Managing cadmium in grazing farm systems in New Zealand

This practical guide from the Cadmium Management Group provides farmers with advice about managing cadmium in New Zealand agriculture, including why it needs to be managed.

What is cadmium?

Cadmium is a widespread, naturally occurring element that is present in low concentrations in soils, rocks, plants and animals. It is not essential for life and in high concentrations can be toxic. Cadmium is absorbed by plant roots and transported to different parts of the plant. In grazing farm systems, uptake by pasture, forage crops or plants used for supplementary feeds provides a pathway for animal intake.

Why can it be an issue?

Cadmium can accumulate in some human and livestock organs, particularly the liver and kidneys, mainly through the consumption of food. Excessive daily intake of cadmium over the long term can lead to health problems in humans and animals. In humans, excessive cadmium increases the risk of kidney and bone disease[1], while in livestock reproduction and the ability to metabolise copper can be reduced[2]. It is therefore important to produce foods in ways that minimise cadmium uptake in order to protect human and livestock health.

New Zealand, through Food Standards Australia New Zealand, has set maximum levels (MLs) for cadmium in food products, including offal for human consumption. Where an ML for cadmium is exceeded, those food products may not legally be sold and the Ministry for Primary Industries will take action to alert the supplier.

Current dietary surveys of New Zealanders indicate that the typical daily intake of cadmium is well below the World Health Organization tolerable monthly intake guidelines, so it is unlikely that at current cadmium levels in food there are adverse health implications for New Zealanders. However, surveys in New Zealand have shown that the amounts of cadmium in some foods have occasionally approached or marginally exceeded these regulatory limits, highlighting the need for vigilance, including managing cropping rotations on pastoral soil.

Non-compliance with MLs in exported food products could result in rejected shipments and may negatively affect the international reputation of New Zealand food products.

Managing soil cadmium is also important to protect the versatility of future farming land-use options.

What are the sources of cadmium?

New Zealand soils contain little cadmium naturally, ranging from less than 0.1 to 0.6 mg/kg. Phosphate fertilisers contain

[1] World Health Organisation 2019. Exposure to cadmium: A major public health concern. www.who.int/ipcs/assessment/public_health/cadmium

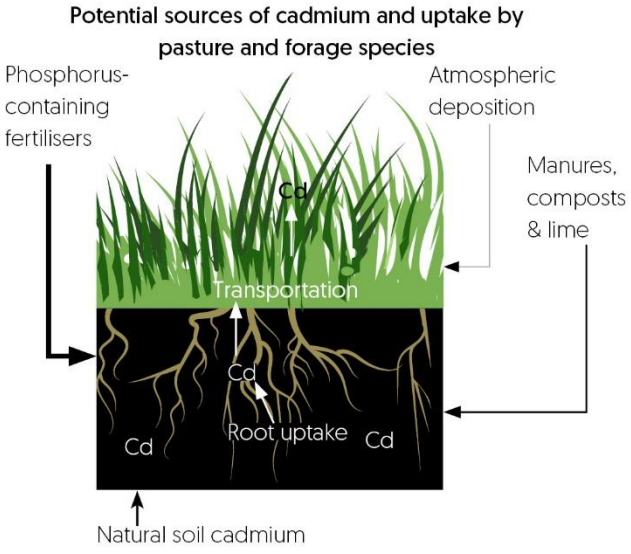
[2] Lane EA et al. 2015. Cadmium exposure and consequence for the health and productivity of farmed ruminants. Research in Veterinary Science 101: 132–139. doi.org/10.1016/j.rvsc.2015.06.004

cadmium as an impurity in phosphate rock, and are the primary input of cadmium to agricultural soils. The fertiliser industry has had a voluntary limit for cadmium levels in phosphate fertilisers of 280 mg cadmium/kg of phosphorus, in place since 1997. Superphosphate is now manufactured using lower-cadmium sources of phosphate rock than before 1997, but the amount of cadmium in a final product still depends on the source of phosphate rock. The average phosphate fertiliser cadmium concentration between 2003 and 2020 was 177 mg/kg of phosphorus[3].

Composts and manures may also contain cadmium (typically <1 mg/kg product). While they generally contribute less cadmium to soils than phosphate fertiliser, management of cadmium should still be considered when using these products. Rain and irrigation water typically have very low amounts, and in agricultural regions the amounts added to the soil from the atmosphere are minimal.

How do plants take up cadmium?

Plants, including forage species, absorb most of their cadmium from soil through their roots, where it can move to the leaves, grains and fleshy fruit. Typically, cadmium accumulates more in the leaves than in roots and grains, with fleshy fruit accumulating the least.



Cadmium added to soil is strongly bound to minerals and organic matter and therefore tends to remain in the topsoil, where it is potentially available to plants. The availability of cadmium to plants is influenced by a number of factors, but in general more cadmium is available as soil pH decreases (becomes more acid). Amounts of soil micro-nutrients, in particular zinc, also affect cadmium uptake by plants, with more cadmium being taken up if soils are low in zinc.

[3] www.fertiliser.org.nz/Site/about/fertiliser_use_in_nz, accessed June 2020.

Uptake can vary considerably among different plant species, and among different varieties or cultivars of the same species, so this may be an important consideration for forage crops. However, the variation in cadmium concentrations of a single cultivar at different locations may be as great as the variation between different cultivars at a single location. This emphasises the importance of understanding the influence of both soil and plant factors on cadmium accumulation in plants.

How is cadmium managed in New Zealand?

A National Cadmium Management Strategy sets out the approach to managing cadmium in the primary sector. Implementation of the Strategy is overseen by the Cadmium Management Group, which includes representatives from the Ministry for Primary Industries (including New Zealand Food Safety), the Ministry for the Environment, Foundation for Arable Research, Beef+Lamb New Zealand, the fertiliser industry (including the Fertiliser Association of New Zealand), DairyNZ, Meat Industry Association, Horticulture New Zealand, Potatoes New Zealand, Federated Farmers, and regional councils, with Manaaki Whenua − Landcare Research providing technical support as an observer.

The Cadmium Management Strategy has the objective:

> ***To ensure that cadmium in rural production poses minimal risks to health, trade, land-use flexibility and the environment over the next 100 years.***

Actions to achieve this include:

- monitoring to ensure the risks are being managed appropriately, and to contribute to the knowledge base of where and how risks from cadmium arise
- controlling the accumulation of cadmium in soils and the management of priority products to protect against non-compliance with food standards
- research on ways to manage cadmium risks
- communications to raise awareness of cadmium as an issue and to promote the use of risk management tools.

Food monitoring

The dietary intake of cadmium among New Zealanders is monitored through the New Zealand Total Diet Study. The study is undertaken by New Zealand Food Safety approximately every 5 years. Samples are taken from products sold in supermarkets and other retail outlets that are representative of foods in the New Zealand diet.

Other surveys of food residues may also include data on cadmium, including periodic specific priority product surveys. Current priority products from livestock are kidneys and livers for human consumption because cadmium does not accumulate to any appreciable levels in muscle meat or milk, but the value of offal exports have been increasing.

Cadmium tends to accumulate in the kidneys and liver of livestock, and increases with the age of the animal. The risk of non-compliance with the maximum level (ML) for kidneys is currently managed by excluding kidneys from ruminant livestock

(excluding deer) greater than 2 years old[4], from the human food chain. However, levels higher than the ML can also be found in animals less than 2 years old, and so awareness and management of cadmium in soil and forage species is needed.

Soil and fertiliser cadmium monitoring

Soil monitoring is undertaken through testing for cadmium alongside routine nutrient analysis in agricultural soils. Regional councils also test for cadmium in soils across a range of landscapes for State of the Environment reporting. Fertiliser companies also regularly test cadmium levels in their phosphate fertiliser products, which is audited through the Fertmark quality assurance programme run by the Fertiliser Quality Council.

The accumulation of soil cadmium in agricultural land can be managed using the Tiered Fertiliser Management System, which sets out increasingly stringent restrictions on the choice and rate of phosphate fertiliser as soil cadmium increases. The soil cadmium tiers represent amounts of soil cadmium ranging from natural background (Tier 0, <0.6 mg Cd/kg soil) up to an agreed maximum threshold of 1.8 mg/kg soil (Tier 4). The Tiered Fertiliser Management System is available on the Fertiliser Association of NZ website (www.fertiliser.org.nz/site/resources/tools).

However, non-compliance with food standards can occur even when farming on low-cadmium soils. Regardless of soil cadmium levels, monitoring and the agronomic management considerations outlined in this pamphlet are still important for protecting the versatility of farming land-use options, and controlling the risk of exceeding food standards due to plant uptake of soil cadmium.

Cadmium in New Zealand food and exports

The 2016 Total Diet Study found that the typical diet of New Zealanders is well within the World Health Organization's recommended limits for cadmium intake, and also within the range reported in international dietary surveys[5]. It also found no evidence of an increase in cadmium exposure through diet, and no consequent increase in dietary risk.

Nationally and internationally MLs for cadmium in food products are set to protect public health, and to be reasonably achievable from the perspectives of sound primary industry production and natural resource management. These MLs can vary among countries. Domestic products must comply with MLs set by Food Standards Australia New Zealand and exported products need to comply with the importing countries' MLs. The table below shows the MLs set for animal products by Food Standards Australia New Zealand, the European Commission and the Codex Alimentarius.

Table: Maximum limits for cadmium in animal products established by Food Standards Australia New Zealand (Standard 1.4.1), the European Commission (EC 1881/2006) and Codex 193-1995. Correct as at March 2020.

Product	FSANZ (mg/kg fresh weight)	EC, Codex (mg/kg fresh weight)
Kidney of cattle, sheep and pig	2.5	1.0
Liver of cattle, sheep and pig	1.25	0.5
Muscle of cattle, sheep and pig	0.05	0.05

How can I manage for low cadmium in grazing systems?

Non-compliance with food standards is likely to be the greatest risk posed by cadmium at the current levels in New Zealand agricultural soils. For grazed livestock it is principally the offal (kidney) food standard that is being managed and monitored, as cadmium does not tend to accumulate to any appreciable amount in meat and milk. The level of livestock exposure through plant uptake by different pasture and forage crops/varieties (or ingested weeds) can vary considerably. In addition to knowing cadmium uptake characteristics of forage species, knowing your soil properties will help to identify when there is a higher risk of having increased plant uptake.

Soil properties such as pH, organic matter and clay content can significantly affect how much cadmium is taken up by plants. This means soil tests for cadmium, pH, organic matter and Olsen P provide valuable information for monitoring and managing soil cadmium and its uptake by plants.

A number of complementary approaches can be used to help achieve low cadmium in grazing systems.

Reducing cadmium inputs – don't over-fertilise!

Phosphate fertilisers are the primary source of cadmium in agricultural soils, so reducing their application rate and/or switching to lower-cadmium-containing fertilisers (e.g. phosphoric-acid- or nitric-acid-derived fertilisers) will reduce the input of cadmium to soils. Olsen P is a key indicator of phosphate fertiliser requirements and phosphorus fertiliser can be reduced where Olsen P is at the recommended levels for your pasture or forage crop and soil type. Advice on the appropriate rate can be obtained by soil testing, from your soils and fertility advisor, and by using the nutrient management model OverseerFM®. Also see the Fertiliser Association tools page for more information (www.fertiliser.org.nz/Site/resources/tools).

Phosphoric-acid-derived fertilisers (e.g. triple superphosphate, DAP) typically have a lower cadmium concentration than sulphuric-acid-derived products (e.g. superphosphate) and rock phosphate. Nitric-acid-derived fertilisers (e.g. complex products, with NPK in each prill) generally have the lowest cadmium concentration.

[4] Officially, animals with six or more permanent incisors.

[5] www.mpi.govt.nz/food-safety/food-monitoring-and-surveillance/new-zealand-total-diet-study/

Lime and composts may also be sources of cadmium in agricultural soils, so you will need to ensure that products containing low levels of cadmium are used.

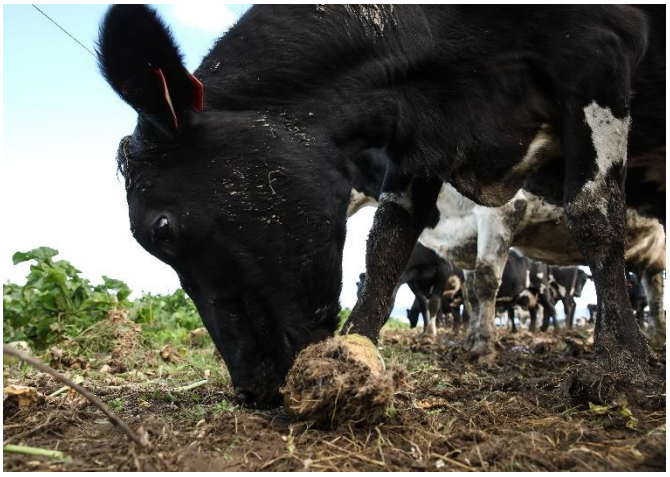
Avoid fertiliser ingestion by livestock

Pastures top-dressed with phosphorus fertiliser should not be grazed for 21 days or until 25 mm of rain has fallen[6]; this is important to avoid fluoride toxicity to stock, but also reduces exposure to cadmium.

Reducing ingestion of contaminated soil

Grazing livestock may consume more than 50 kg of soil a year, so this provides another pathway for ingestion of cadmium. The greatest risk period for large amounts of soil ingestion occurs during the winter grazing months, when soils are wet and forage crops are being grazed, or during drought. Where possible, minimise the risk of animals ingesting soil by:

- avoiding overgrazing
- paying special attention to controlling grazing pressure and management during winter months and drought periods.
- not feeding grain or other supplements on the bare soil surface.



Pasture composition and forage crop selection

Selection of forage species can have a more significant influence on the plant uptake of soil cadmium than any other factor. For example, the forage crops chicory and plantain have been identified as higher-cadmium-accumulating species than ryegrass and white clover. There is an increasing trend for these alternative forage crops to be used to finish young stock, but this may lead to a greater risk of raised cadmium in the offal of these animals.

Different varieties or cultivars can accumulate cadmium at different rates. Testing of a range of chicory cultivars identified higher- and lower-cadmium accumulating cultivars: www.fertiliser.org.nz/Site/research/projects/effect-of-breeding-for-lowered-cadmium-concentrations-in-chicory

Improving soil conditions

In general, plant uptake of cadmium in grazing systems can be reduced by:

- increasing soil pH to the high end of the optimal range for your pasture or forage crop, and ideally above 6
- increasing soil organic matter in fields with low organic matter (if applying composts or similar products, ensure low-cadmium products are used)
- addressing any zinc deficiency of pasture or forage species (international studies have shown this can be important in reducing plant uptake) – zinc status is best measured in plant material.

Cadmium is generally more available to plants in soils with a low clay content. Therefore, the risk of high cadmium in pasture and forage crops is generally greater for sandy soils than clay soils. Plant uptake of cadmium is also generally lower in Granular and Allophanic (volcanic) soils than in non-volcanic soils.

Next steps

You've read this guide. What now? The Cadmium Management Group encourages you to consider how to include management of cadmium in your farm management plan. As first steps, talk with your soils and fertility advisor about including cadmium in your next soil test and the Tiered Fertiliser Management System, and talk to your sector group about monitoring cadmium in your grazing system. To find out more about managing cadmium, check out the links below.

Additional resources

www.mpi.govt.nz (search cadmium)
www.fertiliser.org.nz (search cadmium)
www.beeflambnz.co.nz
www.dairynz.co.nz

For more information contact:

enquiries@beeflambnz.com, 0800 BEEFLAMB (0800 233 352).
info@dairynz.co.nz, and 0800 4324 7969.

This guide is one in a series of guides and sector fact sheets produced by Manaaki Whenua – Landcare Research for the Cadmium Management Group in 2020.

Manaaki Whenua
Landcare Research

[6] www.fertiliser.org.nz/Site/code-of-practice/