Impact of the application of nitrogen from livestock manure on agricultural parcels on water quality: derogation in Flanders

Vandervelpen, D.[a], Maes, S.[a], Tits, M.[a], Elsen, A.[a], Bries J.[a], Vandendriessche, H.[a], Van Overtveld, K.[b], Peeters, L.[b], Batelaan, O.[b], Van Orshoven, J.[b], Vanderborght, J.[b], Diels, J.[b]

[a]Soil Service of Belgium, Heverlee, Belgium

[b]Department of Earth and Environmental Science, K.U. Leuven, Belgium

1. Background & Objectives

In the commission decision of 21 December 2007, the Commission of the European Communities approved the Belgian request, with regard to the region of Flanders, to allow a higher application of livestock manure than provided in Nitrogen Directive 91/676/EEC. In this derogation decision a number of specific conditions were imposed on individual farms applying derogation as well on the competent authorities with regard to monitoring, control and reporting. Since nitrogen fertilizers will become more expensive in the future, it is of great importance to verify the possibility of substitution with livestock manure without impact on soil and water quality. The objective of this research is to assess the impact of derogation on nitrogen losses from the soil and on water quality through a monitoring network of at least 150 farms (target of 180 farms and 225 parcels) during 2007-2010.

2. Materials & Methods

The existing monitoring network for phreatic groundwater was chosen as the basis for the set-up of the derogation monitoring network. This groundwater network consists of 2,107 multilevel monitoring wells with short well screens at 3 depths. The wells are equipped with one or more filter elements of 50 cm in length. Preferably, the first two wells were installed in the oxidized zone of the aquifer, where the third well was installed in the deeper reduced zone. For every well the infiltration area and the travel time for water from the root zone to the uppermost well screen was calculated. Only monitoring wells where the infiltration area was completely located in a single agricultural parcel and had a travel time less than 3 years were selected for the derogation monitoring network. In this way the measured water quality in a monitoring well could be linked to the agricultural parcel. Other selection criteria were willingness of farmer to participate, soil type, derogation/non derogation and cultivated crop. One hundred and twenty one parcels linked to monitoring wells were selected, less than the required 225 parcels. Therefore additional parcels were selected from farmers who volunteered to participate in the network and extra monitoring wells were placed to measure the water quality on their parcels. After the selection of parcels several types of measurements were carried out. Each hydrological year a soil sample was taken before and after winter from 0-90 cm in three layers to measure the amount of nitrate in the soil. This gives information on the nitrate residue after harvest and the nitrate leaching out towards the surface and groundwater. To investigate the quality of the surface and groundwater, water samples from the phreatic monitoring wells, the extra monitoring wells, drains, ditches and canals were taken. In order to measure the water quality on parcels with a water level deeper than 1.5 m, a soil sample was taken from 90-120 cm and from 120-150 cm. Besides a general comparison of all derogation and non-derogation parcels, detailed comparisons were carried out for the most common combinations of cultivated crop (grass and maize) and soil type in Flanders (sand and sandy loam). ANOVA tests ($P \leq 0.05$) were carried out to verify statistical differences of measured nutrients between derogation and non-derogation parcels.

3. Results & Discussion

Differences in nutrient levels in the soil profile were present among different cultivated crops and soil types but less between derogation and non-derogation parcels. No statistically significant differences were found between derogation and non-derogation parcels for nitrate in the soil profile (0-90 cm) at none of the sampling moments. Table 1 shows the nitrate results from the most common combinations (sand/sandy loam, grass/maize).

Table 1. Summary of nitrate-N (kg ha^{-1}) in the soil profile (0 to 90 cm) at different moments for the most important combinations of soil type and cultivated crop for derogation and non-derogation parcels.

Date		Crop	Derogation	Non-derogation	Significance*
Nov 2009	Sand	Grass	57(± 42)	51 (± 36)	n.s.
		Maize	109 (± 49)	93 (± 33)	n.s.
	Sandy loam	Grass	68 (± 34)	85 (± 39)	n.s.
		Maize	80 (± 30)	77 (± 36)	n.s.
Feb 2010	Sand	Grass	38 (± 22)	40 (± 25)	n.s.
		Maize	44 (± 25)	44 (± 15)	n.s.
	Sandy loam	Grass	45 (± 30)	49 (± 16)	n.s.
		Maize	38 (± 16)	37 (± 16)	n.s.
Nov 2010	Sand	Grass	47 (± 42)	39 (± 31)	n.s.
		Maize	77 (± 43)	78 (± 50)	n.s.
	Sandy loam	Grass	41 (± 24)	66 (± 64)	n.s.
		Maize	74 (± 45)	70 (± 37)	n.s.
Feb 2011	Sand	Grass	33 (± 15)	46 (± 21)	n.s.
		Maize	40 (± 12)	45 (± 22)	n.s.
	Sandy loam	Grass	38 (± 24)	36 (± 18)	n.s.
		Maize	43 (± 16)	44 (± 12)	n.s.

*n.s. indicates no statistically significant difference for the ANOVA test ($P \leq 0.05$).

No statistically significant differences were observed between derogation and non-derogation parcels for the concentrations of nitrate in drains, canals and ditches. In the sampling points (phreatic monitoring wells and extra monitoring wells, Table 2) and in soil water (90-120 cm, Table 3) no statistically significant difference was present between derogation and non-derogation parcels.

Table 2. Average value for nitrate (mg NO_3 L^{-1}) of sampling points linked to parcels for all crops and soil types.

Date	N	Derogation	n	Non-derogation	Significance*
2008	47	25 (± 47)	66	29 (± 45)	n.s.
2009	40	31 (± 54)	25	20 (± 41)	n.s.

*n.s. indicates no statistically significant difference for the ANOVA test ($P \leq 0.05$).

Table 3. Average value for nitrate (mg NO_3 L^{-1}) in pore water in the soil layer 90-120cm for all crops and soil types.

Date	Derogation	Non-derogation	Significance*
November 2009	77 (± 58)	95 (±101)	n.s.
February 2010	64 (± 56)	92 (± 77)	n.s.
November 2010	64 (± 63)	77 (± 113)	n.s.
February 2011	48 (± 37)	76 (± 72)	n.s.

*n.s. indicates no statistically significant difference for the ANOVA test ($P \leq 0.05$).

4. Conclusion

Based on the extensive information of the monitoring network it is possible to conclude that application under specific derogation conditions of more nitrogen originating from livestock manure than described in Nitrogen Directive 91/676/EEC has no significant negative impact on water quality in Flanders, regarding nitrate concentration.