

Nitrogen: Is it a SIDE Issue?

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Introduction

Dairy farming has borne the brunt of recent public criticism from anglers and others regarding the desire we all share to keep our country green and our rivers and lakes clear.

Much of the focus has been on nitrogen and especially the leaching of nitrate into rivers, lakes and groundwater. Nitrate contamination of rivers and lakes, termed 'eutrophication', may cause an increase in weed and algae growth. This can make it difficult for boating or swimming and will also require more frequent cleaning of ditches. Fishing may also be affected because fish cannot survive in water that is overloaded with weed and algae growth.

The other main risk of nitrate pollution of surface and groundwater is to human health. A high concentration of nitrate in drinking water is a health hazard, particularly for infants. The Ministry of Health has therefore set a maximum acceptable value of 11.3 mg N/L for drinking water in New Zealand.

This paper will address four key questions:

- Is nitrogen pollution solely a dairy farming (or SIDE) issue?
- Is fertiliser use or animal waste the main nitrogen problem in dairying?
- How does New Zealand's nitrogen use compare internationally?
- How do we use nitrogen without risk to the environment?

Is nitrogen pollution solely a dairy farming issue?

To answer this we will try to compare nitrate losses between different farming systems. This is not a simple exercise because the nitrate loss depends on a wide range of soil, management and climatic factors, as well as the nitrogen input. Nevertheless, comparisons of published research results show that the highest nitrate leaching losses often occur from vegetable crops (see Figure 1). This is because vegetable crops often receive large applications of fertiliser N and the crop root system is shallow, resulting in poor recovery of N by the plant and thus an excess of N for leaching. Typically vegetable crops recover less than 50% of the fertiliser N applied and the recovery can be less than 20% when high rates are used (Haynes 1997). For example, cumulative leaching losses from three vegetable crops grown in NZ (each fertilised with 100 kg N/ha) within a 12-month period were found to be as high as 300 kg N/ha/y (Speirs *et al.*, 1996).

Nitrate leaching losses may also be high from a typical arable crop rotation where pasture is ploughed in the autumn. This is because ploughing causes nitrate to be released from the

breakdown of plant material containing nitrogen, which is then leached by the winter rain (Cameron and Haynes, 1986). When pastures are ploughed in late summer/early autumn the soil mineral N content may increase by about 100-150 kg N/ha (Francis *et al.*, 1995). If the soil is left fallow over winter (i.e. there is no crop) a large amount of mineral nitrogen can be leached during drainage. Nitrogen is also mineralised following cultivation of a legume (e.g. peas, beans) residue (about 30-50 kg N/ha), which can also be leached over winter (Francis *et al.*, 1995). Leaching losses of about 30-80 kg N/ha/y are likely to occur, even from well-managed arable land (Haynes, 1997).

Leaching losses of about 30-80 kg N/ha/y from arable land are therefore similar to the losses reported from dairy farming (e.g. Ledgard *et al.*, 1996; Di and Cameron, 2002).

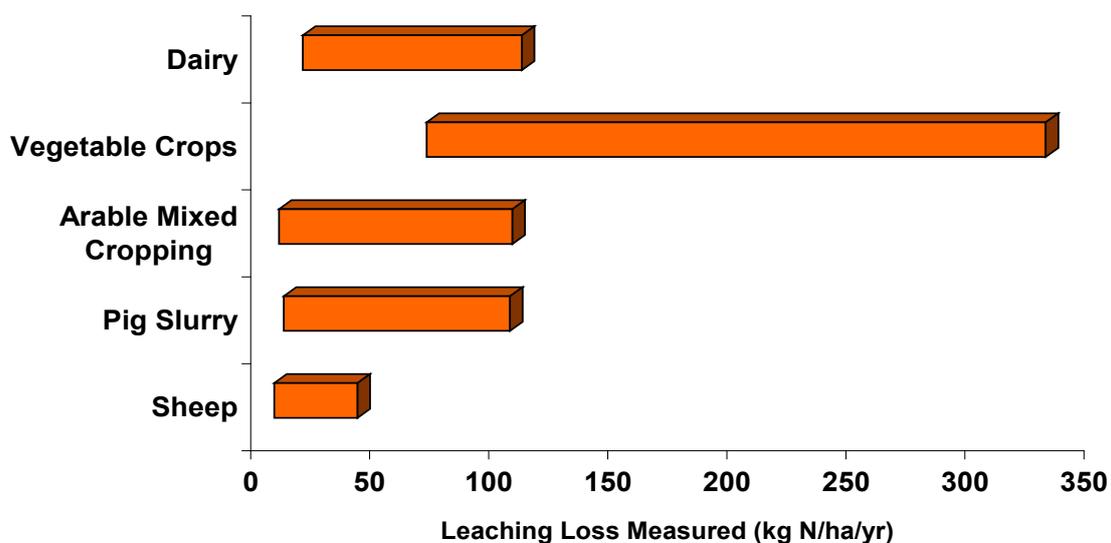


Figure 1: Range of nitrate leaching losses recorded from different farm types (Cameron and Haynes, 1986; Heng *et al.*, 1991; Ruz-Jerez *et al.*, 1995; Ledgard *et al.*, 1996; Francis *et al.*, 1997; Speirs *et al.*, 1996; Carey *et al.*, 1997; Haynes 1997; Di *et al.*, 1998; Cameron *et al.*, 1999; Di and Cameron, 2002)

Is fertiliser use or animal waste the main problem in dairying?

A large proportion, between 60-90%, of the N ingested by a cow is returned to the soil, in the forms of urine and dung. Over 70% of the N returned to the pasture is in the urine. The N loading rate under a cow urine patch is equivalent to about 1000 kg N /ha.

Depending on the stocking rate, 20-30% of the grazed paddock area is covered by cattle urine patches per year. Because of the high loading rate of N under the urine patch, well above the needs of plants, there is a high potential for nitrate leaching to occur when there is drainage

through the soil. The high loading rate of N under the urine patch is often exacerbated by the applications of N fertilizers and waste effluents, as they are applied to both the urine and non-urine patch areas.

Our recent studies have found that nitrate concentrations in the drainage water under a cow urine patch reached a peak of about 120 mg N /L (Figure 2) (Silva *et al.*, 1999). This compared with a peak nitrate concentration of 10 mg /L when urea was applied at 400 kg N ha /yr.

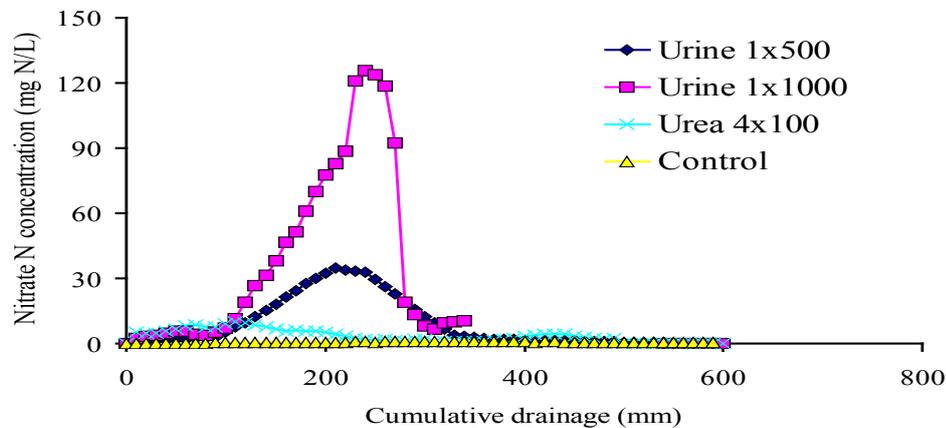


Figure 2: Nitrate leaching losses under cow (1000 kg N/ha) and sheep (500 kg N/ha) urine patches compared with those from urea (Di and Cameron, 2002).

Because urine patches do not cover the total area of a paddock, the contribution of urine-N to the overall nitrate leaching loss from a grazed paddock needs to be weighted by the fraction of area that is covered by urine. Assuming that 25% of the paddock area was covered by urine per year, then the nitrate leaching loss from the whole paddock was about 33 kg N ha/yr when no other N fertilizers were applied. When urea was applied at rates up to 400 kg N ha/yr on top of the urine patches, the nitrate leaching loss from the whole paddock ranged from 36-60 kg N ha/yr (Silva *et al.*, 1999).

Therefore, it is clear that in grazed pastures cow urine returns represent a greater source of nitrate leaching loss than N fertiliser use alone.

How does New Zealand's nitrogen use compare internationally?

It is helpful to keep things in perspective and to compare New Zealand's nitrogen use efficiency to other countries. The OECD report on Environmental Indicators, released in 2000, shows that New Zealand leads the world in efficient nitrogen use (OECD, 2001). New Zealand has an efficiency of 98% whereas the OECD average is 62% (Figure 3).

The OECD report gives data on nitrogen uptake in crops and pasture in comparison with nitrogen inputs in fertiliser, manure, biological nitrogen fixation, and atmospheric deposition. Our use of clover-based pastures, a lack of housed animals, and strategic use of fertilizers can explain our efficiency. Other contributing factors are that we don't import animal feed from other countries, and, because we are not an industrial nation, atmospheric deposition is virtually non-existent.

Although critics of the report have pointed out that the calculation is done on a whole country basis, the same is true for all countries. New Zealand has a similar proportion of agricultural land as Australia, Spain, Ireland and Denmark, but efficiency of use here is over 30% higher. Comparisons with countries such as Canada (75%) and Australia (62%) suggest that it is our clover-based pastures and strategic use of fertiliser that are the important factors.

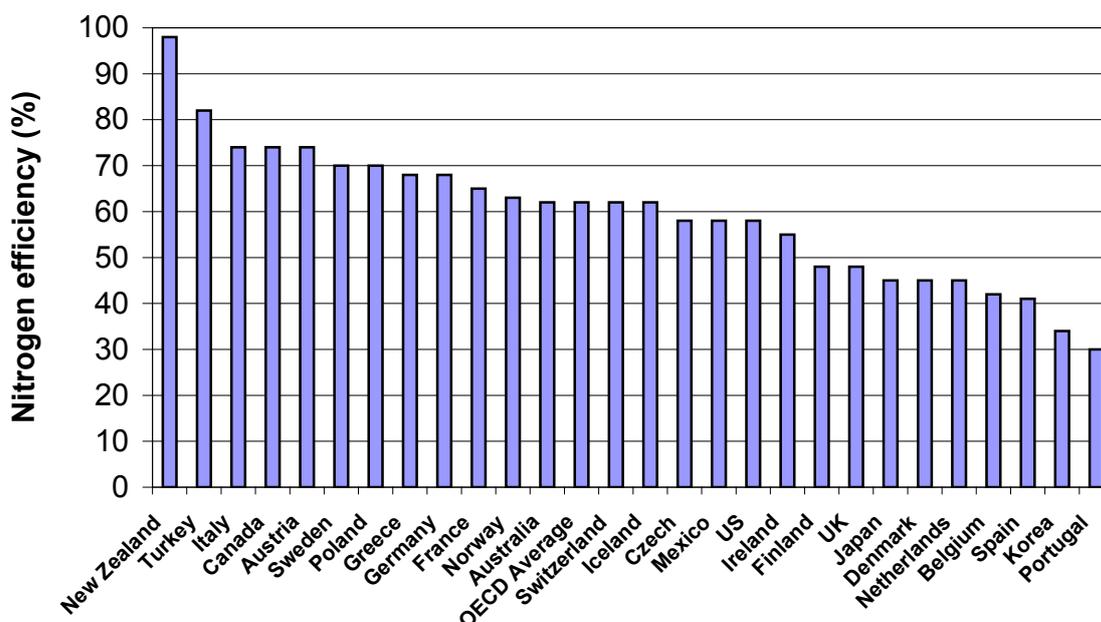


Figure 3: Nitrogen efficiency based on the soil surface nitrogen balance: 1995 – 97. Percentage of nitrogen uptake (output) compared to nitrogen input.

How can we use nitrogen with minimum risk to the environment?

It is best to use nitrogen fertiliser strategically to meet feed deficits. Best responses are achieved in early spring. To achieve the best response it is necessary to have a pasture cover of about 1,800 to 2,000 kg DM/ha. After applying fertiliser it is worthwhile leaving the pasture for about 2 to 3 weeks before grazing, this will ensure that the best response is achieved.

Fertiliser can be lost if it is applied too early in the spring. As a rough rule of thumb, 50 mm of rainfall on a wet soil could leach the band of fertiliser to about 100–50 mm depth

(depends on the soil). If the soil is dry then the depth of leaching is less because much of the water is used to satisfy the soil moisture deficit (e.g. during irrigation in summer).

It is essential to maintain a high soil fertility to get the maximum benefit from the nitrogen applied. Regular soil tests are needed to check on fertility and to decide on the fertiliser needs. Nitrogen should not be used in place of superphosphate or other P fertilisers if the soil tests show that these are needed. Most N fertilisers acidify the soil and it is important to monitor soil pH and to apply lime more often.

Research has shown that nitrogen fertiliser is most efficient when applied at rates of between 20 to 40 kg N/ha per application (i.e. giving a production increase of about 12 kg dry matter per kilogram of nitrogen applied). Application rates above 40 kg N/ha give a smaller increase in dry matter production per kilogram of nitrogen applied and, at 100 kg N/ha only 7 kg dry matter per kilogram N is achieved.

In summary;

- Apply less than 200 kg N/ha of N fertiliser per year, depending on the soil type, climate and management.
- Apply less than 40 kg N/ha per application.
- Apply when soil temperature is above 4°C in spring and above 7°C in autumn, i.e. not too early in spring or too late in autumn.

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Summary workshop

Questions

- Where does the 200 kg N/ha come from? Research overseas and in NZ. Canterbury research under irrigation conditions. Over 200 kg N/ha the leaching rate started to exceed the drinking water standards. Ruakura has also done similar research with the same results. The soil type and amount of water applied will affect the amount of leaching. 200 kg/N is based on a grazed system.
- What application regime was used during the 200 kgN/ha research? 20-40kg/ha at the strategic farming times throughout the year.
- The Canterbury Farmer of the Year has been using 300 kgN/ha. Is this the success we should be promoting? The winner was utilising best practise and using OVERSEER. But still important to ask the question how much N is being leached out.
- Why is the urine so high in N, has there been research into what goes into the cow and the management that is affecting this? Optimum for cow feed is 2%, while the optimum for pasture growth is 4%. The extra 2% is what gets excreted in urine and faeces. Dexcel and AgResearch are doing some of this work.
- What should the dairy industry do to ameliorate the bad public perception? Tidy up the 5% causing the problems. Put them under pressure. Educate the press on the good things we do within the industry.
- How effective are riparian strips in controlling nitrogen. Keeping fertiliser out of the stream is a first step during application. Plants or long grass also intercept sediment prior to it entering the stream.
- Is there a figure comparing the amount of water flowing overland vs. water flowing through the soil profile? Different for each soil type. Most water and most N will be going vertically through the soil profile. If there is a clay layer or a pan then the vertical flow will get to this and then be redirected laterally and go into drains or streams. Overland flow is the main transporter of sediment and Phosphorus, while N mainly gets transported through the soil profile and gets lost through leaching.
- What happens to leaching when you have low N? The more N applied the less the clover will fix.
- N use is economic on farm, why would we stop? Or does it need to be? Public pressure an influence. Are we going to be pro-active or do we wait until it is ruined and we can no longer fix it.? Threat of regulations being imposed if we do not.
- Are we working toward restrictions on stocking rate? Stocking rate is extremely important in N leaching. Setting maximum stocking rate has happened overseas but with time who knows.