LEACHING OF N COMPOUNDS FROM SWARDS USED FOR DAIRYING THAT ARE N-BASED AND IRRIGATED WITH DIRTY WATER/SLURRY

END OF PROJECT REPORT

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SUMMARY

A study was carried out to investigate nitrate leaching on a dairy farm in Co. Cork. The farm had a history of high nitrate-N in borehole waters and the study aimed to elucidate the causative factors for this. Physical and chemical data regarding the soils, the hydrology, and the N input/output balances were determined and collated.

Results showed that nitrate-N concentrations > the EU maximum allowable concentration (MAC) of 11.3 mg/l for drinking water occurred in soil drainage from the light textured soils studied due to a large imbalance between N inputs and outputs. High fertiliser N usage, animal manure and dirty water applications, atmospheric N depositions and soil organic N mineralisation in combination produced these results . While it is recognised that nitrate leaching will vary in amount from year to year the lessons from the study are clear - light textured soils that are used for intensive dairying and which receive high inputs of N are prone to release drainage water high in nitrate.

INTRODUCTION

There are two (1975, 1980) Directives from the European Communities specifically introduced to protect drinking water quality. These Directives require that nitrate-N concentrations in drinking water used for human consumption and water to be used for such do not exceed 11.3 mg/l nitrate-N; the recommended guideline value is half that amount.

A further Directive (1991), concerned with the protection of waters against pollution caused by nitrate from agricultural sources, led to the issuing of a "Code of Good Agricultural Practice to Protect Waters from Pollution by Nitrates" (Departments of the Environment and Agriculture, Food and Forestry, 1996). The Code is voluntary but includes guidelines on restricting stocking rates and fertiliser N- use should these be needed in vulnerable zones.

Within the context of the above it was considered important to acquire information on the effect of intensive dairy farming on nitrate-N concentrations in soil drainage water. Nitrogen inputs to farmland in dairy situations arise from fertiliser N, atmospheric deposition, animal manures and dirty water. There is in addition a significant contribution from the soil organic N source which is on-going for much of the year. N losses occur via immobilisation, ammonia volatilisation, denitrification, run-off and leaching. The latter was the aspect of primary interest in the study now reported.. Analyses of 3 borehole (well) waters in Co. Cork, from 1987 to 1992, had revealed nitrate-N levels which were multiples of the MAC. Mineral N contents of soil close to the boreholes, down to a depth of 75cm deep, corroborated these results and showed levels in 1991 of 167, 136 and 117 kg N/ha in boreholes 1, 2, 3, respectively and 137, 100, 90 kg N/ha, respectively, in 1992.

In 1990 irrigation of dirty water was associated with an extremely high soil mineral N level of 648 kg N/ha. It was therefore considered advisable to include this source of N as a variable in a study of the levels of N being leached from swards on the farm grazed by dairy cows receiving ~275 kg/ha fertiliser N.

MATERIALS AND METHODS

Measurements were made of the total N inputs to the grassland by collecting data on total N fertiliser usage, N content of slurries and dirty water and loads of the latter applied per hectare. Soil profiles were described, both physically and chemically, and the general hydrology of the farm was determined using Bromine tracing techniques.

Borehole water analysis information was extended through boring two extra boreholes and soil drainage water was analysed in detail to 150 cm using ceramic cups. Ceramic cup water analysis for nitrate-N extended over 3 drainage seasons. Mineralisation rates and total soil mineral N to 75 and 90 cm deep were determined; double ring infiltration rates and inverted auger hydraulic conductivity rates were measured also.

RESULTS

SOILS

The soils on the farm associated with boreholes 1 to 5 were --
1: A sandy loam to 60 cm deep, 2: a sandy loam to 60 cm deep; 3: a sandy loam over sandy silt loam to 73 cm deep; 4: a sandy silt loam over sandy loam to 106 cm deep; 5: a sandy silt loam to 50 cm deep over clay loam to 70 cm deep.

The results of heavily irrigating dirty water on two plots of the farm in 1995 were clear in that those plots receiving the irrigated water had soil mineral N contents of 143, 279 kg/ha to 75 cm deep and 168, 324 kg/ha to 90 cm deep compared to 73 and 88 kg/ha to those depths in a plot not irrigated with dirty water.

Significant relationships ($P<0.01$) and ($P<0.02$) were observed between the quantity of inorganic soil N available for leaching (y) and the N applied to each plot. The relationship was $y = 0.141x + 6.77$ ($R2 = 0.61$) for x = total N applied and $y = 0.216x -22.2$ ($R2 = 0.5$) for x = available inorganic N. Maximum soil inorganic N levels were observed in all plots studied in late September /early October; mean levels were 15 to 29 µg N/g dry soil with ranges up to 233 µg N/g dry soil.

SOIL WATER

A summary of the soil solution nitrate-N concentration at 150 cm deep for the 1994/95 and 1995/96 drainage seasons can be seen in Table 1.

Table 1 Summary of soil solution nitrate-N concentrations (mg/l) measured at 150cm deep in four plots related to boreholes with high nitrate.

Drainage Year	Plot (Borehole No)				Four plot low-high
	5(2)	**16(3)**	**3a(4)**	**7(5)**	**Overall Mean**
Range	8 - 41	4 - 62	7 - 37	12 - 64	10 - 51
1994/95 Mean	27	23	24	31	26
Range	13 - 49	5 - 81	21 - 44	15 - 43	14 - 54
1994/95 Mean	30	24	31	25	28

All plots produced water samples at the 150 cm depth during the 1994/95 drainage season. The mean soil solution concentration in each plot sampled at the 150 cm depth was > 11.3 mg/l nitrate-N; the four plot mean was 26 mg/l. Plots 16 and 3a had the lowest mean nitrate-N concentrations at the 150 cm depth but even these were double the MAC.

During the 1995/96 drainage season all borehole plots had mean nitrate-N concentrations in the soil solution > 11.3 mg/l; maximum concentrations ranged 43 to 81 mg/l. The overall mean concentration for the four plots was 28 mg/l.

The high mean soil solution concentrations in plots 5 and 3a were related to the highest inorganic N application rates from 1993 to 1995, inclusive. These plots received mean application rates of 672 and 677 kg N/ha per year over the three years while the other two plots received only 405 and 488 kg N/ha per year in those years.
The two plots (6, 6a) selected for treatment with heavy loads of dirty water in 1995, to monitor effects on soil solution nitrate-N concentrations, showed levels typically rising to >80 mg/l in November-December and up to 120 mg/l in one plot. The mean soil solution nitrate-N concentrations for these plots in the monitoring period were 49 and 59 mg/l, i.e., > 4 to 5 times the MAC.

An overall farm gate N budget calculated for the three years 1993-1995, allowing 25 kg N/ha as atmospheric deposition, showed that the excess N input (input-output) was in the range 271 to 340 kg N /ha. Only 24, 21, 21% of net N inputs were removed from the farm in commercial products in 1993,1994 and 1995.

CONCLUSIONS

Light textured soils used for grazing by dairy cows which receive high overall rates of N applications are vulnerable to nitrate leaching. Standard N fertiliser dressings plus liberal amounts of dirty water onto such soils also make them vulnerable to nitrate leaching. The concentrations may be double the maximum allowable concentration of 11.3 mg/l nitrate-N.

Nitrogen fertiliser alone, if applied according to the grass demand, is unlikely to cause elevated levels of nitrate-N in the soil solution. Exceptions to this may occur where high rates of mineralisation of organic N happen by virtue of inherent soil characteristics or past management.

Farm gate budgeting and nutrient management planning are necessary in order to attempt to bring N inputs closer to balance with N outputs and to minimise the risks of nitrate leaching to groundwater on vulnerable soils.