

Leaching of nitrate from a grassland field

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Introduction

Agricultural activities are the major cause of non-point pollution. Mechanization of agriculture, artificial fertilizer use and overall intensification of farming has played a major role in the increased incidence of pollution by agricultural activities. Carton *et al.* (2006) reported the effects of agricultural practices on nitrate leaching from an intensively managed dairy farm and showed that mean concentrations of nitrate nitrogen in the groundwater beneath the farm during the two monitoring years exceeded the maximum admissible concentration (MAC) for drinking water. While average nitrate nitrogen concentration in soil water were less than MAC, there was a trend for increased nitrogen loading to result in elevated concentrations of nitrate nitrogen in soil water and ground water. Grassland devoted to 90% of agricultural land in Ireland, almost all fertilizer and animal manures is surface applied, with little incorporation through the soil. This means that most fertilizer and manure tends to accumulate in the top few centimeters of soil, so that this layer can become saturated or nearly saturated with organic compounds in specific nitrate. During rainfall events, water that runs over or infiltrates through this enriched surface soil can carry significant amounts of nitrate with it. This, in turn, can enrich surface water and contribute to eutrophication (Tunney *et al.* 2000).

According to the Environmental Protection Agency (Lucey 2005), eutrophication of inland waters is the main environmental issue in Ireland. A chemical analysis of water samples from a ground water well in Skeagh yard nearby the Hill Field in the UCD Research Farm showed high nitrate concentration of 55 mg NO₃/L which exceeded the EU drinking water standards (Hart pers comm). The Hill Field at the UCD Research Farm was chosen as being representative of good versatile land, with undulating topography, on which moderate to intensive farming is practised in the drier rainfall areas of Ireland. Historically the field was included in the tillage rotation of the farm, but it has been in permanent grass for the last 25 years.

Material and Methods

Field management

The Hill Field is normally grazed by sheep and young cattle from August to December, and from February to April each year. One cut of silage is taken between the middle and the end of May. Chemical fertilizer in the form of urea is applied at a rate of 60 kg N/ha before grazing commences

in the spring and again at a rate of 180 kg N/ha when it is closed up for silage. After silage cutting, animal slurry (a mixture from cattle and pigs) is applied at a rate of 27 m³/ha along with calcium ammonium nitrate at a rate of 100 kg N/ha. No P or K chemical fertilizer, in addition to that applied in slurry, has been used for the last 5 years, but the field has received occasional, but unquantified, additional applications of slurry when conditions demanded outside the grazing periods.

Survey and sampling

Five monitoring stations were set up in the Hill Field at meter contours. Suction lysimeters (Prenart Teflon and ceramic soil water samplers) were installed in the five stations at depths to 85 cm. Soil water samples were collected when their volumes were large enough to permit analysis.

Nitrate analysis

All water samples were filtered through 0.45- μ M Millipore filter paper immediately after collection. Nitrate were analyzed by ion chromatography (IC), using anion exchange column and conductivity detection.

Results and Discussion

Nitrate (NO₃) concentrations were very high in soil water samples and averages concentration of NO₃ in soil water were greater than MAC. These values appear to confirm the views of Stevens *et al.* (1999) that high levels of Nitrate applied in fertilizer or manure may impact adversely groundwater quality, and leads to groundwater contamination.

The results show that there was considerable variation in nitrate concentrations from station to station, and between samples obtained by Teflon and ceramic water samplers in the same station. Some of the latter variation would have been due the different depths that Teflon (25, 65 and 86cm) and ceramic cups (30, 50 and 70 cm) were installed at, and the fact that the monitoring period was not the same for both types of samplers. There was a clear tendency for concentrations to decrease with depth for Teflon samples, but that trend was not so consistent in ceramic cup samples (Table 1). It is possible that these differences were simply due to soil heterogeneity. The mean NO₃ concentrations in Teflon and ceramic soil water samples were very high, with concentrations in Teflon soil water samples ranging from 51 -903 μ g/ml at 25 cm depth, 4 - 576 μ g/ml at 65 cm depth, and from 6 - 675 μ g/ml at 85

Table 1. Mean NO₃ concentrations (µg/ml) in Teflon and ceramic soil water samples for each Station in the Hill Field.

Sampler type	Depth (cm)	Station				
		S1	S2	S3	S4	S5
Teflon	25	140	271	150	202	351
	65	235	-	202	241	178
	85	127	-	245	390	113
Ceramic	30	194	-	595	-	203
	50	163	-	659	-	406
	70	157	-	1008	-	443

cm depth. Even allowing for differences in installation depths, nitrate concentrations in ceramic soil water samples tended to be greater than those in Teflon cup samples. Ceramic soil water samples at depth 30 cm had the highest range of NO₃ concentrations (64 - 1954 µg/ml), while at 50 cm depth the range was 136 – 688 µg/ml, compared with 26 - 1285 µg/ml at 70 cm depth.

The NO₃ concentration varied from one station to another. The highest variation occurred with Teflon and ceramic cup samples at different depths, and even at the one depth in the same station. Differences were apparent even between the shallowest Teflon and ceramic samplers that were inserted at almost the same depth. The highest NO₃ concentrations were recorded in a ceramic cup samples collected from Station 3, where NO₃ concentrations were higher than in other stations, and even higher than in Teflon cup samples (Table 1). Because

values were unexpectedly high, ceramic cups were tested for possible contamination after removal from the field. After soaking in de-ionised water in the lab, water that entered the cups was tested and found to be low in nitrate, thereby, eliminating any possibility that the high values recorded were due to NO₃ contamination of the cups.

Conclusion

The results show that the leaching of NO₃ is very high. The differences reported for the 2 types of sensors must be taken into consideration. Although no sampling was carried out below the root zone but it must be assumed that the high concentrations measured would constitute a threat to groundwater resources and high concentration of NO₃ in the well due to leaching of nitrate from root zone.

References

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