8.4.2 Soil contamination

8.4.2.1 Contaminants that create a soil conservation issue

A range of contaminants have been, and continue to be, applied to the soil through activities such as fertiliser application, sewage and effluent disposal, pest control and industrial operations. Many of these activities have been localised in their application, for example, sheep dips and weed spraying. Some contaminants are moved through the soil and into the ground water system. Other contaminants are biodegradable and break down over a short time into benign components.

Contaminants likely to cause a significant adverse effect from a soil conservation perspective, by changing the qualities of the soil, are those that will have impacts that persist longer than 25 years, including those that:

(a) are widespread in their application;

(b) have low mobility within the soil;

(c) are persistent (do not break down over time, or have a long half-life); and

(d) are toxic to soil organisms.

These contaminants are of concern because of their long-term (greater than 25 years) adverse effects on:

(i) the functioning of soil ecosystems, and, consequently, the life-supporting capacity and productivity of the soil. Soil quality factors such as soil structure, organic matter and soil fertility are all dependent on the functioning of the soil biota;

(ii) the availability and versatility of the land for a range of uses. With respect to arable land, the accumulation of contaminants in the soil may render it unsuitable for the production of certain food products if this poses a hazard to people's health.

Contamination of the soil will have adverse effects on the mauri of the land. To Ngāi Tahu, mauri is the life force of the land - its life-supporting capacity and its ability to nurture the full range of habitats of healthy plants and animals that provide mahinga kai.

Contamination puts at risk the wellbeing of future generations by reducing the potential of the land for a range of uses.

8.4.2.2 Extent and severity of soil contamination in Canterbury

There are currently only two contaminants that meet the criteria listed in 8.4.2.1 for being of regional significance for soil conservation in Canterbury. These are:

(a) DDT and its residues DDD and DDE, persisting in soils as a result of past widespread treatment of grass grub infestations; and

(b) cadmium accumulating in soils from the past and present widespread use of phosphate fertilisers (cadmium is an impurity of phosphate rock).

Another contaminant of phosphate rock – fluorine – also meets the criteria in 8.4.2.1, however, less is known about the significance of this contaminant for the functioning of soil ecosystem processes and the implications for human health.

While these are the only contaminants that are currently of concern it will be necessary to monitor for the use of other persistent contaminants which have the potential to become significant in their distribution.

The principal areas of accumulation of cadmium and DDT in Canterbury have been the intensively used agricultural soils of the Canterbury plains and downs and, to a lesser extent, the inland basins such as Culverden, Hanmer and Mackenzie. Activities such as cropping, dairying and intensive grazing that require large inputs of fertilisers or pesticides, create the greatest risk for widespread soil contamination.

8.4.2.2.1 DDT

While DDT contamination has long-term implications for productive land use in Canterbury, it is not seen as an issue for which Environment Canterbury needs to develop policies through this plan.

The use of the organochlorine pesticide DDT was banned in 1970, but the levels in some mid-Canterbury soils have shown little reduction in concentrations of DDT or its residues DDD and DDE since then. DDT contamination is an issue for human and animal heath if it gets into the food chain. From a soil conservation perspective, however, there is little opportunity for the management of DDT or DDT-residue levels in the soil because:

(a) DDT is no longer being applied to soils so activities resulting in soil contamination are not an issue;

(b) DDT residues will break down very slowly over time, leading to improved soil quality and versatility; and

(c) land management practices have limited impact on the rate of breakdown of DDT residues, although they can influence the availability and uptake of residues by grazing animals, for example through the use of grazing management techniques to minimise the uptake of DDT residues by stock.

The main issue for DDT contamination is a health and environmental issue. The setting of standards for contaminant levels in food products, and the control of DDT levels in food products, is managed by the Ministries of Agriculture and Forestry, and Health. Dairy and meat companies also manage contaminant levels in food products through the monitoring of residue levels. DDT and its residues accumulate in the food chain, with increasing concentrations developing at higher trophic levels. Sediment movement into streams or coastal areas, containing DDT residues, can lead to further contamination within the food chain.

8.4.2.2.2 Cadmium

Phosphate fertilisers contain a range of potentially toxic impurities that can accumulate in the soil, including arsenic, cadmium, chromium, fluorine, strontium, thorium, uranium and zinc. Of these, cadmium is the element of most concern, because it creates the greatest potential risks to animal health, food quality and soil quality.

Cadmium contamination is considered a significant resource management issue for arable soils in Canterbury, and an issue for which Environment Canterbury needs to develop policies through this plan.

Cadmium exists naturally in many soils at very low concentrations. The widespread and long-term use of phosphate fertilisers, however, has led to elevated concentrations of cadmium in the more intensively developed arable and pastoral soils throughout Canterbury. Recent surveys of mid-Canterbury arable soils[23] showed mean cadmium concentrations of 0.3 mg/kg, compared with 0.17 mg/kg for similar unfertilised soils. These are still low relative to contamination levels in many overseas countries and fall well within the guidelines suggested by the Ministry of Health for safe soil contaminant levels. Being a metal, cadmium does not break down over time, so the continued use of phosphate fertilisers will result in the cumulative increase in concentrations of cadmium in the soil. Once in the soil, cadmium has very low mobility as it binds strongly to the organic matter rich topsoil. Mobility may be increased under conditions of high acidity, low organic matter content and high soil moisture.

[23] Roberts, A.H.C., Longhurst, R.D., and Brown, M.W. 1995. *Cadmium survey of South Auckland Market Gardens and Mid-Canterbury Wheat Farms.* Report to New Zealand Fertiliser Manufacturers Research Association. AgResearch, Ruakura, Hamilton.

Plants are able to take up cadmium from the soil, with the amount varying considerably between species and between cultivars of the same species. Some wheat cultivars accumulate high levels of cadmium which may exceed the limits for cereal and bread production. Humans and other animals consuming plants with elevated cadmium concentrations, in turn, accumulate cadmium in their kidneys and, to a lesser extent, in their livers, with concentrations increasing with age[24]. New Zealand does not export the kidneys of stock older than two years because of the potential for cadmium accumulation in these organs.

Studies by the Canadian EPA[25] have reported that cadmium concentrations above a threshold of 2mg/kg cadmium in soil can have adverse effects on soil health by impairing the physiology and functioning of soil micro-organisms and affecting soil maintenance processes such as nitrogen fixation. Exposure to cadmium above this threshold may also result in the altered composition of soil communities.

The Ministry of Health has set guidelines for acceptable concentrations of cadmium in soils and produce for New Zealand. While these apply to the discharge of sewage effluent, they do provide a useful guide for setting limits for the general accumulation of cadmium in the soil. The key limits for cadmium include:

(a) maximum residue levels of cadmium in food products should not exceed 1mg/kg;

(b) maximum cadmium levels in soils should not exceed 3mg/kg; and

(c) cadmium application to soils should not exceed 200gCd/ha/yr.

These figures fit within the range of limits set overseas, although there is still some uncertainty as to the nature of the impacts of cadmium on humans and on the soil ecosystem functioning.

The risk that cadmium poses to the health of humans and animals, and to the healthy functioning of soil processes, suggests that a precautionary approach should be taken to minimising the accumulation of cadmium, particularly in the face of increasing intensification of land use and dependence on fertiliser inputs.

A key initiative to controlling cadmium inputs has been a voluntary agreement made in 1996, by members of the fertiliser industry, to reduce the level of cadmium impurities in superphosphate fertiliser[26]. By importing and blending a range of low cadmium sources of phosphate rock, the industry has reduced the cadmium content of superphosphate by a third - from 420mg Cd/kgP to 280mg Cd/kgP. As superphosphate is the most widely used phosphate fertiliser in New Zealand, this agreement will enable a significant reduction to be made in the amount of cadmium being applied to agricultural soils, and the rate at which it accumulates.

8.4.2.2.3 Fluorine

Fluorine is a highly reactive element and, therefore, almost always exists as fluoride compounds in nature. Fluoride-containing minerals occur naturally in most soils, but these concentrations can increase two to ten times in soils under pasture that has a long history of phosphate fertiliser use, demonstrating that this is the main contributory factor for fluorine

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[24] Black, A.L. 1988. *Toxic effects of Cadmium in Animals and Man. In Proceedings No.2: Cadmium accumulations in Australian Agriculture, National Symposium, Canberra, 1-2 March 1988. J Simpson., and B. Curnow (eds)*

[25] Health Canada, 1994

[26] Media statement by Dr Hilton Furness on August 19, 1996 for New Zealand Fertiliser Manufacturers' Research Association.

accumulation in New Zealand pastoral topsoils[27]. While fluorine is associated with the development of healthy bones and teeth in animals and humans, it is well known that high concentrations can be toxic, resulting in bone enlargement and kidney failure.

In contrast to cadmium accumulation, plant uptake of fluorine is low in most pastoral soils[28]. Fluoride compounds, added in phosphatic fertilisers, bind strongly to the soil particles and only a small fraction is available for plant uptake. Because of its low mobility, fluoride compounds tend to accumulate in the topsoil and do not move readily into the ground water. The level of sorption to soil particles increases with increasing clay content, and decreases with increasing pH. Uptake of fluorine in animals occurs mainly through soil ingestion. Uptake can be minimised by maintaining good pasture cover, reducing stocking rates, especially during winter, and withholding stock from recently fertilised pastures.

Fluorine accumulation in the topsoil can also be potentially harmful to soil micro-organisms, including nitrogen-fixing bacteria in pasture legumes. The effect of sustained, but low, levels of fluorine on soil microbial activity needs to be studied further.

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[27] Loganathan, P. et al 2003. *Fertiliser contaminants in New Zealand grazed pasture with special reference to cadmium and fluorine; a review.* Aust, J Soil Research 41: 501-532

[28] Loganathan, P. et al 2003. as above