

Cadmium in Taranaki soils

An assessment of cadmium accumulation in Taranaki soils
from the application of superphosphate fertiliser
2005

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Executive summary

The purpose of the report is to assess the extent of cadmium accumulation in Taranaki soils. The report aims to determine if cadmium accumulation is an issue in Taranaki and what measures if any need to be put in place to mitigate cadmium accumulation.

Cadmium is a trace contaminant that is present in phosphate rock at varying levels (depending on the source of the rock).

The application of superphosphate-based fertiliser to soil leads to the accumulation of cadmium.

Cadmium accumulates in agricultural soils because it is not mobile.

Cadmium in the New Zealand environment has received increasing attention over the past 40 years because of the possibility it may enter the food chain via agricultural products. The growth of urban expansion in New Zealand has brought about a fresh concern with regards to cadmium accumulation in New Zealand soils, because of the possibility of uptake by children in direct contact with soil.

The Taranaki Regional Council has from time to time investigated levels of cadmium in soil (in 1996 & 1998-2001). These studies have found no cause for concern.

A national survey on agriculture topsoils and pastures was undertaken over the 1998 – 2000 period. Cadmium balance estimates at that time indicated that it would take between 790 and 1000 years to reach the investigation levels on sheep/beef soils and between 170 and 360 years on dairy soils in Taranaki to reach the then current investigation levels.

However, fresh speculation over the rate at which cadmium might accumulate, together with a recent change in the guideline to a much more stringent concentration, meant that it was appropriate to re-appraise the situation in Taranaki. This re-appraisal is represented here.

The report has been developed from a template provided for use generally throughout New Zealand. The template outlines a framework to be used on a region specific basis for assessing cadmium.

The average concentration of cadmium in soil in Taranaki is less than half the current 1.0 mg Cd/kg soil limit.

Using a basic approach to predicting cadmium accumulation the calculated rate of cadmium accumulation for Taranaki soils is currently 0.002 mg Cd/kg soil/year. At this rate of increase it will be 265 years before the average concentration of cadmium in soil in Taranaki exceeds the current 1.0 mg Cd/kg soil limit.

Internationally and in New Zealand, the health and scientific communities are conscious of cadmium as a potential health issue. In New Zealand the fertiliser industry has put a voluntary management plan in place whilst the food authorities continue to monitor the situation.

The cadmium levels in Taranaki soils are not considered a major environmental problem, nor are they at a level that might affect the region's health via the food chain. There is no justification for a regulatory intervention at this time.

This report has been peer-reviewed by soil scientists of Landcare Research, and its findings and conclusions supported in that review.

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1 Introduction

1.1 Purpose

The purpose of the report is to assess the extent of cadmium accumulation in Taranaki soils. The report aims to determine if cadmium accumulation is an issue in Taranaki soils and what measures if any need to be put in place to mitigate cadmium accumulation.

The report has been developed from a template adopted for investigative purposes. The template outlines a framework to be used on a regional basis for assessing cadmium.

1.2 Structure

The report is divided into five sections.

Section 1 introduces the report and provides background information in relation to the report.

Section 2 follows a framework designed to assess cadmium accumulation in Taranaki.

Section 3 discusses the issues encountered when using this framework.

Section 4 provides recommendations to reduce the accumulation of cadmium in Taranaki soils.

Section 5 summarises the findings of the report.

1.3 Background

1.3.1 Cadmium and agricultural soils

Cadmium is a naturally occurring heavy metal that at elevated levels can be toxic to animals and humans. It is naturally present in soil. There are four main sources of cadmium in agricultural soils. One source is geologic cadmium occurring from parent rock (Adriano 1986; Cook and Freney 1988). The other three sources are anthropogenic and are the result of: phosphate fertiliser application; atmospheric deposition arising from industry operations; and sewage sludge and industrial waste application to agricultural lands. These three anthropogenic sources are the major contributors to the burden of cadmium and its accumulation in agricultural soils internationally (Loganathan et al. 2003).

In New Zealand phosphate fertilisers derived from phosphate rock are the major source of cadmium accumulation (Roberts et al. 2002). Numerous studies have been carried out over the years and all attribute cadmium accumulation in New Zealand soils to the use of phosphate fertiliser (Williams and David 1973; Rothbaum et al. 1986; Bramley 1990; McIntosh et al. 1997; Sparling *et al.* 2001; & Loganathan *et al.* 2003). The application of phosphate fertiliser will form the focus of this report.

1.3.2 Cadmium in New Zealand

Over the last 40 years serious consideration has been given to cadmium as a food contaminant in New Zealand (Roberts et al. 1994). Cadmium in New Zealand pastoral soils became an issue during the 1980s to 1990s, due to reports of cadmium accumulation in offal products of grazing animals¹.

In 1994 fertiliser companies in New Zealand agreed on a timetable for reducing the cadmium content in fertiliser to mitigate cadmium accumulation. The companies have complied with this timetable and currently the cadmium content in fertiliser made in New Zealand is not greater than 280 mg/kg phosphorus. Prior to the voluntary agreement, the average cadmium content was taken as 420 mg/kg phosphorus.

The health and scientific communities are conscious of cadmium as a potential health issue, and a sound management plan is in place. In 1992 the Department of Health published a guideline document that recommended an upper limit for soil cadmium of 3 mg/kg. The recommended upper limit for total cadmium in New Zealand agricultural soils is now 1 mg/kg (New Zealand Water and Wastes Association, 2003). The limit above which agricultural soils are considered contaminated is 1.4 mg/kg (New Zealand Water and Wastes Association, 2003).

The soil limit of 1 mg/kg has been derived by the New Zealand Water and Wastes Association. The Association notes that:

The Ministries of Environment, Health, and Agriculture and Forestry were represented on the Steering Committee overseeing the development of the Guidelines, but the Guidelines are not published by these Ministries and are not government policy. However, the Ministries consider that the Guidelines improve and expand on the best practice set out in existing guidelines and, in supporting a nationally consistent approach to biosolids management, see value in their adoption and use in New Zealand (New Zealand Water and Wastes Association, 2003).

The soil limit of 1 mg/kg is a guideline set primarily to minimise cadmium concentrations in animal and crop products and to avoid barriers to international trade; it is a guideline that once reached should signal the need for an investigation to take place, to determine the cause and to recommend initiatives to reduce the level of cadmium (NZWWA, 2003). That is, it is a general precautionary guideline. Exceedance of this guideline, even if widespread, does not mean that there is a direct threat to human health or that all or any produce is unfit for consumption.

For comparative purposes, it can be noted the Canadian Soil Quality Guidelines for cadmium (1999) are 1.4 mg/kg for agricultural soil and 10 mg/kg for residential soils; the Australian National Environmental Protection Measure (1999) for cadmium is 20 mg/kg for residential and educational areas; the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines (1992) note that background levels in Australia and New Zealand are 0.04 - 2 mg/kg and the

¹ During 1988-1992, 1 in every 5 sheep and cattle kidneys tested in New Zealand had a cadmium concentration above the maximum permissible concentration of 1 mg/kg fresh weight, a value set by the New Zealand Ministry of Health (1984).

investigation level is 3 mg/kg. The Dutch action level (1994) is 12 mg/kg. The tolerated levels of cadmium in both agriculture and residential soils in New Zealand are as low as or lower than those of many member countries in the European Union and the United States.

1.3.3 Fertiliser use in New Zealand

New Zealand soils in their natural state are not nutrient rich and require fertiliser to sustain economic crop and stock carrying yields. Traditionally, fertiliser application has been in the form of single superphosphate.

Very heavy dressings of superphosphate were typically used when breaking in bush and establishing pasture.

During the 1960's -1970's, the subsidisation of fertiliser in New Zealand led to its liberal application with run-offs and other polluting effects, such as cadmium accumulation. In the early 1980's the subsidies were dropped and fertiliser sales fell dramatically from the artificially high level of 2.5 million tonnes in 1979, to the low of 1.2 million tonnes in the late eighties. Fertiliser sales during this period largely consisted of lime and superphosphate fertilisers. Since then, consumption has recovered to the more market driven level of 2.1 million tonnes where it is today. Fertiliser sales now consist of nitrogenous and phosphatic fertilisers.

Along with the levels applied, the type of fertiliser applied has also altered over the years, due to a change in farm management practices, and an increase in fertiliser alternatives and options. As a result, the annual application of phosphatic fertiliser for 2004 was only 260,200 tonnes (Agriculture Production Statistics, 2004), or only 10% of the usage twenty-five years ago.

1.3.3.1 Cadmium and phosphate fertiliser

Cadmium occurs naturally in phosphate fertiliser rock. In the past, the main source of phosphate for New Zealand fertilisers had been predominantly sourced from locations² which had a high natural cadmium content.

In more recent times, the cadmium level of New Zealand fertilisers have been reduced by blending rocks with lower cadmium content; due at large, to the voluntary limit on cadmium and the depletion of fertiliser rock from locations with a high cadmium content.

1.3.3.2 Phosphatic fertiliser use in Taranaki

Fertiliser use in Taranaki has been dominated by phosphate fertiliser (Roberts *et al*, 1998; Statistics New Zealand 2004). This is due to two factors, namely the volcanic soils of the region and the dominance of dairying farming in the region.

The volcanic soils of the region are deficient in phosphate and require the application of phosphate fertiliser to enhance pasture growth, whilst the phosphate fertiliser requirements are higher for dairying (Roberts *et al*. 1993) than for other types of farming (i.e. sheep and beef) on equivalent soils (Morton *et al*. 1994).

²Fertiliser rock has predominately been sourced from Nauru Island in the past.

Data on phosphatic fertiliser application in Taranaki for this report has been obtained from the Department of Statistics. The data is incomplete, and the following limitations must be noted:

- Environment Waikato advises that superphosphate fertiliser has been applied in New Zealand for 60-65 years. The Council has been provided with one figure for 1957 (50 years ago) and then a more complete data set from 1961 onwards. For the sake of calculating total historical cadmium loadings in Taranaki, 1957 has been taken as the starting point, and the 1957 figure has been used for the 1958-1960 years. By making no provision for the period prior to 1957, this will underestimate the quantity of cadmium historically applied in the region. As noted earlier, very heavy dressings were typically used to establish new pasture, with subsequent lesser dressings used for maintenance purposes.
- Data is missing for the years 1997-2001. There is no regional data yet available for 2003 and 2004. The data for 2002 shows a dramatic decline in the use of superphosphate by this year. For the sake of calculating pasture loadings, the average for the 1961-1996 period has been applied to 1997, and then the 2002 figure used for the period 1998-2004. This is likely to under-represent the actual loadings for this period.
- The historical application rate per hectare has been calculated based on the extent of pasture used for dairy farming in Taranaki in 1994, of 186,193 hectares. The area has declined more recently, to about 161,500 hectares.
- Some hill country pasture (not included in the dairy pasture figure, because it is used for beef and sheep pasture) has also had superphosphate applied e.g. by air. Analysis of the data for the period 1981-1986, which includes a separate category for aerial topdressing, shows that the total amount applied by air was about 6% of the total use of phosphatic fertiliser. This would have included some application to dairy pasture. Therefore it is considered that calculations of past application rates based on the area used for dairy pasture may over-estimate the loading rate by up to 6% (the maximum quantity of superphosphate that may in fact not have been applied to dairy pasture).
- The average cadmium concentration of phosphatic fertiliser is given by A.H.C Roberts for the period prior to 1997 as 420 mg Cd per kg P applied (Roberts *et al.* 1998). This is somewhat but not hugely (i.e. 50%) above the level for the years following the adoption of the voluntary limit, of 280 mg Cd per kg P or 25 mg Cd per kg fertiliser. The cadmium level in earlier years might be different from 420 mg Cd/kg P.

Taking the above approximations into account, 200 tonnes of cadmium have been applied to Taranaki soils (to a total area of somewhere between 186,000 hectares as used for dairying in 1994, and 385,011 hectares, the total land area used for dairying and beef/sheep), from 1957 to 2004.

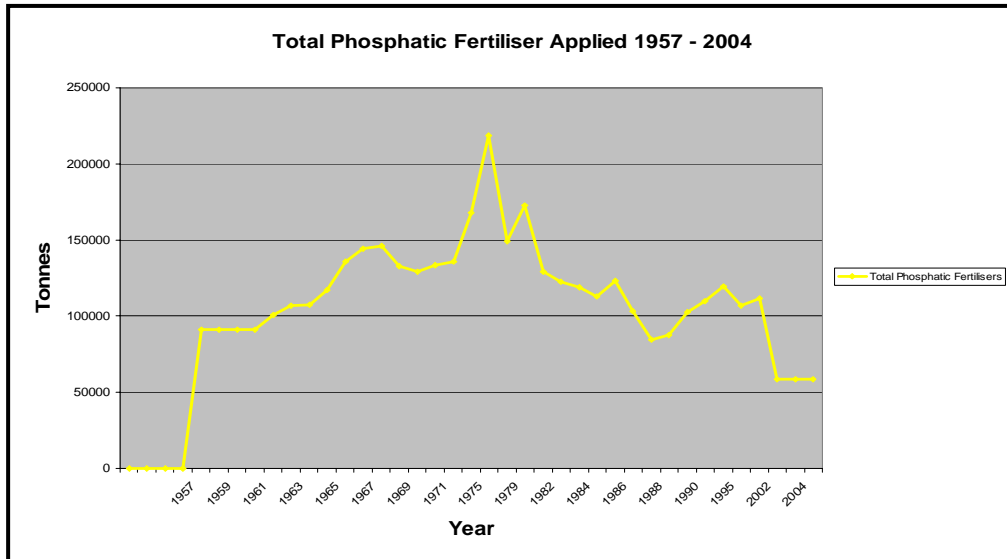


Figure 1 Total phosphatic fertiliser applied 1957 - 2004

From 1957 – 1997, the average annual application of phosphate based fertiliser was 121,759 tonnes; by 2002 (taken as representing the period from 1997) the annual application had fallen to 58,564 tonnes, a decline of 51.9%. As illustrated by **Figure 1**, the application of phosphatic fertiliser in Taranaki has been in gradual decline since the mid 1970s.

1.3.4 New Zealand management practices

The cadmium issue in New Zealand is now being managed through four main mechanisms:

- The Fertiliser Manufacturers³ voluntary cadmium limit;
- The maximum permitted concentration for cadmium in any food for human consumption imposed by the Food Standards Australia New Zealand (FSANZ);
- The Ministry of Health in association with its international equivalents has set guidelines covering cadmium content in foodstuffs and conducts regular research in relation to dietary intake; and

³ Ballance Agri-Nutrients and Ravensdown Fertiliser Co-operative belong to the Fertiliser Manufacturers Association and have voluntarily reduced the content of cadmium in their fertiliser. Between them they market more than 90% of the fertiliser sold in New Zealand and represent approximately 45,000 farmer shareholders (Furness, 2001).

- The nutrient budget that is part of the Dairying and Clean Stream Accord supported and monitored by Fonterra; that promotes the effective management of fertiliser application to mitigate any polluting effects.

All four mechanisms have been implemented nationally to reduce cadmium in New Zealand soils at a practicable and an achievable level.

In addition, a Cadmium Working Group is currently being formed in New Zealand. The Group is supported by the Chief Executives of Environment Waikato, ECAN, Meat and Wool New Zealand, Fonterra, Dairy Insight, New Zealand Manufactures Research Association, Ministry for the Environment, VegFed, Meat Industry Association, and the Arable Food Industry. The terms of reference for this group are contained in **Appendix I** of the report.

Invitations for membership have been extended to the organisations listed above. The Group will focus on the issues surrounding cadmium in New Zealand soils and produce a report that discusses such issues.

It is anticipated that the working group will have its first meeting in August 2005 and that a final report will be delivered early 2006.

A food toxicology intake study has also been commissioned by NZFSA and final results will be available soon.

Independently of this review, the NZFSA has been conducting a national survey of cadmium levels in offals as part of their ongoing review for meeting export requirements.

MAF is also continuing a watching brief on international developments including the EU, SPS agreements and the World Trade Organisation. There is no progress on an EU directive that is considering the issue of lowering fertiliser cadmium standards. The issue of cadmium in New Zealand soils is being very closely monitored.

2 Framework

2.1 Policy position

In examining the issue of cadmium accumulation in soil, this report has utilised a framework distributed by Environment Waikato. The comments, questions to direct considerations, and checklist provided within the Framework are presented within the boxes in this section.

Framework comment:

A central question in assessing whether this issue might trigger Regional Council regulatory involvement is whether a specific Regional Policy statement or Regional Plan provision exists relating to the future sustainability of the soil resource, or soil contamination.

Framework questions:

Does relevant policy covering future uses of the soil resource, or soil contaminants exist in your region? If not, should it?

If so, what are the relevant policy statements?

Are there implications for fertiliser use in relation to a Permitted Activity Rule?

Taranaki Regional Council's policy position:

The Taranaki Regional Council addresses soil health and sustainability in both its Regional Policy Statement and Regional Soil Plan. The relevant provisions are:

The **Taranaki Regional Policy Statement Section 3.2.2** states that:

The application of agrichemicals, and the disposal of industrial, agricultural, domestic and other contaminants on to or into soil, will be carried out in such a way as to safeguard the life-supporting capacity of soils, maintain soil versatility and productivity and protect human and animal life.

The **Regional Soil Plan for Taranaki Policy 2.3 & 2.4** states that:

The Taranaki Regional Council will encourage land management practices that avoid adverse increase in residual soil contaminant levels in the Taranaki region, by promoting:

- a) *The careful consideration of the appropriateness of types of agrichemical and fertilisers and quantities to be applied; and*
- b) *The careful use of other agricultural compounds that may also give rise to soil health issues.*

The Taranaki Regional Council will monitor soil health, and gather and provide information on soil health issues in the Taranaki region.

The approach is non-regulatory. In the case of cadmium levels in Taranaki, if it was thought to be an issue, the Taranaki Regional Council would in the first instance raise public awareness on soil health issues and/or promote the adoption of practices by farmers that will avoid or minimise soil structure degradation, soil nutrient depletion and/or residual soil contamination problems

Framework checklist:

*Does relevant policy covering future uses of the soil resource, or soil contaminants exist in your region? If not, should it? **Yes, relevant policy exists.***

*Are there implications for fertiliser use in relation to a Permitted Activity Rule? **No.***

2.2 Magnitude

Framework comment:

Cadmium accumulation is likely to be occurring at a reasonably rapid rate in soils under pastoral use (dairy, sheep, and beef farms), arable crops, and horticulture. Within horticulture, the fastest rate of cadmium accumulation is in soil under potatoes. Soil used for commercial forestry is also accumulating cadmium, but the accumulation rate for this land use is less than one-tenth of the rate for pastoral soils. It is useful to have an understanding of the land areas involved in each category.

Framework questions:

How many hectares fall into each of these land use categories in your region (by hectares and percent of total land area)?

Of these, what proportion is in the higher accumulation group (pastoral, arable and horticultural soils)?

Magnitude in Taranaki:

Taranaki is region with a rather specialised economic base of agriculture. The agriculture activities are centred on dairying, sheep and beef, and to a lesser extent, deer, goats, horticulture and forestry.

At the last Agricultural Production Census in 2002, land use for grazing accounted for 385,011 hectares or 53% of the region's total land area. Land in horticulture accounted for 1,161 hectares or 0.2% of the total land area, and land in plantation forestry accounted for 28,000 hectares or 4%.

Table 1 Land use in the Taranaki region by area. The land uses deemed subject to more rapid cadmium accumulation are indicated by shading

Land use type	Hectares	Percent of Taranaki (%)
Dairying ⁴	161,520	22%
Meat and wool ⁵	222,330	30.8%
Horticulture	1,161	0.2%
Production forestry	28,000	4%
Other ⁶	310,599	43%
Total	723,610	100%

⁴ Data derived from multiplying average dairy farm size by the number of dairy farms, eg 80 ha x 2,019 farm = 161,520 ha.

⁵ The "Meat and Wool" category refers to all types pastoral farming including beef, sheep, deer, pigs, goats and mixed livestock.

⁶ The "Other" category refers to the remainder of the Taranaki land area and includes protection of forestry, reverting scrub, existing natural bush, towns, lakes, and rivers.

Framework checklist:

Of these, what proportion are in the higher accumulation group (pastoral, arable and horticultural soils)? As indicated by the table, 53% of land use in Taranaki falls into the higher cadmium accumulation group as classified by the framework.

2.3 Land use change**Framework comment:**

Over time, some horticultural soils are redeveloped for residential use. At this point it is appropriate to consider whether contaminant levels will meet guideline values for residential soils. Similarly, over time some pastoral soils are redeveloped for horticulture or residential use. Some pastoral soils will have sufficient cadmium that they may be unsuitable for growing specific vegetable or grain crops, due to food standards being exceeded. It is useful to have an understanding of areas in your region likely to see the most pressure for residential and horticultural redevelopment.

Framework questions:

What areas of your region are experiencing the most pressure for conversion between land uses?

Land use change in Taranaki:

In Taranaki the majority of land usage is in the form of dairy farming, the actual land mass used for this activity over the years has been fairly static and very little change has taken place (Statistics New Zealand, 2002).

There has been no change to horticulture, with forestry increasing on steeper pastoral land. Some lifestyle block developments have occurred in and around New Plymouth and coastal developments are being developed along with some new subdivisions around Taranaki⁷. However, the developments in these areas are not large and are illustrated in the table below.

Table 2 Land use in the Taranaki region 1994 - 2002

Land use type	1994 Hectares	2002 Hectares	% Change
Dairying	186,193	161,520	-10.86 %
Meat and wool	245,714	222,330	-9.52%
Horticulture	1,161	1,161	0%
Production forestry	16,000	28,000	75%
Other	274,805	310,449	13%
Total	723,610	723,610	0%

While 53% of land use in Taranaki is categorised as land that is subject to comparatively rapid cadmium accumulation there has been little change in terms of

⁷ Information on land use change has been obtained from the three District Councils in Taranaki.

the use of this land. This is due, at large, to the specialised agriculture economic base of Taranaki. This absence of land use change nullifies the risk that results from the transfer of agriculture soils to residential blocks.

Framework checklist:

What areas of your region are experiencing the most pressure for conversion between land uses? At large, Taranaki is not experiencing any significant change in terms of land use.

Note: Future land use change may become an issue, however all indicators in Taranaki at present state that any change in land use will not be significant⁸.

2.4 Current soil status

2.4.1 Accurate estimates

Framework comments:

It is useful to have region-specific information about the cadmium status of your agricultural soils.

Framework questions:

Is recent survey data available for your region?

If not, are archived soil samples from the 500 soils (or any other) programme available, which could now be analysed?

What depth were samples collected to? Are they surface soils (e.g. typically 0-7.5 cm for pastoral sampling, and 0-15 cm for horticultural).

How do these concentrations compare with the background concentration of cadmium (0.15 mg/kg) and the current recommended agricultural guideline (1 mg/kg)?

Taranaki specific information:

The most recent survey data available on cadmium in Taranaki soils is obtained from the 500 Soils Project compiled during 1998 to 2001. The project was supported by the Ministry for the Environment Sustainable Fund. Relevant data from 48 Taranaki sites sampled were compiled in one single report. The data on the chemical, physical, and biological condition of the soil, and of residual contaminants, were compared against international standards and/or recommendations of the Workshops on Soil Quality Standards.

With regard to cadmium (Cd) levels the study showed that all sites were well below the NHMRC/ANZECC investigation level of 3 mg Cd/kg that applied at the time of the study. The soil samples were taken at a depth of 0-10 cm. The findings are illustrated in **Table 3** below.

For a comparative analysis the findings from the national survey of soil levels conducted in the early 1990s are listed below in **Table 4** (Roberts *et al*, 1996). The soils

⁸ Information on land use change has been obtained from the three District Councils in Taranaki.

samples were taken at a depth of 0-7.5 cm. The levels recorded are similar to that of the levels recorded in the 1998-2001 500 Soils Project.

Table 3 Cadmium in Taranaki topsoils (1998-2001)

Minimum Cd mg/kg levels	0.04 Cd mg/kg
Maximum Cd mg/kg levels	1.05 Cd mg/kg
Average Cd mg/kg levels	0.47 Cd mg/kg

Table 4 Cadmium in Taranaki yellow brown loam soils (data for the 0-7.5 cm layer)

Sample type	Cd
Native	0.11 Cd mg/kg
Dairy farms	0.52 Cd mg/kg
Sheep/beef farms	0.42 Cd mg/kg

Framework checklist:

Is recent survey data available for your region? 1998-2001.

*If not, are archived soil samples from the 500 soils (or any other) programme available, which could now be analysed? **The Council extended the '500 Soils' programme analyses to include cadmium in any case.***

*What depth were samples collected to? Are they surface soils (e.g. typically 0-7.5 cm for pastoral sampling, and 0-15 cm for horticultural. **0-10 cm.***

*How do these concentrations compare with the background concentration of cadmium (0.15 mg/kg) and the current recommended agricultural guideline (1 mg/kg)? **Of the soil samples taken, only one was marginally above the guideline level of 1.0 Cd mg/kg.***

2.5 Future projections for soil

Framework comment:

Reaching the current point of soil cadmium took approximately 60-65 years of widespread superphosphate fertiliser use. Estimates suggest that average cadmium accumulation rates in pastoral soils in the period after 1997, when the fertiliser industry introduced a cap on cadmium content, are about 77% of previous rates.

One type of soil resource loss caused by ongoing cadmium accumulation is represented by the point at which given soil would become unfit for production of a given grain or vegetable crop, in the future. This loss is likely to be happening progressively at current soil cadmium levels, but is difficult to quantify.

The first easily quantifiable point of soil resource loss is the point where the current recommended agricultural guidelines of 1 mg/kg is exceeded. The guideline is partly set on the basis of international trade expectations. This guideline is also a current default for residential soils of pH6 or below.

Environment Waikato Model:

The current cadmium accumulation rate is estimated by: estimating total pastoral, horticultural and arable land area (ha), working out how many kilograms of surface soil in this area, using a soil depth of 7.5 cm, converting the loading in the table to mg cadmium, and dividing the figure by the mass of the surface soil in kg. Field trials suggest that about 10% of cadmium is usually lost to leaching.

Framework questions:

Once you have an estimate of the current average cadmium content of various regional soils the next question to ask is how long it would take to reach the agricultural guideline value on average?

Future projections for Taranaki soils:

Using the model developed by Environment Waikato, it is estimated that **it would take 265 years** more or less before the average soil concentration in Taranaki exceeds the guideline of 1.0 mg Cd/kg soil.

The calculations deriving this figure are set out in the **Appendix II** of this report. The model's outcome of 265 years indicates that there are no substantive issues in terms of cadmium soil contamination with respect to historical and current use of fertiliser in the Taranaki region.

Framework checklist:

*Once you have an estimate of the current average cadmium content of various regional soils the next question to ask is how long it would take to reach the agricultural guideline value on average? **265 years.***

2.6 Soil-food relationship

Framework comment:

A key issue with cadmium is the relationship between cadmium in horticultural and arable soils, and cadmium levels in food crops grown on those soils. There is evidence that food standards for cadmium are being exceeded in a small but significant proportion of wheat and vegetable crops.

Framework questions:

Is recent survey data for cadmium in produce available for your region?

Taranaki soil-food relationship

To date, there is no recent research on the cadmium soil-food relationship in Taranaki; this is due, at large to the specialised economic base of agriculture in Taranaki, centred on dairying, sheep, and beef, reducing the relevance to analyse the effects of cadmium in food crops.

However, of the research that is available on a national wide basis the levels of cadmium found in New Zealand crops and produce are generally below the guideline levels and are consistent with internationally documented levels (Furness, 2003; Ministry of Health, 2000).

Framework checklist:

Is recent survey data for cadmium in produce available for your region? **The most recent set of data is obtained from the 'Soils 500 Project' (1998-2001). However, the Taranaki Regional Council is committed through its State of the Environment Monitoring Programme to repeating the soil characterisation and analysis studies previously carried out within the '500 Soils' programme. These studies are scheduled for the 2006/2007 year.**

3 Issues

3.1 The Framework

The framework is a very useful tool in terms of highlighting the potential adverse effects of cadmium accumulation in New Zealand soils and explaining the significance of this process.

However, a number of the key findings and assumptions of the model are not relevant to the Taranaki region. This is highlighted both in the section on land use change and soil-food relationships. Land use change has been identified elsewhere as a significant development in the issue of cadmium accumulation. The extent of land use change in Taranaki is minimal and it is therefore, not a major factor in evaluating cadmium accumulation in Taranaki.

In addition, the soil-food relationship is identified elsewhere as an area of concern. Once again, it is acknowledged that this is an issue of significance, however in terms of agriculture activities in Taranaki the growth of food crops is relatively small. More relevant is the pathway via dairy produce.

3.2 The Model

The model developed by Environment Waikato for calculating cadmium accumulation has a number of fundamental flaws when comparing the calculated results to the actual historical data and soil analysis measured in Taranaki.

The Environment Waikato model uses a mixing depth of 7.5 cm for dairy soils and a soil mass of 750,000 kg per hectare, as the basis for calculating accumulation. The model also assumes a 10% loss of cadmium from the soil (all pathways) and a background concentration of 0.15 mg Cd/kg soil.

Based on this methodology, the average concentration of cadmium in dairying soils in Taranaki should have reached 1.56 mg/kg soil.

However, the average is in fact 0.47 mg Cd/kg soil, as recorded in the Soils 500 Project. The highest level found in Taranaki was 1.05 mg Cd/kg soil. That is, the current average residual level is only one third of that predicted by Environment Waikato's model; the model overstates the rate of increase by a factor of more than four. This overestimation by the model indicates that there is an inaccuracy in the structure of the model.

In addition, the model does not take into account the positive effects of the voluntary limit imposed by the Fertiliser Research Association that has reduced cadmium concentrations by one-third; the nutrient budgeting expectation that is part of the Dairy and Clean Stream Accord; and the significant decline in superphosphate use in the last seven years (to less than half of what it has been traditionally).

3.3 The way forward

The use of actual data as a basis for prediction is considered much more robust than the EW model. The calculations set out here indicate that based on historical accumulation and at current usage rates of superphosphate-based fertilisers it is

likely to be more than 250 years before average soils in Taranaki exceed the investigation guideline.

To maintain current production, farmers in Taranaki need to continue to apply P fertiliser. Dairy farming soils are considered to be at greatest risk of Cd accumulation because of their greater use of P fertiliser. Rates of increase suggest there is no immediate cause for concern nor need for regulatory intervention.

It is considered prudent for reasons of food safety, market access, and public reassurance, to continue to monitor Cd levels in Taranaki soils, especially those under intensive dairy farming with a history of high use of phosphatic fertilisers. Areas found to have high Cd levels could have specific management applied to those sites.

The Council's current monitoring programme is considered to be a well-constructed and appropriate soil health monitoring programme.

4 Recommendations

Using historical data, the results of soil analyses, and models for predicting future application, a best estimate is that it will take 265 years, more or less, before the agriculture soils in the region reach the guideline level of 1.0 Cd mg/kg on average. While this is not a cause for alarm a number of initiatives are recommended by the Taranaki Regional Council to further reduce the cadmium content of soils in Taranaki and to extend the timeframe for reaching the guideline level. The recommendations are:

- encouraging the fertiliser industry to continue to explore and pursue further reductions in the cadmium content of phosphatic fertiliser;
- continue to include analyses for cadmium in its current soil monitoring programme for the state of the environment monitoring;
- seek through the regional plan process and by other means, to encourage farmers to recognise existing levels of phosphate in soil within nutrient budgeting so that phosphate applications are reduced to a minimum consistent with sustainable pasture management;
- encourage New Zealand authorities, such as the New Zealand Food Safety Authority, Ministry of Agriculture and Forestry, and the Ministry of Health, to explore the setting of soil guidelines that are appropriate for, based on and differentiate between various land uses and exposure/uptake pathways (for example, dairying, beef and mutton pasture, in-ground horticultural crops, and orchards);
- provide the Cadmium Working Group with information and assistance to enable them to complete their task of monitoring regional cadmium levels;
- encourage these authorities to explore the setting of soil guidelines that are appropriate for and take into account the relative risks associated with different soil types (for example, volcanic allophanic soils, peats, and sandy soil);
- continue to monitor the application, on an annual basis, of fertilisers in the Taranaki region;
- strongly advocate to Ministry of Agriculture and Forestry and the New Zealand Department of Statistics that they continue the gathering of regional farm data each year, and that this data includes information on fertiliser application rates; and
- support Taranaki Groundspread Fertiliser Association in their spreadmark certification programme allowing effective fertiliser spreading to land.

5 Conclusion

The cadmium levels in Taranaki soils and food chain are not considered a major environmental problem, nor are they affecting the region's health.

In New Zealand phosphate fertilisers are the major source of cadmium accumulation. The data available to the Taranaki Regional Council highlights that the trend in the application of phosphate fertiliser is to decrease its use.

The Taranaki Regional Council addresses soil health in both its Regional Policy Statement and Regional Soil Plan for Taranaki. In the case of cadmium, if it was thought to be an issue a number of measures would be implemented.

There has been very little change in terms of land use, thereby reducing the risk that results from the transfer of agriculture soils to residential blocks.

Using the model developed by Environment Waikato the most likely rate of cadmium increase is 0.002 mg Cd/kg/year. At this rate of increase it will be 265 years before the average soil concentration in Taranaki exceeds the current 1.0 mg Cd/kg soil limit.

Internationally and in New Zealand, the health and scientific communities are conscious of cadmium as a potential health issue, and in New Zealand a sound management regime is in place.

The cadmium levels in Taranaki soils and food chain are not considered a major environmental problem, nor are they affecting the region's health. There is no justification for a regulatory intervention at this time.

A number of recommendations are suggested by the Taranaki Regional Council to further reduce the accumulation of cadmium accumulation in soils in Taranaki and to extend the timeline for reaching the guideline level.

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Appendix I
Working Group on Cadmium Proposed Terms of Reference

Proposed Terms of Reference

Matters to be considered

The group's purpose will be to facilitate constructive dialogue between key stakeholders, to research and explore the issues and impacts of cadmium (Cd) in the New Zealand agriculture and food system, and to develop responses as required.

The group's key outputs would initially be two major reports:

The first is to be a scoping report, canvassing the cadmium issue at a national level. The report would consider:

- the extent of Cd accumulation throughout the country; including source and sinks.
- the variation between different regions, types of agriculture;
- the implications of such accumulation for trade, future soil use and other issues deemed relevant; and
- an assessment of the risks and implications.

It is expected that this first report would review the existing scientific and other research, although some primary research may also be necessary.

The second report is to be a solutions report, outlining policy options to address the issue. This report should consider:

- given the findings of the first report, what are appropriate options for management of cadmium.
- an assessment of the options.

Process

The working group on cadmium would be responsible to the Environment Chief Executive's Forum through the Chief Executive of the Ministry of Agriculture and Forestry. The Chief Executive's forum will assess the ongoing role of the group at the completion of the second report.

The working group will be chaired by John Hellstrom. The proposed composition will be MAF, Ministry for the Environment, New Zealand Food Safety Authority, Environment Waikato, ECAN, and representatives from vegetable, arable crops, dairy, sheep and beef sectors and fertiliser industry.

Funding

Representatives on the working group will be funded by their own organisations. MAF will fund the chair. Where additional research is required, participant organisations may be invited to provide additional financial support. Any such requirements will be established at the outset of the working group.

Servicing

The working group will be serviced by MAF with input from other relevant departments (i.e. Ministry for the Environment

Appendix II

Calculation of theoretical and actual cadmium accumulation rates

Calculation of theoretical and actual cadmium accumulation rates

Average rate of application of superphosphate fertilisers per year in Taranaki 1957-1997 (41 years): 121,759 tonnes (data from Statistics NZ)

Average cadmium concentration prior to 1997 was 420 mg Cd per kg P, or 37.5 mg Cd per kg superphosphate (37.5 g/tonne) (data from AHC Roberts)

Therefore average annual application rate of cadmium is 37.5 g/tonne x 121,759 tonnes, or 4566 kg, per year

Allow for 41 years (1957-1997 inclusive).

Total Cd application 4566 kg x 41 years: 187206 kg, or **187.2 tonnes**

(This figure could be up to 25% low- Environment Waikato suggests 60-65 years of fertiliser application, or 48-53 years prior to 1997. This calculation uses 41 years)

Average application rate of superphosphate 1997-2004: 58,600 tonnes

Average cadmium concentration 25 mg Cd per kg superphosphate.

Therefore average annual application rate is 25 g/tonne x 58,600 tonne, or 1465 kg per year

Total Cd application 1465 kg x 7 years: **10.3 tonnes**

Land area for application: 186,200 ha, to a depth of 7.5 cm (as modelled by EW),

or 139,650,000 tonnes soil at a density of 1.0

Therefore modelled Cd accumulation is 197.5 tonnes/139,650,000 tonnes,

or 1.41 mg/kg.

Given background Cd of 0.15 mg/kg,

current average soil Cd level in Taranaki should be more than $1.41 + 0.15 = 1.56$ mg/kg.

But the actual average soil concentration by measurement is 0.47 mg/kg, and the accumulation over a background of 0.15 mg/kg is 0.32 mg/kg. This is less than 23% of the modelled rate of accumulation.

The 'real' rate of accumulation has been 0.007 mg Cd/kg soil/year.

With the concentration of Cd now only 66% of what it was, and superphosphate application now only 48% of what it was, the projected 'real' rate of Cd accumulation for Taranaki for the future is 0.002 mg Cd/kg soil/year. At this rate, it will take 265 years for the average Cd level of 0.47 mg/kg to reach 1.00 mg/kg.

Qualifying note: this calculation assumed that all superphosphate fertiliser in Taranaki was applied only to dairying pasture. With an equivalent area used for beef/sheep, the area of land used in the above calculation could (at most) be doubled by assuming that the use of fertiliser on such pasture was up to equal to the usage on dairying pasture. This would double the rate of accumulation calculated. However, this is considered unrealistic. As noted in the body of the report, it is more likely that the 6% of fertiliser applied from the air represents that proportion of fertiliser used on beef and sheep land.

On the other hand, if fertiliser use prior to 1957 is taken into account, then the historical application rate calculated above could be up to 25% low and the 'real' accumulation rate should accordingly be reduced by up to 25%.