0.6
Fenpropathrin		<0.12		<0.3		<0.3				<0.6
Fenpropimorph		<0.12		<0.3		<0.3				<0.6
Fenvalerate A		<0.24		<0.7		<0.6				<1.1
Fenvalerate B		<0.24		<0.7		<0.6				<1.1
Flusiazole		<0.12		<0.3		<0.3				<0.6
Fluvalinate A		<0.24		<0.7		<0.6				<1.1
Fluvalinate B		<0.24		<0.7		<0.6				<1.1
Hexazinone		<0.12		<0.3		<0.3				<0.6
Hexythiazox		<0.24		<0.7		<0.6				<1.1
Iprodione		<0.49		<1.3		<1.2				<2.2
Isofenphos		<0.12		<0.3		<0.3				<0.6
Linuron		<0.24		<0.7		<0.6				<1.1
Malathion		<0.24		<0.7		<0.6				<1.1
Methiocarb		<1.2		<3.3		<2.9				<5.6
Methomyl		<1.2		<3.3		<2.9				<5.6
Mevinphos		<0.24		<0.7		<0.6				<1.1
Myclobutanil		<0.12		<0.3		<0.3				<0.6
Naled		<1.2		<3.3		<2.9				<5.6
Nitrothal-isopropyl		<0.12		<0.3		<0.3				<0.6
Omethoate		<1.2		<3.3		<2.9				<5.6
Oxyfluorfen		<0.12		<0.3		<0.3				<0.6
Paclobutrazol		<0.24		<0.7		<0.6				<1.1
Parathion (ethyl)		<0.24		<0.7		<0.6				<1.1
Parathion-methyl		<0.12		<0.3		<0.3				<0.6
Penconazole		<0.12		<0.3		<0.3				<0.6

ANAEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere
mg/kg dry weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Dewatered Slg
Lab No.	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2
Pendimethalin		<0.12		<0.3		<0.3				<0.6
cis-Permethrin		**1.15**		**20.9**		**0.6**				**1.2**
trans-Permethrin		**1.71**		**4.3**		**0.4**				**0.8**
Phorate		<0.12		<0.3		<0.3				<0.6
Phosmet		<0.24		<0.7		<0.6				<1.1
Pirimicarb		<0.12		<0.3		<0.3				<0.6
Pirimiphos-methyl		<0.12		<0.3		<0.3				<0.6
Prochloraz		<0.24		<0.7		<0.6				<1.1
Procymidone		<0.12		<0.3		<0.3				<0.6
Prometryn		<0.12		<0.3		<0.3				<0.6
Propazine		<0.12		<0.3		<0.3				<0.6
Prothiofos		<0.24		<0.7		<0.6				<1.1
Pyrazophos		<0.24		<0.7		<0.6				<1.1
Simazine		<0.12		<0.3		<0.3				<0.6
Sulfotep		<0.12		<0.3		<0.3				<0.6
Terbacil		<0.12		<0.3		<0.3				<0.6
Terbuthylazine		<0.12		<0.3		<0.3				<0.6
Terbuthylazine-desethyl		<0.12		<0.3		<0.3				<0.6
Tetrachlorvinphos		<0.24		<0.7		<0.6				<1.1
Thiometon		<0.12		<0.3		<0.3				<0.6
Triazophos		<0.24		<0.7		<0.6				<1.1
Trifluralin		<0.12		<0.3		<0.3				<0.6
vinclozolin		<0.12		<0.3		<0.3				<0.6

ANAEROBIC SLUDGES ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES

Local Body	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere				**Number**
Mg/kg dry weight	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 7)**
Lab No:	116306/4	116306/5	116306/6		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	33.8	44.6	43.3		93.9	0.9	
Acephate					-	<1.2	0
Acetochlor					-	<0.12	0
Alachlor					-	<0.12	0
Atrazine					-	<0.12	0
Azinphos-methyl					-	<1.2	0
Bendiocarb					-	<0.24	0
Bifenthrin					-	<0.12	0
Bromacil					-	<0.12	0
Bromopropylate					-	<0.12	0
Bupirimate					-	<0.12	0
Buprofezin					-	<0.12	0
Captan					-	<0.49	0
Carbaryl					-	<0.24	0
Cabofuran					-	<1.2	0
Carboxin					-	<0.12	0
Chlorfenvinphos					-	<0.24	0
Chlorothalonil					-	<0.24	0
Chlorpyrifos					-	<0.24	0
Chlorpyrifos-methyl					-	<0.24	0
Cyanazine					-	<0.24	0
Cyfluthrin A					-	<0.49	0
Cyfluthrin B					-	<0.49	0
Cyhalothrin A					-	<0.24	0
Cyhalothrin B					-	<0.24	0
Cypermethrin A					-	<0.49	0
Cypermerthin B					-	<0.49	0
Cyproconazole					-	<0.12	0
Deltamethrin					-	<0.24	0
Demeton-S-methyl					-	<0.24	0
Diazinon					**2.1**	**<0.13**	**1**
Dichlofluanid					-	<0.24	0

ANAEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 7)**
Lab No.	116306/4	116306/5	116306/6		**MAX.**	**MIN.**	**>LOD**
Dichlorvos					-	<0.24	0
Dimethoate					-	<0.24	0
Diphenylamine					-	<0.12	0
Disulfoton					-	<0.12	0
Etrimfos					-	<0.24	0
Fenamiphos					-	<0.24	0
Fenaromol					-	<0.12	0
Fenpropathrin					-	<0.12	0
Fenpropimorph					-	<0.12	0
Fenvalerate A					-	<0.24	0
Fenvalerate B					-	<0.24	0
Flusiazole					-	<0.12	0
Fluvalinate A					-	<0.24	0
Fluvalinate B					-	<0.24	0
Hexazinone					-	<0.12	0
Hexythiazox					-	<0.24	0
Iprodione					-	<0.49	0
Isofenphos					-	<0.12	0
Linuron					-	<0.24	0
Malathion					-	<0.24	0
Methiocarb					-	<1.2	0
Methomyl					-	<1.2	0
Mevinphos					-	<0.24	0
Myclobutanil					-	<0.12	0
Naled					-	<1.2	0
Nitrothal-isopropyl					-	<0.12	0
Omethoate					-	<1.2	0
Oxyfluorfen					-	<0.12	0
Paclobutrazol					-	<0.24	0
Parathion (ethyl)					-	<0.24	0
Parathion-methyl					-	<0.12	0
Penconazole					-	<0.12	0

ANAEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere				**Number**
mg/kg dry weight	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 7)**
Lab No.	116306/4	116306/5	116306/6		**MAX.**	**MIN.**	**>LOD**
Pendimethalin					-	<0.12	0
cis-Permethrin					**28.2**	**0.4**	**7**
trans-Permethrin					**14.5**	**0.3**	**7**
Phorate					-	<0.12	0
Phosmet					-	<0.24	0
Pirimicarb					-	<0.12	0
Pirimiphos-methyl					-	<0.12	0
Prochloraz					-	<0.24	0
Procymidone					-	<0.12	0
Prometryn					-	<0.12	0
Propazine					-	<0.12	0
Prothiofos					-	<0.24	0
Pyrazophos					-	<0.24	0
Simazine					-	<0.12	0
Sulfotep					-	<0.12	0
Terbacil					-	<0.12	0
Terbuthylazine					-	<0.12	0
Terbuthylazine-desethyl					-	<0.12	0
Tetrachlorvinphos					-	<0.24	0
Thiometon					-	<0.12	0
Triazophos					-	<0.24	0
Trifluralin					-	<0.12	0
vinclozolin					-	<0.12	0

AEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
Mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
% Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
Acephate	<1.2	<4	<2.2	<2.9	<3.3		<20		
Acetochlor	<0.12	<1	<0.2	<0.3	<0.3		<5		
Alachlor	<0.12	<1	<0.2	<0.3	<0.3		<5		
Atrazine	<0.12	<1	<0.2	<0.3	<0.3		<5		
Azinphos-methyl	<1.2	<4	<2.2	<2.9	<3.3		<20		
Bendiocarb	<0.23	<2	<0.4	<0.6	<0.7		<9		
Bifenthrin	<0.12	<1	<0.2	<0.3	<0.3		<5		
Bromacil	<0.12	<2	<0.2	<0.3	<0.3		<9		
Bromopropylate	<0.12	<1	<0.2	<0.3	<0.3		<5		
Bupirimate	<0.12	<2	<0.2	<0.3	<0.3		<9		
Buprofezin	<0.12	<2	<0.2	<0.3	<0.3		<9		
Captan	<0.47	<4	<0.9	<1.2	<1.3		<20		
Carbaryl	<0.23	<2	<0.4	<0.6	<0.7		<9		
Cabofuran	<1.2	<2	<2.2	<2.9	<3.3		<9		
Carboxin	<0.12	<2	<0.2	<0.3	<0.3		<9		
Chlorfenvinphos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Chlorothalonil	<0.23	<1	<0.4	<0.6	<0.7		<5		
Chlorpyrifos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Chlorpyrifos-methyl	<0.23	<1	<0.4	<0.6	<0.7		<5		
Cyanazine	<0.23	<2	<0.4	<0.6	<0.7		<9		
Cyfluthrin A	<0.47	<4	<0.9	<1.2	<1.3		<20		
Cyfluthrin B	<0.47	<4	<0.9	<1.2	<1.3		<20		
Cyhalothrin A	<0.23	<2	<0.4	<0.6	<0.7		<9		
Cyhalothrin B	<0.23	<2	<0.4	<0.6	<0.7		<9		
Cypermethrin A	<0.47	<4	<0.9	<1.2	<1.3		<20		
Cypermerthin B	<0.47	<4	<0.9	<1.2	<1.3		<20		
Cyproconazole	<0.12	<2	<0.2	<0.3	<0.3		<9		
Deltamethrin	<0.23	<2	<0.4	<0.6	<0.7		<9		
Demeton-S-methyl	<0.23	<2	<0.4	<0.6	<0.7		<9		
Diazinon	<0.12	<1	<0.2	<0.3	<0.3		<5		
Dichlofluanid	<0.23	<1	<0.4	<0.6	<0.7		<5		

AEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No.	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
Dichlorvos	<0.23	<1	<0.4	<0.6	<0.7		<5		
Dimethoate	<0.23	<2	<0.4	<0.6	<0.7		<9		
Diphenylamine	<0.12	<1	<0.2	<0.3	<0.3		<5		
Disulfoton	<0.12	<2	<0.2	<0.3	<0.3		<9		
Etrimfos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Fenamiphos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Fenaromol	<0.12	<2	<0.2	<0.3	<0.3		<9		
Fenpropathrin	<0.12	<2	<0.2	<0.3	<0.3		<9		
Fenpropimorph	<0.12	<1	<0.2	<0.3	<0.3		<5		
Fenvalerate A	<0.23	<2	<0.4	<0.6	<0.7		<9		
Fenvalerate B	<0.23	<2	<0.4	<0.6	<0.7		<9		
Flusiazole	<0.12	<2	<0.2	<0.3	<0.3		<9		
Fluvalinate A	<0.23	<2	<0.4	<0.6	<0.7		<9		
Fluvalinate B	<0.23	<2	<0.4	<0.6	<0.7		<9		
Hexazinone	<0.12	<1	<0.2	<0.3	<0.3		<5		
Hexythiazox	<0.23	<2	<0.4	<0.6	<0.7		<9		
Iprodione	<0.47	<4	<0.9	<1.2	<1.3		<20		
Isofenphos	<0.12	<1	<0.2	<0.3	<0.3		<5		
Linuron	<0.23	<2	<0.4	<0.6	<0.7		<9		
Malathion	<0.23	<1	<0.4	<0.6	<0.7		<5		
Methiocarb	<1.2	<1	<2.2	<2.9	<3.3		<5		
Methomyl	<1.2	<4	<2.2	<2.9	<3.3		<20		
Mevinphos	<0.23	<1	<0.4	<0.6	<0.7		<5		
Myclobutanil	<0.12	<2	<0.2	<0.3	<0.3		<9		
Naled	<1.2	<4	<2.2	<2.9	<3.3		<20		
Nitrothal-isopropyl	<0.12	<1	<0.2	<0.3	<0.3		<5		
Omethoate	<1.2	<4	<2.2	<2.9	<3.3		<20		
Oxyfluorfen	<0.12	<1	<0.2	<0.3	<0.3		<5		
Paclobutrazol	<0.23	<2	<0.4	<0.6	<0.7		<9		
Parathion (ethyl)	<0.23	<2	<0.4	<0.6	<0.7		<9		
Parathion-methyl	<0.12	<1	<0.2	<0.3	<0.3		<5		
Penconazole	<0.12	<1	<0.2	<0.3	<0.3		<5		

AEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No.	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
Pendimethalin	<0.12	<1	<0.2	<0.3	<0.3		<5		
cis-Permethrin	**0.14**	**2**	**19.6**	<0.3	<0.3		<5		
trans-Permethrin	**0.12**	**1**	**7.8**	<0.3	<0.3		<5		
Phorate	<0.12	<2	<0.2	<0.3	<0.3		<9		
Phosmet	<0.23	<2	<0.4	<0.6	<0.7		<9		
Pirimicarb	<0.12	<2	<0.2	<0.3	<0.3		<9		
Pirimiphos-methyl	<0.12	<1	<0.2	<0.3	<0.3		<5		
Prochloraz	<0.23	<2	<0.4	<0.6	<0.7		<9		
Procymidone	<0.12	<2	<0.2	<0.3	<0.3		<9		
Prometryn	<0.12	<1	<0.2	<0.3	<0.3		<5		
Propazine	<0.12	<1	<0.2	<0.3	<0.3		<5		
Prothiofos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Pyrazophos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Simazine	<0.12	<2	<0.2	<0.3	<0.3		<9		
Sulfotep	<0.12	<1	<0.2	<0.3	<0.3		<5		
Terbacil	<0.12	<2	<0.2	<0.3	<0.3		<9		
Terbuthylazine	<0.12	<1	<0.2	<0.3	<0.3		<5		
Terbuthylazine-desethyl	<0.12	<1	<0.2	<0.3	<0.3		<5		
Tetrachlorvinphos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Thiometon	<0.12	<2	<0.2	<0.3	<0.3		<9		
Triazophos	<0.23	<2	<0.4	<0.6	<0.7		<9		
Trifluralin	<0.12	<1	<0.2	<0.3	<0.3		<5		
vinclozolin	<0.12	<1	<0.2	<0.3	<0.3		<5		

AEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
Mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 9)**
Lab No:	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
Acephate		<20		<5.6	<20		-	<1.2	0
Acetochlor		<5		<0.56	<6		-	<0.12	0
Alachlor		<5		<0.56	<6		-	<0.12	0
Atrazine		<5		<0.56	<6		-	<0.12	0
Azinphos-methyl		<20		<5.6	<20		-	<1.2	0
Bendiocarb		<10		<1.1	<10		-	<0.23	0
Bifenthrin		<5		<0.56	<6		-	<0.12	0
Bromacil		<10		<0.56	<10		-	<0.12	0
Bromopropylate		<5		<0.56	<6		-	<0.12	0
Bupirimate		<10		<0.56	<10		-	<0.12	0
Buprofezin		<10		<0.56	<10		-	<0.12	0
Captan		<20		<2.2	<20		-	<0.47	0
Carbaryl		<10		<1.1	<10		-	<0.23	0
Cabofuran		<10		<5.6	<10		-	<1.2	0
Carboxin		<10		<0.56	<10		-	<0.12	0
Chlorfenvinphos		<10		<1.1	<10		-	<0.23	0
Chlorothalonil		<5		<1.1	<6		-	<0.23	0
Chlorpyrifos		<10		<1.1	<10		-	<0.23	0
Chlorpyrifos-methyl		<5		<1.1	<6		-	<0.23	0
Cyanazine		<10		<1.1	<10		-	<0.23	0
Cyfluthrin A		<20		<2.2	<20		-	<0.47	0
Cyfluthrin B		<20		<2.2	<20		-	<0.47	0
Cyhalothrin A		<10		<1.1	<10		-	<0.23	0
Cyhalothrin B		<10		<1.1	<10		-	<0.23	0
Cypermethrin A		<20		<2.2	<20		-	<0.47	0
Cypermerthin B		<20		<2.2	<20		-	<0.47	0
Cyproconazole		<10		<0.56	<10		-	<0.12	0
Deltamethrin		<10		<1.1	<10		-	<0.23	0
Demeton-S-methyl		<10		<1.1	<10		-	<0.23	0
Diazinon		<5		<0.56	<6		-	<0.12	0
Dichlofluanid		<5		<1.1	<6		-	<0.23	0

AEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 9)**
Lab No.	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**>LOD**
Dichlorvos		<5		<1.1	<6		-	<0.23	0
Dimethoate		<10		<1.1	<10		-	<0.23	0
Diphenylamine		<5		<0.56	<6		-	<0.12	0
Disulfoton		<10		<0.56	<10		-	<0.12	0
Etrimfos		<10		<1.1	<10		-	<0.23	0
Fenamiphos		<10		<1.1	<10		-	<0.23	0
Fenaromol		<10		<0.56	<10		-	<0.12	0
Fenpropathrin		<10		<0.56	<10		-	<0.12	0
Fenpropimorph		<5		<0.56	<6		-	<0.12	0
Fenvalerate A		<10		<1.1	<10		-	<0.23	0
Fenvalerate B		<10		<1.1	<10		-	<0.23	0
Flusiazole		<10		<0.56	<10		-	<0.12	0
Fluvalinate A		<10		<1.1	<10		-	<0.23	0
Fluvalinate B		<10		<1.1	<10		-	<0.23	0
Hexazinone		<5		<0.56	<6		-	<0.12	0
Hexythiazox		<10		<1.1	<10		-	<0.23	0
Iprodione		<20		<2.2	<20		-	<0.47	0
Isofenphos		<5		<0.56	<6		-	<0.12	0
Linuron		<10		<1.1	<10		-	<0.23	0
Malathion		<5		<1.1	<6		-	<0.23	0
Methiocarb		<5		<5.6	<6		-	<1.2	0
Methomyl		<20		<5.6	<20		-	<1.2	0
Mevinphos		<5		<1.1	<6		-	<0.23	0
Myclobutanil		<10		<0.56	<10		-	<0.12	0
Naled		<20		<5.6	<20		-	<1.2	0
Nitrothal-isopropyl		<5		<0.56	<6		-	<0.12	0
Omethoate		<20		<5.6	<20		-	<1.2	0
Oxyfluorfen		<5		<0.56	<6		-	<0.12	0
Paclobutrazol		<10		<1.1	<10		-	<0.23	0
Parathion (ethyl)		<10		<1.1	<10		-	<0.23	0
Parathion-methyl		<5		<0.56	<6		-	<0.12	0
Penconazole		<5		<0.56	<6		-	<0.12	0

AEROBIC SLUDGES **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 9)**
Lab No.	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**>LOD**
Pendimethalin		<5		<0.56	<6		-	<0.12	0
cis-Permethrin		<5		<0.56	<6		**19.6**	**0.14**	**3**
trans-Permethrin		<5		<0.56	<6		**7.8**	**0.12**	**3**
Phorate		<10		<0.56	<10		-	<0.12	0
Phosmet		<10		<1.1	<10		-	<0.23	0
Pirimicarb		<10		<0.56	<10		-	<0.12	0
Pirimiphos-methyl		<5		<0.56	<6		-	<0.12	0
Prochloraz		<10		<1.1	<10		-	<0.23	0
Procymidone		<10		<0.56	<10		-	<0.12	0
Prometryn		<5		<0.56	<6		-	<0.12	0
Propazine		<5		<0.56	<6		-	<0.12	0
Prothiofos		<10		<1.1	<10		-	<0.23	0
Pyrazophos		<10		<1.1	<10		-	<0.23	0
Simazine		<10		<0.56	<10		-	<0.12	0
Sulfotep		<5		<0.56	<6		-	<0.12	0
Terbacil		<10		<0.56	<10		-	<0.12	0
Terbuthylazine		<5		<0.56	<6		-	<0.12	0
Terbuthylazine-desethyl		<5		<0.56	<6		-	<0.12	0
Tetrachlorvinphos		<10		<1.1	<10		-	<0.23	0
Thiometon		<10		<0.56	<10		-	<0.12	0
Triazophos		<10		<1.1	<10		-	<0.23	0
Trifluralin		<5		<0.56	<6		-	<0.12	0
vinclozolin		<5		<0.56	<6		-	<0.12	0

POND SEDIMENTS **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
Mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
% Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
Acephate								<3.8
Acetochlor								<0.4
Alachlor								<0.4
Atrazine								<0.4
Azinphos-methyl								<3.8
Bendiocarb								<0.8
Bifenthrin								<0.4
Bromacil								<0.4
Bromopropylate								<0.4
Bupirimate								<0.4
Buprofezin								<0.4
Captan								<1.5
Carbaryl								<0.8
Cabofuran								<3.8
Carboxin								<0.4
Chlorfenvinphos								<0.8
Chlorothalonil								<0.8
Chlorpyrifos								<0.8
Chlorpyrifos-methyl								<0.8
Cyanazine								<0.8
Cyfluthrin A								<1.5
Cyfluthrin B								<1.5
Cyhalothrin A								<0.8
Cyhalothrin B								<0.8
Cypermethrin A								<1.5
Cypermerthin B								<1.5
Cyproconazole								<0.4
Deltamethrin								<0.8
Demeton-S-methyl								<0.8
Diazinon								<0.4
Dichlofluanid								<0.8

POND SEDIMENTS **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No.	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
Dichlorvos								<0.8
Dimethoate								<0.8
Diphenylamine								<0.4
Disulfoton								<0.4
Etrimfos								<0.8
Fenamiphos								<0.8
Fenaromol								<0.4
Fenpropathrin								<0.4
Fenpropimorph								<0.4
Fenvalerate A								<0.8
Fenvalerate B								<0.8
Flusiazole								<0.4
Fluvalinate A								<0.8
Fluvalinate B								<0.8
Hexazinone								<0.4
Hexythiazox								<0.8
Iprodione								<1.5
Isofenphos								<0.4
Linuron								<0.8
Malathion								<0.8
Methiocarb								<3.8
Methomyl								<3.8
Mevinphos								<0.8
Myclobutanil								<0.4
Naled								<3.8
Nitrothal-isopropyl								<0.4
Omethoate								<3.8
Oxyfluorfen								<0.4
Paclobutrazol								<0.8
Parathion (ethyl)								<0.8
Parathion-methyl								<0.4
Penconazole								<0.4

POND SEDIMENTS **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No.	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
Pendimethalin								<0.4
cis-Permethrin								<0.4
trans-Permethrin								<0.4
Phorate								<0.4
Phosmet								<0.8
Pirimicarb								<0.4
Pirimiphos-methyl								<0.4
Prochloraz								<0.8
Procymidone								<0.4
Prometryn								<0.4
Propazine								<0.4
Prothiofos								<0.8
Pyrazophos								<0.8
Simazine								**1.46**
Sulfotep								<0.4
Terbacil								<0.4
Terbuthylazine								<0.4
Terbuthylazine-desethyl								<0.4
Tetrachlorvinphos								<0.8
Thiometon								<0.4
Triazophos								<0.8
Trifluralin								<0.4
vinclozolin								<0.4

POND SEDIMENTS **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
Mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 3)**
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
Acephate	<5.5	<5							-	<3.8	0
Acetochlor	<0.56	<0.5							-	<0.4	0
Alachlor	<0.56	<0.5							-	<0.4	0
Atrazine	<0.56	<0.5							-	<0.4	0
Azinphos-methyl	<5.5	<5							-	<3.8	0
Bendiocarb	<1.1	<1							-	<0.8	0
Bifenthrin	<0.56	<0.5							-	<0.4	0
Bromacil	<0.56	<0.5							-	<0.4	0
Bromopropylate	<0.56	<0.5							-	<0.4	0
Bupirimate	<0.56	<0.5							-	<0.4	0
Buprofezin	<0.56	<0.5							-	<0.4	0
Captan	<2.2	<2							-	<1.5	0
Carbaryl	<1.1	<1							-	<0.8	0
Cabofuran	<5.5	<5							-	<3.8	0
Carboxin	<0.56	<0.5							-	<0.4	0
Chlorfenvinphos	<1.1	<1							-	<0.8	0
Chlorothalonil	<1.1	<1							-	<0.8	0
Chlorpyrifos	<1.1	<1							-	<0.8	0
Chlorpyrifos-methyl	<1.1	<1							-	<0.8	0
Cyanazine	<1.1	<1							-	<0.8	0
Cyfluthrin A	<2.2	<2							-	<1.5	0
Cyfluthrin B	<2.2	<2							-	<1.5	0
Cyhalothrin A	<1.1	<1							-	<0.8	0
Cyhalothrin B	<1.1	<1							-	<0.8	0
Cypermethrin A	<2.2	<2							-	<1.5	0
Cypermerthin B	<2.2	<2							-	<1.5	0
Cyproconazole	<0.56	<0.5							-	<0.4	0
Deltamethrin	<1.1	<1							-	<0.8	0
Demeton-S-methyl	<1.1	<1							-	<0.8	0
Diazinon	<0.56	<0.5							-	<0.4	0
Dichlofluanid	<1.1	<1							-	<0.8	0

POND SEDIMENTS **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 3)**
Lab No.	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**>LOD**
Dichlorvos	<1.1	<1							-	<0.8	0
Dimethoate	<1.1	<1							-	<0.8	0
Diphenylamine	<0.56	<0.5							-	<0.4	0
Disulfoton	<0.56	<0.5							-	<0.4	0
Etrimfos	<1.1	<1							-	<0.8	0
Fenamiphos	<1.1	<1							-	<0.8	0
Fenaromol	<0.56	<0.5							-	<0.4	0
Fenpropathrin	<0.56	<0.5							-	<0.4	0
Fenpropimorph	<0.56	<0.5							-	<0.4	0
Fenvalerate A	<1.1	<1							-	<0.8	0
Fenvalerate B	<1.1	<1							-	<0.8	0
Flusiazole	<0.56	<0.5							-	<0.4	0
Fluvalinate A	<1.1	<1							-	<0.8	0
Fluvalinate B	<1.1	<1							-	<0.8	0
Hexazinone	<0.56	<0.5							-	<0.4	0
Hexythiazox	<1.1	<1							-	<0.8	0
Iprodione	<2.2	<2							-	<1.5	0
Isofenphos	<0.56	<0.5							-	<0.4	0
Linuron	<1.1	<1							-	<0.8	0
Malathion	<1.1	<1							-	<0.8	0
Methiocarb	<5.5	<5							-	<3.8	0
Methomyl	<5.5	<5							-	<3.8	0
Mevinphos	<1.1	<1							-	<0.8	0
Myclobutanil	<0.56	<0.5							-	<0.4	0
Naled	<5.5	<5							-	<3.8	0
Nitrothal-isopropyl	<0.56	<0.5							-	<0.4	0
Omethoate	<5.5	<5							-	<3.8	0
Oxyfluorfen	<0.56	<0.5							-	<0.4	0
Paclobutrazol	<1.1	<1							-	<0.8	0
Parathion (ethyl)	<1.1	<1							-	<0.8	0
Parathion-methyl	<0.56	<0.5							-	<0.4	0
Penconazole	<0.56	<0.5							-	<0.4	0

POND SEDIMENTS **ORGANONITRATE/ORGANOPHOSPHATE PESTICIDES**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 3)**
Lab No.	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**>LOD**
Pendimethalin	<0.56	<0.5							-	<0.4	0
cis-Permethrin	<0.56	<0.5							-	<0.4	0
trans-Permethrin	<0.56	<0.5							-	<0.4	0
Phorate	<0.56	<0.5							-	<0.4	0
Phosmet	<1.1	<1							-	<0.8	0
Pirimicarb	<0.56	<0.5							-	<0.4	0
Pirimiphos-methyl	<0.56	<0.5							-	<0.4	0
Prochloraz	<1.1	<1							-	<0.8	0
Procymidone	<0.56	<0.5							-	<0.4	0
Prometryn	<0.56	<0.5							-	<0.4	0
Propazine	<0.56	<0.5							-	<0.4	0
Prothiofos	<1.1	<1							-	<0.8	0
Pyrazophos	<1.1	<1							-	<0.8	0
Simazine	**0.22**	<0.5							**1.46**	**0.22**	**2**
Sulfotep	<0.56	<0.5							-	<0.4	0
Terbacil	<0.56	<0.5							-	<0.4	0
Terbuthylazine	<0.56	<0.5							-	<0.4	0
Terbuthylazine-desethyl	<0.56	<0.5							-	<0.4	0
Tetrachlorvinphos	<1.1	<1							-	<0.8	0
Thiometon	<0.56	<0.5							-	<0.4	0
Triazophos	<1.1	<1							-	<0.8	0
Trifluralin	<0.56	<0.5							-	<0.4	0
vinclozolin	<0.56	<0.5							-	<0.4	0

SECTION 14

POLYCHLORINATED BIPHENYLS (PCBs)

ANALYTICAL METHODOLOGY

RJ Hill Laboratories Ltd Method for PCBs

Extraction - Solids

Based on USEPA method 3545. The samples were homogenised with sodium sulphate and extracted using accelerated solvent extraction (ASE) with dichioromethane. Surrogates of 133 µg/kg (equivalent in solid) were added to the homogenised sample prior to extraction.

Extraction - Liquids

Samples were extracted with dichloromethane using a continuous liquid/liquid extraction technique. Surrogates of 0.5 µg/L (equivalent in water) were added to the sample prior to extraction.

Extract Cleanup

An aliquot of each extract was cleaned up by gel permeation chromatography, then passing through a triple series of solid phase extraction cartridges consisting of ENVI-Carb, florisil and SAX/aminopropyl.

Instrumental Analysis

These were determined either by GC-MS using selected ion mode (SIM), or GC-ECD with all positives being confirmed using a second column. Quantitation was performed using internal standardisation and a three point calibration curve for all target compounds.

Samples were analysed by R.J. Hill Laboratories Ltd in accordance with laboratory procedures as covered by IANZ accreditation. Results were reported as mg/kg dry weight for samples considered to be solids, and mg/L for samples considered to be liquids. Results were not corrected for surrogate recovery. The limit of detection for each compound is dependent on its sensitivity to the analytical procedure, the amount of sample taken for analysis, the solids content of each aliquot, and the presence of interfering substances. Generally, limits of detection are apparent when referring to the Tables.

Quality Control

For the PCB compounds, an extraction blank was run with every worksheet, or after every twenty samples. A duplicate and spiked sample were run approximately every twentieth sample. All samples had surrogates (compounds added prior to extraction to monitor efficiency) and internal standards (compounds added immediately prior to analysis to aid analytical quality).

ESR Analytical Method for PCBs

Six samples were tested by the ESR Wellington Science Centre using the isotope dilution method, performed in accordance with the Laboratory's scope of accreditation with IANZ.

The samples were spiked with isotopically labelled surrogate standards and extracted with organic solvent. Extracts were purified with liquid-liquid partitioning and column chromatographic techniques. Measurement was performed using high resolution gas chromatography with high resolution electron impact mass spectrometry.

Results are reported in micrograms per kilogram (µg/kg), equivalent to nanograms per gram (ng/g), milligrams per tonne (mg/t) or ppb (w/w) on a dry weight basis. Results are corrected for the recovery of the $^{13}C_{12}$ surrogate standards. Limits of detection (LOD) are reported to 1 significant figure. The sum of PCBs is reported both excluding LOD values and including half the LOD values.

Toxic equivalents (TEQs) are reported in nanograms per kilogram (ng/kg), equivalent to picograms per gram (pg/g), micrograms per tonne (µg/t) or parts per trillion (ppt). TEQs are calculated using toxic equivalency factors (TEFs) from Ahlborg et al (Chemosphere 28, 10491067, 1994). For non-detected congeners, half the LOD value was used in the TEQ calculation. The total TEQ level is reported both excluding LOD values and including half the LOD values.

ESR tested the Christchurch, Feilding, Rotorua and Mangere samples as 'solid' samples and reported them in w/w units. The Pleasant Point and Greytown samples were tested as 'liquid' samples and were reported in w/v units. They were then converted to w/w so they could be compared with the other samples.

The limit of detection for each congener depended on its sensitivity to the analytical procedure and also varied according to the amount of solid matter in each aliquot taken for analysis. The limits of detection are the 'less than values' reported in Table 14.5.

PCB Nomenclature

- the PCBs (12) with * were reported by RJH but not by ESR. Note RJH usually reports PCB-60 (2,3,4,4',-tetrachlorobiphenyl) but not in this project due to interferences;
- the PCBs (4) with # were reported by ESR but not by RJH;
- the 13 congeners with a TEF are in boldface.
-

PCB-28	2,4,4'-trichlorobiphenyl
PCB-31	2,4',5-trichlorobiphenyl
PCB-44	2,2',3,5'-tetrachlorobiphenyl *
PCB-49	2,2',4,5'-tetrachlorobiphenyl *
PCB-52	2,2',5,5'-tetrachlorobiphenyl
PCB-77	**3,3',4,4'-tetrachlorobiphenyl**
PCB-81	3,4,4',5-tetrachlorobiphenyl *
PCB-86	2,2',3,4,5-pentachlorobiphenyl *
PCB-99	2,2',4,4',5-pentachlorobiphenyl #
PCB-101	2,2',4,5,5'-pentachlorobiphenyl
PCB-105	**2,3,3',4,4'-pentachlorobiphenyl**
PCB-110	2,3,3 ',4',6-pentachlorobiphenyl *
PCB-114	**2,3,4,4',5-pentachlorobiphenyl**
PCB-118	**2,3',4,4',5-pentachlorobiphenyl**
PCB-121	2,3',4,5',6-pentachlorobiphenyl *
PCB-123	**2',3,4,4',5-pentachlorobiphenyl**
PCB-126	**3,3',4,4',5-pentachlorobiphenyl**
PCB-128	2,2',3,3',4,4'-hexachlorobiphenyl *
PCB-138	2,2',3,4,4',5'-hexachlorobiphenyl
PCB-141	2,2',3,4,5,5'-hexachlorobiphenyl *
PCB-149	2,2',3,4',5',6-hexachlorobiphenyl *
PCB-151	2,2',3,5,5',6-hexachlorobiphenyl *
PCB-153	2,2',4,4',5,5'-hexachlorobiphenyl
PCB-156	**2,3,3',4,4',5-hexachlorobiphenyl**
PCB-157	**2,3,3',4,4',5'-hexachlorobiphenyl**
PCB-159	2,3,3',4,5,5'-hexachlorobiphenyl *
PCB-167	**2,3',4,4',5,5'-hexachlorobiphenyl**
PCB-169	**3,3',4,4',5,5'-hexachlorobiphenyl**
PCB-170	**2,2',3,3',4,4',5-heptachlorobiphenyl**
PCB-180	**2,2',3,4,4',5,5'-heptachlorobiphenyl**
PCB-183	2,2',3,4,4',5',6-heptachlorobiphenyl #
PCB-187	2,2',3,4',5,5',6-heptachlorobiphenyl #
PCB-189	**2,3,3',4,4',5,5'-heptachlorobiphenyl**
PCB-194	2,2',3,3',4,4',5,5'-octachlorobiphenyl

PCB-202 2,2',3,3',5,5',6,6'-octachlorobiphenyl #
PCB-206 2,2',3,3',4,4',5,5',6-nonachlorobiphenyl
PCB-209 decachlorobiphenyl *

PCB numbering follows the convention described by Ballschmiter and Zell (Fresenius Z. Anal. Chem. Vol. 302, 20-31, 1980).

Samples

Refer Section 3 in Part A for a more detailed description of the samples.

Six samples were tested by ESR for PCBs. These PCB tests were performed principally as a quality control check on the 66 samples tested by RJ Hill Laboratories Ltd.

All sludge samples were dispatched to RJ Hill Laboratories where they were stored at 4°C. The more solid samples were sub-sampled by taking several cores from various parts of the containers using a stainless steel corer. The more liquid samples were shaken before pouring off the sub-samples. The six sub-samples were sent to ESR in glass jars in chillibins containing ice packs. The sub-samples were prepared from (RJH sample numbers quoted):

- Christchurch City Council - a mixture of samples 115724/2 & 4, dewatered biosolids of 17 and 18 March
- Rotorua District Council - a mixture of samples 116021/3 & 4, dewatered biological sludge, and compost
- Watercare Services Ltd sample 116306/5, lime stabilised biosolids
- Manawatu District Council sample 115685/3, air dried biosolids
- South Wairarapa District Council sample 116452/2, ex Greytown pond sediments
- Timaru District Council sample 115887/2, ex pond sediments at Pleasant Point.

QUALITY ASSURANCE

The ESR PCB Analytical Results

The ESR results appear in Table B 14.5.

Individual PCB results are reported in micrograms per kilogram (µg/kg), equivalent to nanograms per gram (ng/g), milligrams per tonne (mg/t) or ppb (w/w) on a dry weight basis.

Toxic equivalents (TEQs) are reported in nanograms per kilogram (ng/kg), equivalent to picograms per gram (pg/g), micrograms per tonne (µg/t) or parts per trillion (ppt).

The factors for calculating the TEQs appear in the table that compares the results from the two laboratories, Table B 14.6.

Comparison of the ESR and RJ Hill Results

The results for the six samples that were tested in both laboratories appear in Table B 14.6.

Note that ESR reported results for four congeners that RJ Hill did not report, ie PCBs 99, 183, 187 and 202.

RJ Hill reported results for 12 congeners that ESR did not report, namely PCBs 44, 49, 81, 86, 110, 121, 128, 141, 149, 151, 159 and 209.

RJ Hill reported a single concentration for PCBs 157 and 180, whereas ESR reported these separately.

RI Hill reported a single concentration for PCBs 128 and 167, whereas ESR reported PCB 167 but not PCB 128.

Both laboratories reported a single value for PCBs 28 + 31.

The ESR results included all the PCB congeners that had a toxic equivalent factor (TEF) at the time of analysis – these are indicated in Table B14.6. The number of PCBs with a TEF is currently under discussion with World Health Organisation officials.

Because of the method they used, the ESR results for Timaru and Greytown (the samples they tested as liquids) depend on the accuracy of the dry solids determination, whereas only Hill's Greytown result depends on the dry solids test. Most of the dry solids determinations obtained by the two laboratories were reasonably in agreement. However, the Greytown results differed by a factor of two. If the correct dry solids content was indeed RJ Hill's 0.9%, then ESR's PCB results for Greytown should all be half those reported. Conversely, if the correct dry solids was 0.45%, then the Hill results for Greytown should be doubled. Intuitively, the 0.9% result seems more likely for sludge from the bottom of a pond, and more in keeping with similar samples submitted in this project. Naturally it is assumed that the samples were split in an accurate manner, but there can be no guarantee of this - if that were the case, then both dry solids measurements could be correct.

The ESR results are about 20-100 times more sensitive than the RJ Hill results (the RJH technique was selected on a cost effective basis so that all 66 samples could be analysed). That means that a lot of the R.1 Hill results have 'less than' values which makes a comparison between the two sets more difficult. In summary though, there were very few pairs that had significantly different individual results. There were 114 paired results. Of these, both laboratories gave 'less than values' for 33 pairs. One laboratory quoted a 'less than' while the other quoted a real number in 59 of the pairs – in only 9 of these pairs was the 'less than value' smaller than the real number. Real numbers were reported in 22 pairs – in 16 of them the larger value was not more than double the other result. Therefore 87% of the paired results could be described as being not significantly different.

However, in theory the main difference between the two results could be in the method of reporting. Laboratories only report selected PCB congeners, congeners for which they have a standard. PCBs are found in man-made substances like the Aroclors. Different grades contained mixtures of different congeners. Which congeners are detected in environmental samples depends in part on the Aroclor grade that had been used or discharged in the area, plus the effects of weathering or any degradation.

Not being able to determine the concentration of every PCB congener makes it rather difficult to report the 'total PCB' value. For example, neither ESR nor RJ Hill reported all congeners; nor did they report the same congeners, thereby affecting the comparison of the results:

Christchurch Dewatered Sludge as µg/kg ex Table B14.6	ESR	RJH
sum of congeners	79.2	147
sum of matching congeners	74.4	91
congener sum + half LODs	80.0	177
matching congener sum + half LODs	75.2	113

The RJ Hill result for the sum of *matching* congeners is much closer to the ESR result. By standardising on the ESR congeners (24 of them *cf* 30 for RJ Hill) the RJ Hill 'total' of 147 µg/kg reduces by 56 to 91 µg/kg, a reduction of 38%.

Adding half the value of the ESR 'less thans' does not have a marked effect on their total congener result because their LODs are so low (but imagine the impact of reporting about 200 congeners!). Table B 14.6 also shows that the RJ Hill sum of congeners + half the LODs results for the Timaru sample becomes quite high, simply because the nature of the sample did not allow them to obtain a very low LOD. Some parties may find the ESR method to suit their needs - ie less likely to infringe any limit based on this method of reporting. The more sensitive ESR method is more expensive so a natural reaction would be to have fewer samples tested. This may not be the most desirable environmental outcome.

Then again, some parties may prefer the RJ Hill method - for example, in Table B 14.6 the ESR found a total congener content of 14.9 µg/kg in the Timaru sample but RJ Hill Labs reported 0 µg/kg because all their results were below their LOD.

This discussion suggests that to be fair, an agreed number of congeners needs to be tested by all laboratories involved in this type of work, and a fairly low, consistent LOD is required - this implies only one standard method should be used in compliance or regulatory work.

The most logical approach is to report only those congeners that have a Toxic Equivalent Factor and to report PCBs as TEQs + half the LODs, provided the LODs are reasonably consistent. These issues have been addressed by the Ministry for the Environment in the current process of developing national standards (Simon Buckland, pers. comm.).

The TEQ approach is the only approach which assesses ecological risk and as such will be used in regulatory work. 'Total' PCBs are still recommended for work such as suspected contaminated site investigations and general surveys.

However, for meaningful results, a low LOD is required for compliance and regulatory work. The 'compromise' method selected by RJ Hill Laboratories for this general survey would not be sensitive enough for compliance or regulatory work. Table B 14.6 shows that the TEQ plus half LOD total is almost entirely dependent on the concentration of PCB-126 or its LOD – if the LOD of PCB-126 is high the total is high. Table B14.6 also shows clearly the impact of not using the lowest possible LODs. For this reason, Tables B14.1 – B 14.4 do not include TEQs.

Local Body	**Timaru**	**Christchurch**	**South Wairarapa**	**Manawatu**	**Rotorua**	**Watercare**
Treatment Plant	Pleasant Pt	Bromley	Greytown	Feilding	Dewatered	Mangere
Sample	Pond Sed	Dewatered	Pond Sed	Air dried	+ Compost	Lime stable
Lab No.	115887/2	115724/2,4	116452/2	115685/3	116021/3,4	116306/5
% dry solids (ESR)	23.1	19.4	0.45	70.0	13.9	42.3
µg/kg dry weight						
PCB-28 + 31 (Tri)	2.44	19.5	1.51	1.86	22.4	7.04
PCB-52 (Tetra)	0.85	12.1	0.81	0.94	7.17	4.73
PCB-77 (Tetra)	0.077	0.54	0.067	0.10	0.59	0.35
PCB-99 (Penta)	0.42	1.53	0.52	0.59	2.45	1.20
PCB-101 (Penta)	1.93	7.97	2.23	2.61	10.1	4.73
PCB-105 (Penta)	0.33	1.45	0.22	0.47	1.43	0.87
PCB-114 (Penta)	<0.2	<0.4	<0.2	<0.06	<0.5	<0.3
PCB-118 (Penta)	1.05	4.00	0.84	1.52	6.01	2.72
PCB-123 (Penta)	<0.2	<0.9	<0.2	<0.2	<0.9	<0.5
PCB-126 (Penta)	0.020	<0.1	<0.02	<0.1	<0.1	<0.1
PCB-138 (Hexa)	3.08	14.0	3.41	3.85	18.4	6.07
PCB-153 (Hexa)	1.64	6.37	2.19	1.89	13.8	2.87
PCB-156 (Hexa)	0.18	0.76	0.18	0.26	1.01	0.39
PCB-157 (Hexa)	0.048	0.18	<0.2	0.064	<0.3	0.10
PCB-167 (Hexa)	0.34	1.54	0.28	0.50	1.26	0.76
PCB-169 (Hexa)	<0.01	<0.02	<0.01	<0.02	<0.05	<0.01
PCB-170 (Hepta)	0.72	3.33	0.63	0.78	4.50	1.22
PCB-180 (Hepta)	0.67	2.44	0.77	0.62	4.41	0.95
PCB-183 (Hepta)	0.28	0.96	0.29	0.24	1.80	0.36
PCB-187 (Hepta)	0.65	2.10	0.75	0.54	3.68	0.84
PCB-189 (Hepta)	<0.05	<0.1	<0.1	<0.05	<0.5	<0.05
PCB-194 (Octa)	0.12	0.41	<0.2	0.10	0.37	0.16
PCB-202 (Octa)	0.037	<0.1	<0.1	<0.05	<0.2	<0.05
PCB-206 (Nona)	0.037	<0.1	<0.2	<0.08	<0.2	<0.1
Sum of congeners excl. LODs	14.9	79.2	14.7	16.9	99.4	35.4
Sum of congeners incl. half LODs	15.1	80.0	15.3	17.2	101	35.9
Total TEQ, **ng/kg** excl. LODs	2.37	1.66	0.30	0.50	2.05	0.92
Total TEQs, **ng/kg** incl half. LODs	2.49	6.91	1.47	5.63	7.57	6.07

Table B 14.5: The ESR results for PCBs
Note units in the TEQ rows (ng/kg = pg/g)

Local Body	**Timaru**		**Christchurch**		**Sth Wairarapa**		**Manawatu**	
Treatment Plant	Pleasant Point		Bromley		Greytown		Feilding	
Sludge sample	Pond sediment		Dewatered		Pond sediment		Air dried	
RJH Sample No.	115887/2		115724/2 & 4		116452/2		115685/3	
	ESR	**RJH**	**ESR**	**RJH**	**ESR**	**RJH**	**ESR**	**RJH**
% dry solids	23.1	19.9	19.4	20.7	0.45	0.9	70.0	74.9
PCB-28 + 31 (Tri)	2.44	<10	19.5	30	1.51	<1.1	1.86	<2
PCB-44 (Tetra)	-	<10	-	8	-	<1.1	-	2
PCB-49 (Tetra)	-	<10	-	6	-	<1.1	-	<2
PCB-52 (Tetra)	0.85	<10	12.1	27	0.81	<1.1	0.94	<2
PCB-77 (Tetra)	**0.077**	**<10**	**0.54**	**<4**	**0.067**	**<1.1**	**0.10**	**<1**
PCB-81 (Tetra)	-	<10	-	17	-	<1.1	-	2
PCB-86 (Penta)	-	<10	-	10	-	<1.1	-	<1
PCB-99 (Penta)	0.42	-	1.53	-	0.52	-	0.59	-
PCB-101 (Penta)	1.93	<10	7.97	7	2.23	<1.1	2.61	2
PCB-105 (Penta)	**0.33**	**<10**	**1.45**	**<4**	**0.22**	**<1.1**	**0.47**	**<1**
PCB-110 (Penta)	-	<10	-	6	-	<1.1	-	2
PCB-114 (Penta)	**<0.2**	**<10**	**<0.4**	**<4**	**<0.2**	**<1.1**	**<0.06**	**<1**
PCB-118 (Penta)	**1.05**	**<10**	**4.00**	**6**	**0.84**	**<1.1**	**1.52**	**1**
PCB-121 (Penta)	-	<10	-	3	-	1.1	-	<2
PCB-123 (Penta)	**<0.2**	**<10**	**<0.9**	**<4**	**<0.2**	**<1.1**	**<0.2**	**<1**
PCB-126 (Penta)	**0.020**	**<10**	**<0.1**	**<4**	**<0.02**	**<1.1**	**<0.1**	**<1**
PCB-138 (Hexa)	3.08	<10	14.0	10	3.41	<1.1	3.85	2
PCB-141 (Hexa)	-	<10	-	<4	-	<1.1	-	<1
PCB-149 (Hexa)	-	<10	-	6	-	<1.1	-	<1
PCB-151 (Hexa)	-	<10	-	<4	-	<1.1	-	<1
PCB-153 (Hexa)	1.64	<10	6.37	7	2.19	<1.1	1.89	2
PCB-156 (Hexa)	**0.18**	**<10**	**0.76**	**<4**	**0.18**	**<1.1**	**0.26**	**<1**
*** PCB-157 (Hexa)**	**0.048**	**-**	**0.18**	**-**	**<0.2**	**-**	**0.064**	**-**
PCB-159 (Hexa)	-	<10	-	<4	-	<1.1	-	<1
**** PCB-167 (Hexa)**	**0.34**	**<10**	**1.54**	**2**	**0.28**	**<1.1**	**0.50**	**<1**
PCB-169 (Hexa)	**<0.01**	**<10**	**<0.02**	**<4**	**<0.01**	**<1.1**	**<0.02**	**<2**
PCB-170 (Hepta)	**0.72**	**<10**	**3.33**	**<4**	**0.63**	**<1.1**	**0.78**	**<1**
*** PCB-180 (Hepta)**	**0.67**	**<10**	**2.44**	**2**	**0.77**	**<1.1**	**0.62**	**<1**
PCB-183 (Hepta)	0.28	-	0.96	-	0.29	-	0.24	-
PCB-187 (Hepta)	0.65	-	2.10	-	0.75	-	0.54	-
PCB-189 (Hepta)	**<0.05**	**<10**	**<0.1**	**<4**	**<0.1**	**<1.1**	**<0.05**	**<1**
PCB-194 (Octa)	0.12	<10	0.41	<4	<0.2	<1.1	0.10	<1
PCB-202 (Octa)	0.037	-	<0.1	-	<0.1	-	<0.05	-
PCB-206 (Nona)	0.037	<10	<0.1	<4	<0.2	<1.1	<0.08	<1
PCB-209 (Deca)	-	<10	-	<4	-	<1.1	-	<1
Sum of congeners excl. LODs	14.9	0	79.2	147	14.7	1.1	16.9	13
Sum of congeners incl. half LODs	15.1	150	80.0	177	15.3	17	17.2	26
Total TEQ, **ng/kg** excl. LODs	2.37	0.0	1.66	1.62	0.30	0.0	0.50	0.10
Total TEQs, **ng/kg** incl. half LODs	2.49	562	6.91	225	1.47	557	5.63	61

* RJ Hill result includes PCB-157 with PCB-180 ** RJ Hill result includes PCB-128 with PCB-167

Table B 14.6: Comparison of ESR and RJ Hill PCB results (cont'd next page), µg/kg dry weight

Local Body	**Rotorua**		**Watercare**		**Toxic Equivalent Factors (no unit)**
Treatment Plant	Dewatered plus		Mangere		
Sludge sample	Compost		Lime stabilised		
RIB Sample No.	116021/3 & 4		116306/5		
	ESR	**RJR**	**ESR**	**RJR**	
% dry solids	13.9	15.8	42.3	44.6	
PCB-28 + 31 (Tri)	22.4	5	7.04	<4	
PCB-44 (Tetra)	-	4	-	<4	
PCB-49 (Tetra)	-	3	-	<4	
PCB-52 (Tetra)	7.17	<6	4.73	<4	
PCB-77 (Tetra)	**0.59**	**<6**	**0.35**	**<4**	**0.0005**
PCB-81 (Penta)	-	<6	-	<4	
PCB-86 (Penta)	-	3	-	<4	
PCB-99 (Penta)	2.45	-	1.20	-	
PCB-10l (Penta)	10.1	4	4.73	7	
PCB-105 (Penta)	**1.43**	**3**	**0.87**	**<4**	**0.0001**
PCB-110 (Penta)	-	3	-	5	
PCB-114 (Penta)	**<0.5**	**<6**	**<0.3**	**<4**	**0.0005**
PCB-118 (Penta)	**6.01**	**3**	**2.72**	**<4**	**0.0001**
PCB-121 (Penta)	-	<6	-	<4	
PCB-123 (Penta)	**<0.9**	**6**	**<0.5**	**<4**	**0.0001**
PCB-126 (Penta)	**<0.1**	**<6**	**<0.1**	**<4**	**0.1**
PCB-138 (Hexa)	18.4	3	6.07	4	
PCB-141 (Hexa)	-	<6	-	<4	
PCB-149 (Hexa)	-	4	-	<4	
PCB-151 (Hexa)	-	<6	-	<4	
PCB-153 (Hexa)	13.8	3	2.87	<4	
PCB-156 (Hexa)	**1.01**	**<6**	**0.39**	**<4**	**0.0005**
*** PCB-157 (Hexa)**	**<0.3**	**-**	**0.10**	**-**	**0.0005**
PCB-159 (Hexa)	-	2	-	<4	
**** PCB-167 (Hexa)**	**1.26**	**4**	**0.76**	**<4**	**0.00001**
PCB-169 (Hexa)	**<0.05**	**<6**	**<0.01**	**<4**	**0.01**
PCB-170 (Hepta)	**4.50**	**<6**	**1.22**	**<4**	**0.0001**
*** PCB-180 (Hepta)**	**4.41**	**3**	**0.95**	**<4**	**0.00001**
PCB-183 (Hepta)	1.80	-	0.36	-	
PCB-187 (Hepta)	3.68	-	0.84	-	
PCB-189 (Hepta)	**<0.5**	**<6**	**<0.05**	**<4**	**0.0001**
PCB-194 (Octa)	0.37	<6	0.16	<4	
PCB-202 (Octa)	<0.2	-	<0.05	-	
PCB-206 (Nona)	<0.2	3	<0.1	<4	
PCB-209 (Deca)	-	<6	-	<4	
Sum of congeners excl. LODs	99.4	56	35.4	16	-
Sum of congeners incl. half LODs	101	96	35.9	70	-
Total TEQ, **ng/kg** excl. LODs	2.05	2.74	0.92	0.0	-
Total TEQs, **ng/kg** incl. half LODs	7.57	338	6.07	225	-

* RJH result includes PCB-157 with PCB-180; ** RJH result includes PCB-128 with PCB-167

Table B 14.6: Comparison of ESR and RJ Hill PCB results (cont'd)

Units are .µg/kg dry weight, except for the TEQ rows

ANALYTICAL RESULTS

Results of the PCB analyses appear in Tables B14.1 – B14.4. PCBs 126 and 169 are listed in these Tables in boldface because they are the two with the highest toxic equivalency factors. To be consistent with almost all the other Tables, results are reported in mg/kg dry weight. As explained earlier, the general method selected for this survey was not sensitive enough to calculate meaningful TEQs.

Three earlier New Zealand results appear in Table 6.12 in Part A. Results from the Eastern Canadian study are summarised in Table 7.9 (along with the OCPs), and some US results are included in Table 7.18.

The USEPA priority pollutants list includes seven PCBs: they are PCB-1016, PCB-1221, PCB-1232, PCB-1242, PCB-1248, PCB-1254, PCB-1260. Sometimes (and more correctly, although it is only a trade name of one manufacturer) Aroclor is used in place of PCB. Aroclors are not individual PCBs, but are products which were marketed under these names and which were mixtures of individual PCBs. The trade name was designed to describe the product; eg Aroclor 1260 contained a mixture of PCBs, which on average contained 12 carbon atoms which were 60% chlorinated.

Discussion

Polychlorinated biphenyls (PCBs) were never manufactured in New Zealand. They have been used in vacuum pumps, fire retardants, carbonless copy paper, in the tanning industry, and as a component of some paints and resins, cutting oils, hydraulic fluids and lubricants. Their widest application was in electrical capacitors and transformers.

In March 1986 the New Zealand Customs Department prohibited the importation of PCBs, and in 1988 an amendment to the Toxic Substances Regulations 1983 prohibited the use and storage of PCBs with effect from 1.1.1994. Following two extensions, this regulation came into effect on 1.8.95. The Ministry of Health has encouraged the collection and destruction (overseas) of PCBs for some time now, so theoretically there are none left in New Zealand!

In the raw sludges, 8 of the 30 PCB congeners analysed were found above their limits of detection (LOD) in Carterton and Wainuiomata sludges, and 7 were found in Mangere sludge. Whether any congener is detected is a function of the LOD so the preceding sentence must be interpreted carefully; for example, the LOD for congeners in the Mangere sample was 0.0003 mg/kg whereas the LOD in the Levin sample was only 0.1 mg/kg. That means if a PCB was detected in Mangere raw sludge at 0.03 mg/kg it could be stated with a high degree of confidence that it was present, and probably at a level quite close to 0.03 mg/kg. However, if that concentration was present in the Levin sample it would not have been reported, and even if 0.1 mg/kg had been reported in the Levin raw sludge, there would have been a relatively low level of confidence in that result. The more toxic congeners (PCB-126 and PCB-169) were not detected in the raw sludges. The highest concentrations of total PCBs found were 0.30 mg/kg in Levin, 0.25 in Bromley and 0.21 in Wainuiomata raw sludges.

In the anaerobic sludges, PCB congeners were found above their LODs in Bromley digested (16 congeners), Bromley dewatered 18/3/98 (15), Bromley dewatered 17/3/98 (11) and Bromley dry biosolids sludges (11). Of the two more toxic congeners, 0.004 mg/kg of PCB-169 was detected in Feilding air dried sludge. The highest concentrations of total PCBs found were 0.17 mg/kg in Bromley dewatered 18/3/98, 0.13 in sludge from the Levin drying beds, 0.11 mg/kg in Bromley dewatered 17/3/98, and 0.10 in Bromley digested sludge.

In the aerobic sludges, PCB congeners were found above their LODs in Rotorua dewatered (16 congeners), Thames (14), Carterton aerobic digesters 1 & 2 (10) and Otaki sludge (10). The more toxic congeners (PCB-126 and PCB-169) were not detected. The highest concentrations of total PCBs found were 0.30 mg/kg in Paraparaumu BNR sludge, 0.23 in Rotorua activated sludge, 0.21 mg/kg in sludge from Thames aerated lagoon, and 0.10 mg/kg in Rotorua dewatered sludge.

In the pond sediments and composts, PCB congeners were found above their LODs in the distribution end of the Bromley ponds (22 congeners), the far end (17), and the Bromley compost (12). The more toxic congeners (PCB-126 and PCB-169) were not detected. The highest concentrations of total PCBs found were 0.38 mg/kg in the distribution end of the Bromley ponds and 0.14 mg/kg in the sediment from the far end.

The median total PCBs concentrations for each of the sludge groupings were:

raw sludges	0.006 mg/kg
anaerobic sludges	0.015 mg/kg
aerobic sludges	0.022 mg/kg
sediments/composts	0.002 mg/kg.

The PCB congeners that were found most often were (in order of frequency, and with the maximum concentration, mg/kg, in brackets):

Raw Sludges	Anaerobic	Aerobic	Sediments
PCB-52	PCB-110	PCB-28+31 (0.20)	PCB-153 (0.045)
PCB 28+31 (0.10)	PCB-44	PCB-101 (0.08)	PCB-138 (0.041)
PCB-44 (0.11)	PCB-28+31	PCB-52 (0.07)	PCB-149 (0.034)
	PCB-101		PCB-101 (0.033)
	PCB-52 (0.057)		

It would appear that the most common congeners in the 66 sewage sludges were PCBs-28+31, 44, 52 and 101. Those with larger numbers were more common in the sediments: PCBs-138, 149 and 153. None of these PCBs has been assigned a toxic equivalency factor (TEF). Note that congeners #44 and 149 were not reported by ESR.

PCB-28+31 are trichlorobiphenyls, PCBs-44, 52 are tetrachlorobiphenyls, PCB-101 is a pentabiphenyl, and PCBs-138, 149 and 153 are hexabiphenyls. This distinctive pattern possibly indicates the biodegradability of the congeners — ie, the predominant congeners in the sediments are those with the largest molecules or the most chlorine atoms — those that are probably the most resistant to biological or chemical degradation.

All congeners in the three New Zealand samples reported in Table 6.12 in Part A were below their LODs (of 0.002 — 0.01 mg/kg).

The Eastern Canadian survey (see Table 6.12) found that total PCBs in one of the five towns sampled averaged 0.3 mg/kg, while the mean values in the other towns were less than 0.5 mg/kg.

The US study (Table 7.18) reported results in different units, based on the commercial product. Some products were found in about 10% of samples, one at a quite high level.

National standards or guidelines are often set at about 0.3 mg/kg total PCBs – see Table 5.5 in Part A. This survey suggests that New Zealand sludges do not seem to exceed that level at present, and with a gradual reduction in the presence of PCBs, they are unlikely to exceed the limit in the future. In the present survey, two samples contained 0.30 mg/kg 'total' PCBs and one contained 0.38; these were analysed by RJ Hill Laboratories so included congeners additional to those reported by ESR.

In New Zealand it would appear that PCB environmental standards will be based on the TEQ system, using the total TEQ including half the LODs. The concentration has not been set yet. As mentioned above, this approach means the presence of PCB 126 (or its LOD) becomes extremely important. In the six ESR analyses in Table B 14.5, PCB 126 contributed 66-89% of the total TEQ + half LOD values.

RAW SLUDGES **POLYCHLORINATED BIPHENYLS (PCBs)**

Local Body	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview	
mg/kg dry Weight	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg
Lab No.	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1
% Dry Solids	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7
PCB-28 (Tri) + PCB-31 (Tri)	**0.0028**	**0.04**	<0.0012	<0.06	<0.08	<0.005	**0.1**	**0.05**	<0.004	<0.0022
PCB-44 (Tetra)	**0.0018**	**0.11**	<0.0012	<0.06	<0.08	**0.02**	<0.1	**0.02**	<0.004	<0.0022
PCB-49 (Tetra)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	**0.01**	<0.004	<0.0022
PCB-52 (Tetra)	**0.0018**	**0.006**	**0.0018**	**0.08**	<0.08	<0.005	**0.2**	**0.01**	<0.004	<0.0022
PCB-77 (Tetra)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-81 (Tetra)	**0.0013**	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	**0.04**	**0.092**	<0.0022
PCB-86 (Penta)	<0.0010	**0.01**	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-101 (Penta)	<0.0010	**0.03**	<0.0012	<0.06	<0.08	**0.008**	<0.1	<0.01	<0.004	<0.0022
PCB-105 (Penta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-110 (Penta)	**0.0020**	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	**0.02**	<0.004	<0.0022
PCB-114 (Penta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-118 (Penta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-121 (Penta)	**0.0013**	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-123 (Penta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	**0.02**	<0.004	<0.0022
PCB-126 (Penta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-128 + PCB-167 (Hexa+Hexa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-138 (Hexa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-141 (Hexa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-149 (Hexa)	**0.0013**	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	**0.01**	<0.004	<0.0022
PCB-151 (Hexa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-153 (Hexa)	**0.0013**	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-156 (Hexa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-157 + PCB-180 (Hexa+Hepta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-159 (Hexa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-169 (Hexa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-170 (Hepta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-189 (Hepta)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-194 (Octa)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PCB-206 (Nona)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
PAB-209 (Deca)	<0.0010	<0.01	<0.0012	<0.06	<0.08	<0.005	<0.1	<0.01	<0.004	<0.0022
Total PCB (Sum of individual Congeners excluding LODs)	0.014	0.250	0.002	0.080	0.000	0.028	0.300	0.210	0.092	0.000
Total PCB (Sum of individual Congeners including half LODs)	0.025	0.375	0.019	0.950	1.200	0.098	1.700	0.320	0.150	0.033
No. of congeners (of 30) > LOD	8	5	1	1	0	2	2	8	1	0

RAW SLUDGES POLYCHLORINATED BIPHENYLS (PCBs)

Local Body	Invercargill	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare				
		Fielding	Rosedale	Bay – Mech.		Mangere				**Number**
mg/kg dry Weight	Wool Scour	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg				**(from 16)**
Lab No.	116836/2	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	9.8	2.7	3.0	18.1	3.1	4.0		29	1.6	
PCB-28 (Tri) + PCB-31 (Tri)	**0.0026**	<0.02	<0.0013	<0.004	<0.0013	<0.0003		0.1	<0.0003	5
PCB-44 (Tetra)	**0.0004**	<0.02	<0.0013	<0.004	<0.0013	<0.0003		0.11	<0.0003	5
PCB-49 (Tetra)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		0.01	<0.0003	1
PCB-52 (Tetra)	**0.0004**	<0.02	<0.0013	<0.004	<0.0013	**0.0015**		0.2	<0.0013	8
PCB-77 (Tetra)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-81 (Tetra)	**0.0007**	<0.02	<0.0013	<0.004	<0.0013	<0.0003		0.092	<0.0003	4
PCB-86 (Penta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		0.01	<0.0003	1
PCB-101 (Penta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		0.03	<0.0003	2
PCB-105 (Penta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-110 (Penta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	**0.0013**		0.02	<0.0012	3
PCB-114 (Penta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-118 (Penta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	**0.0008**		8E-04	<0.001	1
PCB-121 (Penta)	**0.0005**	<0.02	<0.0013	<0.004	<0.0013	**0.0010**		0.001	<0.0012	3
PCB-123 (Penta)	<0.0004	<0.02	**0.003**	<0.004	<0.0013	**0.0008**		0.02	<0.001	3
PCB-126 (Penta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-128 + PCB-167 (Hexa+Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-138 (Hexa)	<0.0004	<0.02	**0.002**	<0.004	<0.0013	**0.0008**		0.002	<0.001	2
PCB-141 (Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-149 (Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		0.01	<0.0003	2
PCB-151 (Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-153 (Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	**0.0008**		0.0013	<0.0012	2
PCB-156 (Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-157 + PCB-180 (Hexa+Hepta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-159 (Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-169 (Hexa)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-170 (Hepta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-189 (Hepta)	<0.0004	<0.02	<0.0013	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-194 (Octa)	<0.0004	<0.02	<0.0027	<0.004	<0.0013	<0.0003		-	<0.0003	0
PCB-206 (Nona)	<0.0004	<0.02	<0.0027	<0.004	<0.0013	<0.0003		-	<0.0003	0
PAB-209 (Deca)	<0.0004	<0.02	<0.0027	<0.004	<0.0013	<0.0003		-	<0.0003	0
Total PCB (Sum of individual										
Congeners excluding LODs)	0.005	0.000	0.005	0.000	0.000	0.007		0.300	0.000	
Total PCB (Sum of individual										
Congeners including half LODs)	0.010	0.300	0.025	0.060	0.020	0.010		1.700	0.010	
No. of congeners (of 30) > LOD	5	0	2	0	0	7				

ANAEROBIC SLUDGES **POLYCHLORINATED BIPHENYLS (PCBs)**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata
mg/kg dry Weight	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg
Lab No.	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2
% Dry Solids	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0
PCB-28 (Tri) + PCB-31 (Tri)	**0.01**	<0.02	**0.028**	**0.031**	<0.0008	<0.0024	<0.02	**0.018**	<0.0010
PCB-44 (Tetra)	**0.007**	<0.02	**0.007**	**0.008**	<0.0008	<0.0024	**0.02**	**0.015**	**0.0028**
PCB-49 (Tetra)	**0.005**	<0.02	**0.006**	**0.006**	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-52 (Tetra)	<0.004	<0.02	**0.021**	**0.033**	**0.019**	<0.0024	<0.02	**0.057**	**0.0015**
PCB-77 (Tetra)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-81 (Tetra)	<0.004	<0.02	**0.014**	**0.019**	<0.0008	<0.0024	<0.02	**0.009**	<0.0010
PCB-86 (Penta)	**0.005**	<0.02	<0.004	**0.019**	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-101 (Penta)	**0.008**	<0.02	**0.007**	**0.007**	**0.0017**	<0.0024	<0.02	<0.009	<0.0010
PCB-105 (Penta)	**0.005**	<0.02	<0.004	<0.004	**0.0012**	<0.0024	<0.02	<0.009	<0.0010
PCB-110 (Penta)	**0.005**	<0.02	**0.005**	**0.007**	**0.0021**	<0.0024	**0.02**	**0.011**	**0.0020**
PCB-114 (Penta)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-118 (Penta)	**0.005**	<0.02	**0.006**	**0.005**	**0.0011**	<0.0024	<0.02	<0.009	<0.0010
PCB-121 (Penta)	<0.004	<0.02	<0.004	**0.005**	**0.0009**	<0.0024	**0.02**	**0.01**	<0.0010
PCB-123 (Penta)	**0.011**	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-126 (Penta)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-128 + PCB-167 (Hexa+Hexa)	**0.008**	<0.02	<0.004	**0.004**	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-138 (Hexa)	**0.006**	<0.02	**0.009**	**0.010**	**0.0038**	<0.0024	<0.02	<0.009	<0.0010
PCB-141 (Hexa)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-149 (Hexa)	**0.007**	<0.02	**0.005**	**0.006**	**0.0024**	<0.0024	**0.03**	**0.012**	<0.0010
PCB-151 (Hexa)	<0.004	<0.02	<0.004	<0.004	**0.0008**	<0.0024	<0.02	<0.009	<0.0010
PCB-153 (Hexa)	**0.006**	<0.02	**0.006**	**0.008**	**0.0031**	<0.0024	<0.02	<0.009	**0.0013**
PCB-156 (Hexa)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-157 + PCB-180 (Hexa+Hepta)	**0.005**	<0.02	<0.004	**0.004**	**0.0017**	<0.0024	<0.02	<0.009	<0.0010
PCB-159 (Hexa)	**0.005**	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-169 (Hexa)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-170 (Hepta)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-189 (Hepta)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-194 (Octa)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PCB-206 (Nona)	**0.005**	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
PAB-209 (Deca)	<0.004	<0.02	<0.004	<0.004	<0.0008	<0.0024	<0.02	<0.009	<0.0010
Total PCB (Sum of individual									
Congeners excluding LODs)	0.103	0.000	0.114	0.172	0.021	0.000	0.090	0.132	0.008
Total PCB (Sum of individual									
Congeners including half LODs)	0.131	0.300	0.152	0.202	0.029	0.036	0.350	0.234	0.021
No. of congeners (of 30) > LOD	16	0	11	15	11	0	4	7	4

ANAEROBIC SLUDGES POLYCHLORINATED BIPHENYLS (PCBs)

Local Body	Hutt	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato
	Wainuiomata			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa
mg/kg dry Weight	Air Dried Slg	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon
Lab No.	116891/3	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1
% Dry Solids	30.9	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7
PCB-28 (Tri) + PCB-31 (Tri)	<0.004	<0.0024	<0.02	<0.0013	<0.002	<0.0012	**0.009**	**0.009**	**0.02**
PCB-44 (Tetra)	<0.004	<0.0024	<0.02	<0.0013	**0.002**	<0.0012	**0.016**	<0.006	<0.01
PCB-49 (Tetra)	<0.004	<0.0024	<0.02	<0.0013	<0.002	<0.0012	<0.007	<0.006	<0.01
PCB-52 (Tetra)	<0.004	<0.0024	<0.02	<0.0013	<0.002	<0.0012	<0.007	<0.006	<0.01
PCB-77 (Tetra)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-81 (Tetra)	<0.004	<0.0024	<0.02	<0.0013	**0.002**	<0.0012	**0.007**	<0.006	<0.01
PCB-86 (Penta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-101 (Penta)	<0.004	<0.0024	<0.02	<0.0013	**0.002**	<0.0012	**0.013**	<0.006	<0.01
PCB-105 (Penta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-110 (Penta)	<0.004	<0.0024	<0.02	<0.0013	**0.002**	<0.0012	0.**009**	<0.006	<0.01
PCB-114 (Penta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-118 (Penta)	<0.004	<0.0024	<0.02	<0.0013	**0.001**	<0.0012	<0.007	<0.006	<0.01
PCB-121 (Penta)	<0.004	<0.0024	<0.02	<0.0013	<0.002	<0.0012	**0.007**	<0.006	<0.01
PCB-123 (Penta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-126 (Penta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-128 + PCB-167 (Hexa+Hexa)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-138 (Hexa)	<0.004	<0.0024	<0.02	<0.0013	**0.002**	<0.0012	<0.007	<0.006	<0.01
PCB-141 (Hexa)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-149 (Hexa)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-151 (Hexa)	**0.036**	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-153 (Hexa)	<0.004	<0.0024	<0.02	<0.0013	**0.002**	<0.0012	<0.007	<0.006	<0.01
PCB-156 (Hexa)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-157 + PCB-180 (Hexa+Hepta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-159 (Hexa)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-169 (Hexa)	<0.004	<0.0024	<0.02	<0.0013	<0.002	<0.0012	<0.007	<0.006	<0.01
PCB-170 (Hepta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-189 (Hepta)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0012	<0.007	<0.006	<0.01
PCB-194 (Octa)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0024	<0.007	<0.006	<0.01
PCB-206 (Nona)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0024	<0.007	<0.006	<0.01
PAB-209 (Deca)	<0.004	<0.0024	<0.02	<0.0013	<0.001	<0.0024	<0.007	<0.006	<0.01
Total PCB (Sum of individual									
Congeners excluding LODs)	0.036	0.000	0.000	0.000	0.013	0.000	0.061	0.009	0.020
Total PCB (Sum of individual									
Congeners including half LODs)	0.094	0.036	0.300	0.020	0.026	0.020	0.145	0.096	0.165
No. of congeners (of 30) > LOD	1	0	0	0	7	0	6	1	1

ANAEROBIC SLUDGES POLYCHLORINATED BIPHENYLS (PCBs)

Local Body	Watercare	Watercare	Watercare	Watercare				
	Mangere	Mangere	Mangere	Mangere				**Number**
mg/kg dry Weight	Dewatered Slg	Dewatered Slg	Lime stabilised	Air Dried Slg				**(from 22)**
Lab No.	116306/2	116306/4	116306/5	116306/6		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	0.9	33.8	44.6	43.3		93.9	0.9	
PCB-28 (Tri) + PCB-31 (Tri)	<0.0011	**0.027**	<0.004	<0.02		0.031	<0.0008	8
PCB-44 (Tetra)	<0.0011	**0.04**	<0.004	<0.02		0.04	<0.0008	9
PCB-49 (Tetra)	<0.0011	**0.007**	<0.004	<0.02		0.007	<0.0008	4
PCB-52 (Tetra)	<0.0011	**0.013**	<0.004	<0.02		0.057	<0.0011	6
PCB-77 (Tetra)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-81 (Tetra)	<0.0011	<0.005	<0.004	<0.02		0.019	<0.0008	5
PCB-86 (Penta)	<0.0011	<0.005	<0.004	<0.02		0.019	<0.0008	2
PCB-101 (Penta)	<0.0011	**0.008**	**0.007**	<0.02		0.013	<0.0011	8
PCB-105 (Penta)	<0.0011	<0.005	<0.004	<0.02		0.005	<0.0008	2
PCB-110 (Penta)	<0.0011	<0.005	**0.005**	<0.02		0.02	<0.0011	10
PCB-114 (Penta)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-118 (Penta)	<0.0011	<0.005	<0.004	<0.02		0.006	<0.0011	5
PCB-121 (Penta)	<0.0011	<0.005	<0.004	<0.02		0.02	<0.0011	5
PCB-123 (Penta)	<0.0011	<0.005	<0.004	<0.02		0.011	<0.0008	1
PCB-126 (Penta)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-128 + PCB-167 (Hexa+Hexa)	<0.0011	<0.005	<0.004	<0.02		0.008	<0.0008	2
PCB-138 (Hexa)	<0.0011	<0.005	**0.004**	<0.02		0.01	<0.0008	6
PCB-141 (Hexa)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-149 (Hexa)	<0.0011	<0.005	<0.004	<0.02		0.03	<0.0011	6
PCB-151 (Hexa)	<0.0011	<0.005	<0.004	<0.02		0.036	<0.0011	2
PCB-153 (Hexa)	<0.0011	<0.005	<0.004	<0.02		0.008	<0.0011	6
PCB-156 (Hexa)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-157 + PCB-180 (Hexa+Hepta)	<0.0011	<0.005	<0.004	<0.02		0.005	<0.0011	3
PCB-159 (Hexa)	<0.0011	<0.005	<0.004	<0.02		0.005	<0.0008	1
PCB-169 (Hexa)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-170 (Hepta)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-189 (Hepta)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-194 (Octa)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
PCB-206 (Nona)	<0.0011	<0.005	<0.004	<0.02		0.005	<0.0008	1
PAB-209 (Deca)	<0.0011	<0.005	<0.004	<0.02		-	<0.0008	0
Total PCB (Sum of individual								
Congeners excluding LODs)	0.000	0.095	0.016	0.000		0.172	0.000	
Total PCB (Sum of individual								
Congeners including half LODs)	0.017	0.158	0.070	0.300		0.350	0.017	
No. of congeners (of 30) > LOD	0	5	3	0				

AEROBIC SLUDGES **POLYCHLORINATED BIPHENYLS (PCBs)**

Local Body	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically
mg/kg dry Weight	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered
Lab No.	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1
% Dry Solids	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3
PCB-28 (Tri) + PCB-31 (Tri)	**0.0026**	<0.01	**0.010**	<0.0024	<0.0013	<0.01	**0.2**	<0.006	**0.02**
PCB-44 (Tetra)	**0.0016**	**0.01**	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-49 (Tetra)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-52 (Tetra)	**0.0023**	**0.02**	**0.009**	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-77 (Tetra)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-81 (Tetra)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-86 (Penta)	<0.0009	<0.01	<0.0017	**0.0024**	<0.0013	<0.01	<0.1	**0.008**	<0.02
PCB-101 (Penta)	**0.0033**	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	**0.012**	<0.02
PCB-105 (Penta)	<0.0009	**0.01**	<0.0017	**0.0035**	**0.002**	<0.01	<0.1	<0.006	<0.02
PCB-110 (Penta)	**0.0042**	**0.01**	<0.0017	<0.0024	<0.0013	<0.01	<0.1	**0.013**	<0.02
PCB-114 (Penta)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-118 (Penta)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-121 (Penta)	**0.0023**	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-123 (Penta)	**0.0014**	<0.01	<0.0017	<0.0024	**0.002**	<0.01	<0.1	<0.006	<0.02
PCB-126 (Penta)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-128 + PCB-167 (Hexa+Hexa)	<0.0009	<0.01	<0.0017	<0.0024	**0.002**	<0.01	**0.1**	<0.006	<0.02
PCB-138 (Hexa)	**0.0021**	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	**0.008**	<0.02
PCB-141 (Hexa)	<0.0009	<0.01	<0.0017	<0.0024	**0.0013**	<0.01	<0.1	<0.006	<0.02
PCB-149 (Hexa)	**0.0023**	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	**0.008**	<0.02
PCB-151 (Hexa)	<0.0009	<0.01	<0.0017	<0.0024	**0.0013**	<0.01	<0.1	<0.006	<0.02
PCB-153 (Hexa)	**0.0023**	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	**0.009**	<0.02
PCB-156 (Hexa)	<0.0009	<0.01	<0.0017	<0.0024	**0.0013**	<0.01	<0.1	<0.006	<0.02
PCB-157 + PCB-180 (Hexa+Hepta)	<0.0009	<0.01	<0.0017	<0.0024	**0.0013**	<0.01	<0.1	<0.006	<0.02
PCB-159 (Hexa)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-169 (Hexa)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-170 (Hepta)	<0.0009	<0.01	<0.0017	<0.0024	**0.0013**	<0.01	<0.1	<0.006	<0.02
PCB-189 (Hepta)	<0.0009	<0.01	<0.0017	<0.0024	**0.0013**	<0.01	<0.1	<0.006	<0.02
PCB-194 (Octa)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
PCB-206 (Nona)	<0.0009	<0.01	<0.0017	<0.0024	**0.0013**	<0.01	<0.1	<0.006	<0.02
PAB-209 (Deca)	<0.0009	<0.01	<0.0017	<0.0024	<0.0013	<0.01	<0.1	<0.006	<0.02
Total PCB (Sum of individual									
Congeners excluding LODs)	0.024	0.050	0.019	0.006	0.015	0.000	0.300	0.058	0.020
Total PCB (Sum of individual									
Congeners including half LODs)	0.033	0.180	0.043	0.040	0.024	0.150	1.700	0.130	0.310
No. of congeners (of 30) > LOD	10	4	2	2	10	0	2	6	1

AEROBIC SLUDGES **POLYCHLORINATED BIPHENYLS (PCBs)**

Local Body	Rodney	Rotorua	Rotorua	Thames Coro.	Western BOP				
	Warkworth	Waste		Thames	Te Puke				**Number**
mg/kg dry Weight	Air Dried Slg	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS				**(from 14)**
Lab No.	115840/2	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	14.9	4.2	29.6	0.9	1.4		29.6	0.9	
PCB-28 (Tri) + PCB-31 (Tri)	<0.006	**0.08**	**0.01**	**0.0089**	<0.06		0.2	<0.0013	7
PCB-44 (Tetra)	<0.006	<0.04	**0.007**	<0.0022	<0.06		0.01	<0.0013	3
PCB-49 (Tetra)	<0.006	<0.04	**0.005**	**0.044**	<0.06		0.005	<0.0009	2
PCB-52 (Tetra)	<0.006	**0.07**	<0.004	**0.0222**	<0.06		0.07	<0.0013	5
PCB-77 (Tetra)	<0.006	<0.04	<0.004	<0.0022	<0.06		-	<0.0009	0
PCB-81 (Tetra)	**0.006**	<0.04	<0.004	<0.0022	<0.06		0.006	<0.0009	1
PCB-86 (Penta)	<0.006	<0.04	**0.005**	**0.0078**	<0.06		0.008	<0.0009	4
PCB-101 (Penta)	<0.006	**0.08**	**0.008**	**0.0289**	<0.06		0.08	<0.0013	5
PCB-105 (Penta)	<0.006	<0.04	**0.005**	<0.0022	<0.06		0.01	<0.0009	4
PCB-110 (Penta)	<0.006	<0.04	**0.005**	**0.0200**	<0.06		0.02	<0.0013	5
PCB-114 (Penta)	<0.006	<0.04	<0.004	<0.0022	<0.06		-	<0.0009	0
PCB-118 (Penta)	<0.006	<0.04	**0.005**	**0.0144**	<0.06		0.0144	<0.0009	2
PCB-121 (Penta)	<0.006	<0.04	<0.004	**0.0222**	<0.06		0.0222	<0.0013	2
PCB-123 (Penta)	<0.006	<0.04	**0.011**	**0.0100**	<0.06		0.011	<0.0017	4
PCB-126 (Penta)	<0.006	<0.04	<0.004	<0.0022	<0.06		-	<0.0009	0
PCB-128 + PCB-167 (Hexa+Hexa)	<0.006	<0.04	**0.008**	<0.0022	<0.06		0.1	<0.0009	3
PCB-138 (Hexa)	<0.006	<0.04	**0.006**	**0.0267**	<0.06		0.0267	<0.0013	4
PCB-141 (Hexa)	<0.006	<0.04	<0.004	<0.0022	<0.06		0.0013	<0.0009	1
PCB-149 (Hexa)	<0.006	<0.04	**0.007**	**0.0156**	<0.06		0.0156	<0.0013	4
PCB-151 (Hexa)	<0.006	<0.04	<0.004	<0.0022	<0.06		0.0013	<0.0009	1
PCB-153 (Hexa)	<0.006	<0.04	**0.006**	**0.0200**	<0.06		0.02	<0.0013	1
PCB-156 (Hexa)	<0.006	<0.04	<0.004	<0.0022	<0.06		0.0013	<0.0009	1
PCB-157 + PCB-180 (Hexa+Hepta)	<0.006	<0.04	**0.005**	**0.0056**	<0.06		0.0056	<0.0009	3
PCB-159 (Hexa)	<0.006	<0.04	**0.005**	<0.0022	<0.06		0.005	<0.0009	1
PCB-169 (Hexa)	<0.006	<0.04	<0.004	<0.0022	<0.06		-	<0.0009	0
PCB-170 (Hepta)	<0.006	<0.04	<0.004	**0.0056**	<0.06		0.0056	<0.0009	2
PCB-189 (Hepta)	<0.006	<0.04	<0.004	<0.0022	<0.06		0.0013	<0.0009	1
PCB-194 (Octa)	<0.006	<0.04	<0.004	<0.0022	<0.06		-	<0.0009	0
PCB-206 (Nona)	<0.006	<0.04	**0.005**	<0.0022	<0.06		0.005	<0.0009	2
PAB-209 (Deca)	<0.006	<0.04	<0.004	<0.0022	<0.06		-	<0.0009	0
Total PCB (Sum of individual									
Congeners excluding LODs)	0.006	0.230	0.103	0.212	0.000		0.300	0.000	
Total PCB (Sum of individual									
Congeners including half LODs)	0.093	0.770	0.131	0.230	0.900		1.700	0.024	
No. of congeners (of 30) > LOD	1	3	16	14	0				

POND SEDIMENTS/COMPOST **POLYCHLORINATED BIPHENYLS (PCBs)**

Local Body	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry Weight	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No.	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
% Dry Solids	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
PCB-28 (Tri) + PCB-31 (Tri)	**0.025**	<0.0002	<0.0011	**0.0013**	**0.02**	<0.0044	<0.02	**0.0008**
PCB-44 (Tetra)	**0.007**	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-49 (Tetra)	**0.005**	**0.0035**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-52 (Tetra)	**0.014**	**0.0082**	<0.0011	<0.0002	<0.01	***0.0078**	<0.02	**0.0008**
PCB-77 (Tetra)	<0.003	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-81 (Tetra)	**0.008**	**0.0068**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-86 (Penta)	**0.01**	**0.0073**	<0.0011	**0.0004**	<0.01	<0.0044	<0.02	<0.0008
PCB-101 (Penta)	**0.033**	**0.0106**	<0.0011	<0.0002	**0.01**	<0.0044	<0.02	**0.0008**
PCB-105 (Penta)	**0.009**	**0.0047**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-110 (Penta)	**0.028**	**0.0127**	<0.0011	<0.0002	**0.01**	***0.0211**	<0.02	<0.0008
PCB-114 (Penta)	<0.003	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-118 (Penta)	**0.017**	**0.0083**	**0.0022**	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-121 (Penta)	<0.003	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-123 (Penta)	**0.021**	**0.009**	**0.0022**	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-126 (Penta)	<0.003	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-128 + PCB-167 (Hexa+Hexa)	**0.004**	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-138 (Hexa)	**0.041**	**0.0209**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-141 (Hexa)	**0.009**	**0.0083**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-149 (Hexa)	**0.034**	**0.0125**	**0.0022**	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-151 (Hexa)	**0.01**	**0.0032**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-153 (Hexa)	**0.045**	**0.0150**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-156 (Hexa)	**0.005**	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-157 + PCB-180 (Hexa+Hepta)	**0.029**	**0.0083**	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-159 (Hexa)	<0.003	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-169 (Hexa)	<0.003	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-170 (Hepta)	**0.017**	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-189 (Hepta)	<0.003	<0.0002	<0.0011	<0.0002	<0.01	<0.0044	<0.02	<0.0008
PCB-194 (Octa)	**0.007**	**0.0025**	<0.0022	<0.0004	<0.01	<0.0044	<0.02	<0.0008
PCB-206 (Nona)	**0.003**	**0.0008**	<0.0022	<0.0004	<0.01	<0.0044	<0.02	<0.0008
PAB-209 (Deca)	<0.003	<0.0004	<0.0022	<0.0004	<0.01	<0.0044	<0.02	<0.0008
Total PCB (Sum of individual								
Congeners excluding LODs)	0.381	0.135	0.007	0.002	0.040	0.000	0.000	0.002
Total PCB (Sum of individual								
Congeners including half LODs)	0.393	0.136	0.024	0.005	0.175	0.066	0.300	0.013
No. of congeners (of 30) > LOD	22	17	3	2	3	2	0	3

POND SEDIMENTS/COMPOST **POLYCHLORINATED BIPHENYLS (PCBs)**

Local Body	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua				
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley					**Number**
mg/kg dry Weight	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost				**(from 14)**
Lab No.	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**>LOD**
% Dry Solids	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	
PCB-28 (Tri) + PCB-31 (Tri)	<0.0011	**0.0020**	<0.01	<0.02		<0.002	<0.01		0.025	<0.0002	5
PCB-44 (Tetra)	<0.0011	<0.0010	<0.01	<0.02		**0.003**	<0.01		0.007	<0.0002	2
PCB-49 (Tetra)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.005	<0.0002	2
PCB-52 (Tetra)	<0.0011	**0.0010**	<0.01	<0.02		**0.009**	<0.01		0.014	<0.0002	6
PCB-77 (Tetra)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		-	<0.0002	0
PCB-81 (Tetra)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.008	<0.0002	2
PCB-86 (Penta)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.01	<0.0008	3
PCB-101 (Penta)	<0.0011	<0.0010	<0.01	<0.02		**0.005**	<0.01		0.033	<0.0002	5
PCB-105 (Penta)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.009	<0.0002	2
PCB-110 (Penta)	<0.0011	<0.0010	<0.01	<0.02		**0.003**	<0.01		0.028	<0.0002	5
PCB-114 (Penta)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		-	<0.0002	0
PCB-118 (Penta)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.017	<0.0002	3
PCB-121 (Penta)	**0.0011**	**0.0010**	<0.01	<0.02		**0.002**	<0.01		0.002	<0.0002	3
PCB-123 (Penta)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.021	<0.0002	3
PCB-126 (Penta)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		-	<0.0002	0
PCB-128 + PCB-167 (Hexa+Hexa)	<0.0011	<0.0010	<0.01	<0.02		**0.002**	<0.01		0.004	<0.0002	2
PCB-138 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		**0.008**	<0.01		0.041	<0.0002	3
PCB-141 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		**0.002**	<0.01		0.009	<0.0002	3
PCB-149 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		**0.005**	<0.01		0.034	<0.0002	4
PCB-151 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.01	<0.0002	2
PCB-153 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		**0.006**	<0.01		0.045	<0.0002	3
PCB-156 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.005	<0.0002	1
PCB-157 + PCB-180 (Hexa+Hepta)	<0.0011	<0.0010	<0.01	<0.02		**0.004**	<0.01		0.029	<0.0002	3
PCB-159 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		-	<0.0002	0
PCB-169 (Hexa)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		-	<0.0002	0
PCB-170 (Hepta)	<0.0011	<0.0010	<0.01	<0.02		**0.002**	<0.01		0.017	<0.0002	2
PCB-189 (Hepta)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		-	<0.0002	0
PCB-194 (Octa)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.007	<0.0002	2
PCB-206 (Nona)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		0.003	<0.0002	2
PAB-209 (Deca)	<0.0011	<0.0010	<0.01	<0.02		<0.002	<0.01		-	<0.0002	0
Total PCB (Sum of individual											
Congeners excluding LODs)	0.001	0.004	0.000	0.000		0.051	0.000		0.381	0.000	
Total PCB (Sum of individual											
Congeners including half LODs)	0.017	0.018	0.150	0.300		0.069	0.150		0.393	0.005	
No. of congeners (of 30) > LOD	1	3	0	0		12	0				

SECTION 15

DIOXINS (polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans)

ANALYTICAL METHODOLOGY

ESR Analytical Method for Dioxins

Six samples were tested by the ESR Wellington Science Centre using the isotope dilution method, performed in accordance with the Laboratory's scope of accreditation with IANZ.

The samples were spiked with isotopically labelled surrogate standards and extracted with organic solvent. The extracts were purified by chemical treatment and solid phase chromatographic techniques. Measurement was performed using high resolution gas chromatography with high resolution electron impact mass spectrometry.

Results are reported in picograms per gram (pg/g), equivalent to nanograms per kilogram (ng/kg), micrograms per tonne (µg/t) or ppt (w/w) (where t = trillion) on a dry weight basis. The sum of the polychlorinated dibenzo-p-dioxins (PCDDs) and the polychlorinated dibenzofurans (PCDFs) is calculated and reported both excluding limit of detection (LOD) values and including half the LOD values.

The total toxic equivalents (I-TEQs) were calculated for each sample using international toxic equivalency factors (I-TEFs). For non-detected congeners, half the LOD value was used in the ITEQ calculation. The total I-TEQ level is reported both excluding LOD values and including half the LOD values.

Limits of Detection

The Christchurch, Feilding, Rotorua and Mangere samples were tested as 'solid' samples and were reported in w/w units.

The Pleasant Point and Greytown samples were tested as 'liquid' samples and were reported in w/v units. They were then converted to w/w so they could be compared with the other samples.

The limits of detection (LOD) varied according to the amount of solid matter in each aliquot taken for analysis. LODs are apparent in the Tables.

Samples

Refer to Section 3 in Part A for a more detailed description of the samples.

Six samples were tested by ESR for both the dioxins and the PCBs. The PCB tests were performed principally as a quality control check on the samples tested by RJ Hill Laboratories Ltd.

All sludge samples were dispatched to RJ Hill Laboratories Ltd where they were stored at 4°C. The more solid samples were sub-sampled by taking several cores from various parts of the containers using a stainless steel corer. The more liquid samples were shaken before pouring off the sub-samples. The six sub-samples were sent to ESR in glass jars in chillibins containing ice packs. The sub-samples were prepared from (RJH sample numbers quoted):

- Christchurch City Council - a mixture of samples 115724/2 & 4, dewatered biosolids of 17 and 18 March
- Rotorua District Council - a mixture of samples 116021/3 & 4, dewatered biological sludge, and compost
- Watercare Services Ltd sample 116306/5, lime stabilised biosolids
- Manawatu District Council sample 115685/3, air dried biosolids
- South Wairarapa District Council sample 116452/2, ex Greytown pond sediments

- Timaru District Council sample 115887/2, ex pond sediments at Pleasant Point.

ANALYTICAL RESULTS

Individual polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) results are reported in picograms per gram (pg/g), equivalent to nanograms per kilogram (ng/kg), micrograms per tonne (μg/t) or ppt (w/w) (where t = trillion) on a dry weight basis. The sum of the PCDDs and PCDFs is calculated and reported both excluding limit of detection (LOD) values and including half the LOD values.

The three compounds in Table B 15.1 that appear in bold face have the highest factors that contribute to the I-TEQ, particularly the dioxin 2378 TCDD; 2378 TCDD is also a USEPA priority pollutant.

Table B 15.2 shows the individual congeners as a percentage of the total congeners.

The total toxic equivalents (I-TEQs) were calculated for each sample using international toxic equivalency factors (I-TEFs). For non-detected congeners, half the LOD value was used in the ITEQ calculation. The total I-TEQ level is reported both excluding LOD values and including half the LOD values. These also appear in Table B 15.1.

Discussion

An excellent source of information on dioxins is "Dioxins and Furans in Sewage Sludges", produced in 1996 by the Foundation for Water Research, commissioned by the Department of the Environment in the UK. The following information has been taken from that publication.

Dioxins are fairly widely distributed in the environment, albeit at rather low concentrations. Dioxins are not produced intentionally. There are 75 possible PCDDs and 135 possible PCDFs (see Table B 15.3). Compounds containing 0, 1, 2 or 3 chlorine atoms are thought to be of no toxicological significance and of those containing 4-8 chlorine atoms, those that are toxic have chlorine atoms at each of the positions 2, 3, 7 and 8. The most toxic congener is 2,3,7,8-TCDD. Once all four of these positions are occupied by chlorine atoms, the presence of additional chlorine atoms generally progressively reduces the toxicity of the congeners.

Table B 15.3: The dioxin/furan congeners

Abbreviation	**Name**	**Number of Possible**	
		Compounds	**2,3,7,8-substituted**
MCDD	monochloroDD	2	0
DCDD	dichloroDD	10	0
TrCDD	trichloroDD	14	0
TCDD	tetrachloroDD	22	1
PeCDD	pentachloroDD	14	1
HxCDD	hexachloroDD	10	3
HpCDD	heptachloroDD	2	1
OCDD	octachloroDD	1	1
MCDF	monochloroDF	4	0
DCDF	dichloroDF	16	0
TrCDF	trichloroDF	28	0
TCDF	tetrachloroDF	38	1
PeCDF	pentachloroDF	28	2
HxCDF	hexachloroDF	16	4
HpCDF	heptachloroDF	4	2
OCDF	octachloroDF	1	1

where DD is dibenzo-p-dioxin and DF is dibenzofuran

Dioxin sources include:

- chemical manufacturing (mainly PCP, 2,4,5-T and 2,4-D - note that production has either ceased or impurity levels are strictly controlled these days),
- incineration or burning of solid wastes (including sludge, medical and hazardous), fossil fuels in power plants, domestic wood and coal fires, motor vehicle exhausts, scrap metal reclamation, metal smelting, accidental fires,
- slow release from contaminated sites, dumps etc.

In the UK about 1990, the main dioxin production sources were considered to be municipal solid waste incineration (about 20%); manufacture and use of PCP (about 30%); domestic coal fires (about 13%).

Municipal solid waste is not incinerated in New Zealand. The use of PCP and 2,4,5-T is now strictly controlled or banned in New Zealand – see Organochlorine Pesticides Section.

Woodward-Clyde NZ Ltd, in a 16.5.96 report to Christchurch City Council, stated that a 1991 study of dioxin levels in paper products found TEQ values ranging from 0.6 - 16.8 pg/g for items such as paper plates, cups, filters, diapers and tissues. The study referred to was overseas. As pulp and paper manufacturing processes move away from using chlorine, these levels should fall. New Zealand's paper manufacturers no longer use elemental chlorine.

The price of dioxin testing is such that only six samples could be included in this survey. Results of another five samples (from Christchurch, New Plymouth and Wellington) have been made available and appear in Table 6.13 in Part A. These additional samples were collected over the past 2 years and were also analysed by ESR in Wellington.

None of the six sewage sludge samples tested in the present survey contained 2378 TCDD (the most toxic dioxin) above the samples' limit of detection. However, this congener was found at about 3 pg/g in New Plymouth sludge (Table 6.13); 2,4,5-T (a source of traces of 2378 TCDD) was manufactured in New Plymouth some years ago.

The two next most toxic congeners (23478 PeCDF and 12378 PeCDD) were found in the Greytown and Auckland samples in the 5-19 pg/g range. The Greytown sample was tested as a liquid (0.45% dry solids) so required a large multiplication factor in converting to pg/g units. Samples tested in other New Zealand surveys contained 1-4 pg/g of these two congeners.

The total toxic equivalents (I-TEQ) in this survey ranged from 3 to 106 pg/g (3 to 34 pg/g not including the Greytown result). Including half the limit of detection (LOD) values for the congeners reported being present at less than their LOD did not make a large difference. The median dioxin content found in the 6 samples tested in this project was 17.3 pg/g TEQ, and the median in the 5 samples in Table 6.13 was 6.6 pg/g (range 5.3 to 11.5 pg/g).

The total PCDD + PCDF congeners found in the present survey ranged from 1,850 to 31,900 pg/g, although five of the samples fell in the 1,850 to 5,810 pg/g range. Again, including half the limit of detection (LOD) values for the congeners reported being present at less than their LOD made little difference. The totals for samples reported in Table 6.13 were 1000-4000 pg/g.

Table B 15.2 shows the individual congeners as a percentage of the total congeners. This table shows that the tetra- and penta- congeners comprised a very small proportion of the total, in fact, less than 5% for all samples except the Rotorua and Auckland samples where they were about 8%. The hexa-congeners were also a small proportion of the total, in fact all were about 3% of the total except at Auckland where they comprised about 8%.

The hepta- congeners were present at higher proportions, mostly in the 11-18% range, except at Greytown where they comprised 25% of the total. Octa-chloro-dibenzofuran (OCDF) was fairly insignificant. The most prominent congener in all eleven New Zealand samples (ie including the samples in Table 6.13 in Part A) was OCDD (octa-chloro-dibenzo-p-dioxin), comprising 65-80% of the total congeners. Section 7.3 notes that globally, the octa and hepta congeners are almost always the commonest. All eleven New Zealand samples displayed a similar congener make-up.

The authors of the Eastern Canadian study (where 4 samples were tested from each of 6 towns) stated that dioxin levels were low, with TEQs ranging from 3 to 32 pg/g – (fairly similar to the range found in New Zealand samples). Their testing included a sludge that had produced a relatively high result in an earlier survey: 374 pg/g toxic equivalents (TEQ), although results from other samples from the same town were 6, 10 and 14. The high result was above the maximum permissible level of I-TEQ 150 pg/g suggested for use in Ontario agriculture by MD Webber and JA Nichols in "Organic and Metal Contaminants in Canadian Municipal Sludges and a Sludge Compost", Wastewater Technology Centre, 1995.

Compared with the toxic equivalents of dioxins reported in other overseas sewage sludges (refer Table 7.20 in Part A), New Zealand sludges seem to have significantly lower levels. The 11 New Zealand results ranged from 3-106 with a median of about 10 pg/g. Overseas sludges quite often seem to contain several hundred pg/g TEQ, with a median probably falling in the 50-100 pg/g range.

The median dioxin content in UK soils was found to be 2.3 pg/g TEQ in 65 rural soils and 23 pg/g TEQ in 19 urban soils. Table 7.20 shows that the median levels in UK sludges were 23 pg/g TEQ in rural sludges and 53 pg/g TEQ in sludges from industrial towns.

New Zealand sludges seem to have a similar make-up of congeners to overseas sludges.

Not many countries have introduced national standards or guidelines for the concentration of dioxins in order to control the reuse or disposal of sewage sludges - refer to Table 5.5 in Part A.

In July 1992 a limit of 100 ng/kg (pg/g) TEQ dry matter was established in Germany for PCDDs plus PCDFs (dioxins) in sludges used in agriculture, set in conjunction with a sludge application rate limit of 5 tonnes of sludge (dry weight) per hectare over a three year period.

A maximum permissible level of 150 pg/g I-TEQ (0.15 mg/kg) was suggested for use in Ontario agriculture by TE Webber and Nichols in "Organic and Metal Contaminants in Canadian Municipal Sludges and a Sludge Compost", Wastewater Technology Centre, 1995.

A 1998 resource consent for compost application (sewage sludge and greenwaste) in Wellington adopted a limit of 50 ng/kg (ng/kg = pg/g) TEQ for the PCDD/ PCDF dioxins (Condition 12 for Discharge Permit WGN 970210). This concentration was set in conjunction with a specific application rate.

It would appear that most New Zealand sludges would have little difficulty satisfying that limit at present, and with a gradual reduction in the industrial production of dioxins, they are unlikely to exceed the limit in the future.

POLYCHLORINATED DIBENZO-p-DIOXINS (PCCDs) and POLYCHLORINATED DIBENZOFURANS (PCDFs)

		Timaru	Christchurch	Sth. Wairarapa	manawatu	Rotorua	Watercare				
pg/g dry weight		Plrasant Pt.	Bromley 17+18/3	Greytown	Fielding	Mixed DAF	Mangere				
		Pond Sed.	Dewatered SLG.	Pond Sed.	Air Dried	& Compost	Lime Stable				
RJH Lab No		115887/1	115724/2&4	116452/2	115685/3	116021/3&4	116306/5		**MAX**	**MIN**	**MEDIAN**
ESR Lab No		980225/6	980225/1	980225/5	980225/4	980225/2	980225/3				
% Dry Solids – RJH		19.9	20.8/20.7	0.9	74.9	29.6/15.8	44.6				
% Dry Solids – ESR	TE factor	23.1	19.4	0.45	70.0	13.9	42.3				
2378 TCDF	0.1	<1	<3	10.5	<1	<4	<4		10.5	<1	-
Non 2378 TCDF	0	13.5	32.6	130	25.6	35.8	120		130	13.5	34.2
2378 TCDD	**1.0**	**<0.4**	**<2**	**<3**	**<2**	**<9**	**<2**		-	<0.4	**-**
Non 2378 TCDD	0	44.4	19.3	809	75.3	28.5	39.1		809	19.3	41.8
12378 PeCDF	0.05	<0.5	<2	<4	<0.9	<4	9.8		9.8	<0.5	-
23478 PeCDF	**0.5**	**<2**	**<4**	**10.7**	**<0.9**	**<4**	**18.7**		18.7	<0.9	**-**
Non 2378 PeCDF	0	12.3	46	188	27.1	53	213		213	12.3	49.5
12378 PeCDD	**0.5**	**<0.9**	**<3**	**6.2**	**<1**	**<6**	**5.0**		6.2	<0.9	-
Non 2378 PeCDD	0	28	30	352	17.9	22.6	86.7		352	17.9	29
123478 HxCDF	0.1	<1	<6	13.4	<2	<5	31.6		31.6	<1	-
123678 HxCDF	0.1	<2	<5	17.7	<2	<4	29.1		29.1	<2	-
234678 HxCDF	0.1	<2	<6	18.1	<3	<5	40		40	<2	-
123789 HxCDF	0.1	<0.4	<2	<6	<2	<9	<2		-	<0.4	-
Non 2378 HxCDF	0	30.7	75	304	24.8	63	219		304	24.8	69
123478 HxCDD	0.1	<2	<4	23.1	<1	<8	5.7		23.1	<1	-
123678 HxCDD	0.1	13	14.7	103	<5	13.6	13.5		103	<5	13.6
123789 HxCDD	0.1	8	10	40.7	<4	<7	10.8		40.7	<4	9.0
Non 2378 HxCDD	0	79	97	674	36.3	88.6	105		674	36.3	92.8
1234678 HpCDF	0.01	33.2	78.9	297	24.7	67.6	131		297	24.7	73.1
1234789 HpCDF	0.01	<3	<7	29.7	<2	<10	12.5		29.7	<2	-
Non 2378 HpCDF	0	34.4	73	287	17.7	52	50.3		287	17.7	21.5
1234678 HpCDD	0.01	6.7	387	5040	160	358	350		5040	6.7	354
Non 2378 HpCDD	0	306	344	2380	138	307	347		2380	138	325.5
OCDF	0.001	109	294	720	58.3	165	101		720	58.3	137
OCDD	0.001	2860	4340	20400	1230	3650	3870		20400	1230	3760
PCDD + PCDF congeners:											
Excluding LOD values		3580	5840	31900	1850	4900	5810		31900	1850	5355
Including half LOD values		3590	5860	31900	1850	4940	5810		31900	1850	5375
Total Toxic Equivalents:											
Excluding LOD values		5.47	11.8	106	3.14	9.43	34.3		106	3.14	10.6
Inclusing half LOD values		6.84	15.9	108	5.64	18.7	35.6		108	5.64	17.3

TABLE B15.1

DIOXIN CONGENERS AS A PERCENTAGE OF THE TOTAL CONGENERS

	Timaru	Christchurch	Sth. Wairarapa	manawatu	Rotorua	Watercare
	Plrasant Pt.	Bromley 17+18/3	Greytown	Fielding	Mixed DAF	Mangere
	Pond Sed.	Dewatered SLG.	Pond Sed.	Air Dried	& Compost	Lime Stable
RJH Lab No	115887/1	115724/2&4	116452/2	115685/3	116021/3&4	116306/5
ESR Lab No	980225/6	980225/1	980225/5	980225/4	980225/2	980225/3
2378 TCDF			0.03			
Non 2378 TCDF	0.38	0.56	0.41	1.38	0.73	2.07
2378 TCDD						
Non 2378 TCDD	1.24	0.33	2.54	4.07	0.58	0.67
12378 PeCDF						0.17
23478 PeCDF			**0.03**			**0.32**
Non 2378 PeCDF	0.34	0.79	0.59	1.46	1.08	3.67
12378 PeCDD			**0.02**			**0.09**
Non 2378 PeCDD	0.78	0.51	1.10	0.97	0.46	1.49
123478 HxCDF			0.04			0.54
123678 HxCDF			0.06			0.50
234678 HxCDF			0.06			0.69
123789 HxCDF						
Non 2378 HxCDF	0.86	1.28	0.95	1.34	1.29	3.77
123478 HxCDD			0.07			0.10
123678 HxCDD	0.36	0.25	0.32		0.28	0.23
123789 HxCDD	0.22	0.17	0.13			0.19
Non 2378 HxCDD	2.21	1.66	2.11	1.96	1.81	1.81
1234678 HpCDF	0.93	1.35	0.93	1.34	1.38	2.25
1234789 HpCDF			0.09			0.22
Non 2378 HpCDF	0.96	1.25	0.90	0.96	1.06	0.87
1234678 HpCDD	0.19	6.63	15.80	8.65	7.31	6.02
Non 2378 HpCDD	8.55	5.89	7.46	7.46	6.27	5.97
OCDF	3.04	5.03	2.26	3.15	3.37	1.74
OCDD	79.89	74.32	63.95	66.49	74.49	66.61

TABLE B15.2

SECTION 16
TENTATIVELY IDENTIFIED COMPOUNDS

ANALYTICAL METHODOLOGY

A large amount of additional information is generated in the course of performing the standard VOC and SVOC analytical procedures used for determining the concentrations of the organic chemicals discussed in previous sections. For the normal suites of analyses standards are run with the samples to confirm the retention time of each individual compound in the gas chromatographic analysis (GC) and to help calculate concentrations from the peak heights. The mass spectrometer (MS) acts as a second channel, confirming the identifications.

The output of the mass spectrometer is a series of spectral lines which are unique to individual chemicals. In a complex sample like sewage sludge there will be a great number of spectral lines for chemicals other than those in the 'standard suite'. A computer identifies these by referring to data that has accumulated over the years in various mass spectra library records. The library records have data for chemicals that are not often included in analytical suites such as used in this project, that is, mass spectra are obtained for many chemicals for which no standard was included. Hence their identification is not confirmed, ie they are only tentatively identified compounds (TICs).

The mass spectra obtained in this survey were examined and a list of chemicals or groups of chemicals have been reported as TICs. The compounds are not guaranteed to have been identified correctly and the reported concentrations are probably best considered to be semi-quantitative. However, the present information may be useful for comparative purposes when sludge samples are tested in the future, and for when standard analytical suites may be enlarged.

Refer to earlier sections for a description of the analytical techniques (VOC and SVOC) used.

ANALYTICAL RESULTS

Results for the commoner compounds of groups of compounds reported with the TICs appear in Tables B16.1 – B 16.4. Some individual compounds are referred to in the Discussion.

Alkanes are saturated hydrocarbons (single bonds between carbon atoms, eg octane) and alkenes are unsaturated hydrocarbons (at least one pair of carbon atoms joined by a double bond, eg but2-ene).

Alkyl benzenes are benzene based compounds that have an alkane group attached, eg ethylbenzene.

Alkylphenyl acids are benzene based compounds that have an alkyl acid group attached, eg phenylpropionic acid (benzenepropanoic acid).

Azulene compounds are often a combination of 7-ringed and 5-ringed bases, such as cyclopentacycloheptene.

Fatty acid esters are organic acids where the hydrogen ion has been replaced by an organic group, such as ethyl stearate, one of the many esters found in soaps.

Indole based compounds are common decomposition products of protein, produced by animals.

Limonene ($C_{10}H_{16}$) or dipentene is a terpene. It is found naturally in some essential oils of plants and is used as a perfume, a solvent, and in the manufacture of resins and surface active agents.

Terpenes are cyclic hydrocarbons that occur naturally in plants; they have the general formula $(C_5H_8)n$, eg pinene $C_{10}H_{16}$, a principal ingredient of turpentine. Although limonene is a terpene, it was reported separately.

Methanethiol or methyl mercaptan is a natural product and a product of biological degradation. It has a strong, distinctive and unpleasant odour – ethyl mercaptan is used to odourise natural gas. Methanethiol is an alkylthiol.

Siloxanes include the silicones which have a wide range of industrial uses.

Squalene is found in many animal and vegetable oils, and also has several industrial uses.

Steroids and sterols are lipid products that include bile acids, certain hormones, vitamin D and cholesterol, for example.

Naphthalene is the simplest polyaromatic hydrocarbon (PAH). It is a 2-ring system which can react with other groups to form a variety of substituted naphthalenes; two appear in the PAH tables.

Substituted phenols are phenols where a hydrogen atom associated with carbon atoms 2-6 has been replaced by another group or substance, such as the nitro-, chloro- and methyl-phenols. Tannins and lignins are not included.

Organic sulphides are mainly sulphur containing amino acids, and other natural products such as some chemicals found in the onion family. Hydrogen sulphide and other inorganic sulphides are not included, but sulphur is.

Discussion

The median values of the TICs in the four types of sludge appear in Table B 16.5. A dash in the table indicates not detected at high enough concentration to warrant reporting.

Table B 16.5 generally indicates that these TICs are broken down in the treatment process.

A few other compounds were also detected, on occasions, at concentrations high enough to warrant comment.

Eucalyptol, from 1-13 mg/kg, was found in three sludges: Rotorua compost, Featherston pond and Beachlands/Maraetai lagoon. Eucalyptol is the main constituent of oil of eucalyptus, which has pharmaceutical uses. Camphor, which also has pharmaceutical uses, as well as several industrial uses, was also found in the Featherston pond sediments.

Total alcohols, in three samples, ranged from 2-470 mg/kg; they were found in the Dunedin dewatered sludge, Alexandra activated sludge sample and the Invercargill woolscour waste.

Isocyanates were detected in three samples, from 4-120 mg/kg. They were found in sludges from North Shore and Invercargill digesters, and Alexandra activated sludge. Isocyanates have many industrial uses including in the production of insulation materials.

Benzenamines (aniline based compounds) were found in three sludges: Bromley dewatered, Levin digested and Levin airdried. Concentrations were 40-110 mg/kg. Benzenamines are common components of dyestuffs. There are several dyers in Levin.

Alkyl thiols have the general formula R-SH where the sulphur atom is attached to the carbon atom – the sulphur analogues of alcohols. They include the mercaptans. As well as the mecaptans which were identified separately, alkyl thiols were found in Warkworth airdried activated sludge and Tahuna dewatered raw sludge. Concentrations were 80-330 mg/kg.

Polyaromatic hydrocarbons other than those reported in Section 8 of Part B were found in Bromley dried biosolids and the Hutt milliscreenings, at 10-60 mg/kg.

The aerobic sludges from New Plymouth and the Paraparaumu sludge lagoon contained measurable amounts of vitamin E (20-50 mg/kg). Also known as a-tocopherol, it occurs in vegetable leaves, seeds such as corn and sunflower, and in wheat germ. It can be used as an antioxidant in vegetable oils, and medicinally.

TIC, mg/kg	**Raw Sludge**	**Anaerobic**	**Aerobic**	**Sediments**
aldehydes/ketones	4	-	23	-
alkanes/alkenes	55	25	25	14
alkyl benzenes	8.0	6.9	45	14
alkylphenyl acids	223	257	122	-
azulene based	-	-	-	3.8
fatty acid esters	463	16	120	11
indole based	66	39	120	-
limonene	41	14	-	-
methanethiol	11	-	75	-
siloxanes	0.9	0.7	3.3	1.5
squalene	74	30	159	-
steroids	650	1575	87	215
subst naphthalenes	4.6	7.4	13	3.4
subst phenols	-	155	-	20
sulphides (organic)	18	5	28	16
terpenes *	3.6	-	-	1.1

Table B 16.5: Median values of tentatively identified compounds
* not including limonene

RAW SLUDGES **TENTATIVELY IDENTIFIED COMPOUNDS**

Local Body:	Carterton	Christchurch	Christchurch	Dunedin	Dunedin	Dunedin	Horowhenua	Hutt	Hutt	Invercargill	Invercargill
		Bromley	Templeton	Tahuna	Tahuna	Tahuna	Levin	Wainuiomata	Seaview		
mg/kg dry wt	Raw Slg	Raw Slg	lmhoff Tank Slg	Raw Slg	Scum	Dewatered Slg	Raw Slg	Raw Slg	Milliscreens	Raw Slg	Wool Scour
Lab No:	116205/3	116062/5	116062/4	115884/5	115884/4	115884/3	115892/5	116891/1	116891/4	116836/1	116836/2
%DS	4.0	6.4	3.4	5.9	5.7	29	1.6	7.0	24.5	3.7	9.8
aldehydes and ketones									2.2		4
alkanes and alkenes				4.6	2510	500	104	13	6.6	116	450
alkyl benzenes			0.9	2.1	10	5.8	8.2	4.6	10	44	
alkylphenyl acids	275	10				55	1090			135	826
azulene based compounds		295									
fatty acid esters	2400			19700	29400	1600	500	630	40	144	
indole based compounds	48	500	150			54	80			135	
Li3540monene				1.0	130	4.9	70	13	120		
methanethiol	2170			25		2.2	7.2				
siloxanes									1.5		0.8
Squalen18e	55					92					
steroids	540	329	650		350	676	3800	860	340	3540	1360
substituted naphthalenes	670	2.0	0.3	2.1							
substituted phenols											0.3
sulphides (organic)		10		19		17	12			18	
terpenes (noy limonene)		6.4							2.6		

RAW SLUDGES **TENTATIVELY IDENTIFIED COMPOUNDS**

Local Body:	Manawatu	North Shore	Rodney: Army	Rotorua	Watercare					
	Fielding	Rosedale	Bay – Mech.		Mangere					
mg/kg dry wt	Raw Slg	Raw Slg	Dewatered Raw	Primary Slg	Raw Slg					
Lab No:	115685/4	115900/1	115840/1	116021/1	116306/1		**MAX.**	**MIN.**	**>LOD**	**Number**
%DS	2.7	3.0	18.1	3.1	4.0		29	1.6	5	16
aldehydes and ketones			308				308	2	4	3
alkanes and alkenes	55	121	40		4.3		2510	0.9	55	13
alkyl benzenes		8.0		7.4	2.0		44	2	8	11
alkylphenyl acids		333	82	100	170		1090	55	223	10
azulene based compounds							-	-	-	0
fatty acid esters	250	370	530	145	425		29400	40	500	15
indole based compounds			77		38		135	38	66	6
limonene		91			2.0		130	1	41	8
methanethiol					11		2170	2.2	11	5
siloxanes			1.0		0.3		1.5	0.3	0.9	4
squalene			140		48		140	48	74	4
steroids	122	167	1040	100	648		3800	100	648	15
substituted naphthalenes		7.0		9.4			670	0.3	4.6	6
substituted phenols							0.3	-	-	1
sulphides (organic)		23	28	13	34		34	10	18	9
terpenes (noy limonene)			2.4	4.5			6.4	2.4	3.6	4

ANAERUBIC SLUDGES **TENTATIVELY IDENTIFIED COMPOUNDS**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Christchurch	Horowhenua	Horowhenua	Horowhenua	Hutt	Hutt
	Bromley	Bromley	Bromley 17/3	Bromley 18/3	Bromley	Levin	Levin	Levin	Wainuiomata	Wainuiomata
mg/kg dry wt	Digester Slg	Slg Lagoon	Dewatered Slg	Dewatered Slg	Dried Biosolids	Digester Slg	Slg Lagoon	Air Dried ex Beds	Digester Slg	Air Dried Slg
Lab No:	116062/3	115724/5	115724/2	115724/4	115724/3	115892/2	115892/3	115892/4	116891/2	116891/3
%DS	1.7	3.9	20.8	20.7	93.9	1.7	8.8	14.8	4.0	30.9
aldehydes and ketones										
alkanes and alkenes	1000	86	95	75	0.1	25	215	120	21	1.4
alkyl benzenes	86	6.1	100	90		2.4	41	2.4	1.5	
alkylphenyl acids	59					370			50	
azulene based compounds										
fatty acid esters	320					82	1.1	8		
indole based compounds						5.9				
limonene	25					13.5	17	13		
methanethiol										
siloxanes				5.4	0.1			4.7		0.7
squalene										
steroids	470	2360	2330	2585	6	520	4600	2140	210	1690
substituted naphthalenes	21			7.4		1.2		8.0		
substituted phenols		99	19	240						
sulphides (organic)						4.1				
terpenes (noy limonene)	9									

ANAEROBIC SLUDGES TENTATIVELY IDENTIFIED COMPOUNDS

Local Body:	Invercargill	Invercargill	Manawatu	Manawatu	North Shore	North Shore	Sth. Waikato	Sth. Waikato	Watercare	Watercare
			Fielding	Fielding	Rosedale	Rosedale	Tokoroa	Tokoroa	Mangere	Mangere
mg/kg dry wt	Digester Slg	Lagoon, Air Dried	Digester Slg	Air Dried Slg	Digester Slg	Mech. Dewatered	Nth. Lagoon	Sth. Lagoon	Dewatered Slg	Dewatered Slg
Lab No:	116836/3	116836/4	115685/2	115685/3	115900/2	115900/4	116224/2	116224/1	116306/2	116306/4
%DS	4.1	34.8	1.5	74.9	1.7	20.1	23.6	13.7	0.9	33.8
aldehydes and ketones				121						
alkanes and alkenes	20	40	53	52	33	14	10	23	24	13
alkyl benzenes	2.4	6.9			15	2.0	26	4.8	19	14
alkylphenyl acids	830					624			144	
azulene based compounds										
fatty acid esters			233	14	18	2.2				
indole based compounds	73									
limonene	13									
methanethiol										
siloxanes										
squalene		38							22	
steroids	4320	10250	87	295	880	2170	773	1860	600	1460
substituted naphthalenes					1.2					
substituted phenols	560	1080							22	47
sulphides (organic)			0.1	1.0	33	76			82	3
terpenes (noy limonene)										

ANAEROBIC SLUDGES — TENTATIVELY IDENTIFIED COMPOUNDS

Local Body:	Watercare	Watercare					
	Mangere	Mangere					
mg/kg dry wt	Lime stabilised	Air Dried Slg					
Lab No:	116306/5	116306/6		**MAX.**	**MIN.**	**MEDIAN**	**Number**
%DS	44.6	43.3		93.9	0.9	17.5	22
aldehydes and ketones				121	-	-	1
alkanes and alkenes	19	4.8		1000	0.1	25	22
alkyl benzenes	1.9			100	1.5	6.9	17
alkylphenyl acids				830	50	257	6
azulene based compounds		0.6		0.6	-	-	1
fatty acid esters				320	1.1	16	8
indole based compounds				73	5.9	39	2
limonene				25	12.7	14	5
methanethiol				-	-	-	0
siloxanes		0.6		5.4	0.1	0.7	5
squalene				38	22	30	2
steroids	2070	390		10250	6.0	1575	22
substituted naphthalenes				21	1.2	7.4	5
substituted phenols	211			1080	19	155	8
sulphides (organic)	5			82	0.1	4.6	8
terpenes (noy limonene)				9.0	-	-	1

AEROBIC SLUDGES **TENTATIVELY IDENTIFIED COMPOUNDS**

Local Body:	Carterton	Carterton	Christchurch	Central Otago	Kapiti Coast	Kapiti Coast	Kapiti Coast	New Plymouth	Porirua	Rodney
			Bromley	Alexandra	Otaki	Paraparaumu	Paraparaumu	New Plymouth	Mechanically	Warkworth
mg/kg dry wt	Digesters 1/2	Digesters 3/4	Secondary Slg	Biologival Slg	Clarifier Slg	Slg Lagoon	Slg ex BNR/DAF	Dewatered Slg	Dewatered	Air Dried Slg
Lab No:	116205/1	116205/2	116062/1	116279/1	115949/1	115949/3	115949/4	116307/2	116149/1	115840/2
%DS	4.3	8.0	2.3	1.7	1.5	11.1	3.8	13.5	11.3	14.9
aldehydes and ketones				1.2						
alkanes and alkenes	80	215		28		25	5.4	48		55
alkyl benzenes	57	5		80	32					2.7
alkylphenyl acids			43		745			114		
azulene based compounds										
fatty acid esters			23	28	33		700	155	80	52
indole based compounds			174		33	37	200	33		
limonene										
methanethiol					147					
siloxanes										3.3
squalene		250								
steroids	140	4060	87	2	20	906	49		8	33
substituted naphthalenes	50	13						7.8		
substituted phenols										
sulphides (organic)					225		18			
terpenes (noy limonene)										

AEROBIC SLUDGES **TENTATIVELY IDENTIFIED COMPOUNDS**

Local Body:	Rotorua	Rotorua	Thames Coro.	Western BOP					
	Waste		Thames	Te Puke					
mg/kg dry wt	Activated Slg	Dewatered Mixed	Aer. Lagoon	WAS					
Lab No:	116021/5	116021/3	116736/1	115739/1		**MAX.**	**MIN.**	**MEDIAN**	**Number**
%DS	4.2	29.6	0.9	1.4		29.6	0.9	4.3	14
aldehydes and ketones			44			44	1.2	23	2
alkanes and alkenes	9.8	2.4	18	11		215	2.4	25	11
alkyl benzenes			63			80	2.7	45	6
alkylphenyl acids	122	920				920	43	122	5
azulene based compounds						-	-	-	0
fatty acid esters	850	600	410	120		850	23	120	11
indole based compounds	240			120		240	33	120	7
limonene		1.9				1.9	-	-	1
methanethiol		3.4				147	3.4	75	2
siloxanes		0.5	11			11	0.5	3.3	3
squalene	68					250	68	159	2
steroids	64	380	3110	1060		4060	2.0	87	13
substituted naphthalenes						50	7.8	13	3
substituted phenols			340			340	-	-	1
sulphides (organic)	6.3	28		229		229	6.3	28	5
terpenes (noy limonene)		0.5				0.5	-	-	1

POND SEDIMENTS/COMPOST **TENTATIVELY IDENTIFIED COMPOUNDS**

Local Body:	Christchurch	Christchurch	Christchurch	Christchurch	Manukau	N. Plymouth	North Shore	S. Wairarapa
	Bromley	Bromley	Belfast	Templeton	Beachlands-Maraetai	Inglewood	Rosedale	Featherston
mg/kg dry wt	Pond Sed, Entry	Pond Sed (far end)	Pond Sediment	Pond Sediment	Sed ex Lagoon 3	Pond Sediment	Pond Sed	Pond Sediment
Lab No:	116211/2	116211/1	116211/3	116211/4	116187/1	116307/1	115900/5	116452/1
%DS	25.9	2.4	0.9	4.6	7.2	1.8	1.5	1.3
aldehydes and ketones								
alkanes and alkenes	9	55	3.3	0.2	26	190		0.8
alkyl benzenes		14			1.2			
alkylphenyl acids				2.2				
azulene based compounds								
fatty acid esters							58	
indole based compounds								
limonene					10			
methanethiol								
siloxanes	1.3	20	2.2	0.2	1.5		1.5	
squalene	4							
steroids	720	220	1980	11	114	780	44	20
substituted naphthalenes		5.4	1.1			26		
substituted phenols	20	54						
sulphides (organic)	9							
terpenes (noy limonene)					28			0.8

POND SEDIMENTS/COMPOST **TENTATIVELY IDENTIFIED COMPOUNDS**

Local Body:	S. Wairarapa	S. Wairarapa	Timaru	Watercare		Christchurch	Rotorua					
	Greytown	Martinborough	Pleasant Point	Mangere		Bromley						
mg/kg dry wt	Pond Sediment	Pond Sediment	Pond Sed	Pond Sed		Compost	Compost					
Lab No:	116452/2	116452/3	115887/2	116306/3		115724/1	116021/4		**MAX.**	**MIN.**	**MEDIAN**	**Number**
%DS	0.9	1.0	19.9	8.3		50.0	15.8		50	0.9	3.5	14
aldehydes and ketones			258						258	-	-	1
alkanes and alkenes	7	20	170	19		0.5			190	0.2	14	12
alkyl benzenes		10	20	21					21	1.2	14	5
alkylphenyl acids									2.2	-	-	1
azulene based compounds				6.8		0.7			6.8	0.7	3.8	2
fatty acid esters	11	10	37			0.6	1.8		58	0.6	11	6
indole based compounds									-	-	-	0
limonene									9.9	-	-	1
methanethiol									-	-	-	0
siloxanes			24			0.1			24	0.1	1.5	8
squalene									4.0	-	-	1
steroids	380	210	1350	340		63	61		1980	11	215	14
substituted naphthalenes				1.3					26	1.1	3.4	4
substituted phenols				17					54	17	20	3
sulphides (organic)			16	71					71	9	16	3
terpenes (noy limonene)	1.1								28	0.8	1.1	3