National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Agricultural practice and water quality on farms

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Results for 2010 in the derogation monitoring network

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LEI
WAGENINGEN UR

Abstract

Agricultural practice and water quality on farms registered for derogation
Results for 2010 in the derogation monitoring network

This report provides an overview of fertilisation practice in 2010 and of water quality in 2010 and 2011 on grassland farms in the Netherlands that are allowed to use more livestock manure than the limit set in the EU Nitrates Directive (derogation). Data from this research can be used to evaluate the consequences of derogation for the water quality. The water quality values measured in 2010 reflect the consequences of agricultural practice in 2009, which was the fourth year in which the derogation was applied in practice. The water quality values measured in 2011 reflect the consequences of agricultural practice in 2010.

Background derogation monitoring network
The EU Nitrates Directive obliges member states to limit the use of livestock manure to a specified maximum (the application standard for livestock manure of 170 Kg N per hectare). A member state may request permission from the European Commission to deviate from this obligation under specific conditions. In December 2005, the Commission granted the Netherlands the right to derogate from the obligation from 2006 to 2009. On 5 February 2010, this derogation was extended to December 2013. One of the underlying conditions of the derogation is that the Dutch government establishes a monitoring network focused on derogation, and reports the results each year to the Commission.

Monitoring agricultural practice and water quality in 2010
In 2006, the National Institute for Public Health and the Environment (RIVM) and the Agricultural Economics Research Institute (LEI Wageningen UR), set up this derogation monitoring network for the Netherlands. This network measures the effects on agricultural practice and water quality when farmers are allowed to deviate from the European application standard for livestock manure. The derogation monitoring network is part of the Minerals Policy Monitoring Programme (LMM). In 2010 the agricultural practice was measured on 294 grassland farms and the water quality on 290 grassland farms. The monitoring network covers 300 grassland farms. However, fewer than 300 farms are reported due to the fact that some farms did not apply for or were not awarded derogation in the end, or did not continue in the monitoring network on account of termination of business.

Keywords:
agricultural practice, derogation decision, manure, Nitrate Directive, water quality

Rapport in het kort

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie
Resultaten meetjaar 2010 in het derogatiemeetnet

Dit report geeft een overzicht van de bemestingspraktijk in 2010 en de waterkwaliteit in 2010 en 2011 op graslandbedrijven in Nederland die meer dierlijke mest mogen gebruiken dan in de EU-Nitraatrichtlijn is aangegeven (derogatie). De gegevens uit dit onderzoek kunnen worden gebruikt om de gevolgen van derogatie voor de waterkwaliteit te bepalen. De waterkwaliteit gemeten in 2010 geeft de gevolgen weer van de landbouwpraktijk in 2009, het vierde jaar dat de derogatie in de praktijk werd toegepast. De waterkwaliteit gemeten in 2011 geeft de gevolgen weer van de landbouwpraktijk in 2010.

Achtergrond derogatiemeetnet
De Europese Nitraatrichtlijn verplicht lidstaten om het gebruik van dierlijke mest te beperken tot een bepaald maximum (de gebruiksnorm dierlijke mest van 170 kg stikstof per hectare). Een lidstaat kan de Europese Commissie vragen om onder voorwaarden van deze beperking af te wijken. Nederland heeft in december 2005 derogatie gekregen om van 2006 t/m 2009 af te mogen wijken van de gestelde norm voor dierlijke mest. Deze derogatie is op 5 februari 2010 verlengd t/m december 2013. Een van de voorwaarden hiervoor is dat de Nederlandse overheid een monitoringsnetwerk gericht op derogatie inricht en aan de Commissie jaarlijks rapporteert over de resultaten daarvan.

Monitoring van bedrijfsvoering en waterkwaliteit in 2010
Het Rijksinstituut voor Volksgezondheid en Milieu (RIVM) en LEI Wageningen UR, hebben dit monitoringsnetwerk in 2006 voor Nederland opgezet. Dit zogenoemde derogatiemeetnet meet de gevolgen van de landbouwpraktijk en de waterkwaliteit als landbouwbedrijven afwijken van de Europese gebruiksnorm voor dierlijke mest. Het derogatiemeetnet is een onderdeel van het Landelijk Meetnet effecten Mestbeleid (LMM). Voor het derogatiemeetnet is in 2010 van 294 graslandbedrijven de bedrijfsvoering gemonitord en van 290 bedrijven de waterkwaliteit. Het meetnet omvat 300 graslandbedrijven. Dat er minder dan 300 bedrijven zijn gerapporteerd komt doordat sommige bedrijven toch geen derogatie toepasten of toegekend kregen of niet langer deelnamen vanwege bedrijfsbeëindiging.

Trefwoorden:
derogatiebeschikking, landbouwpraktijk, mest, Nitraatrichtlijn, waterkwaliteit

Preface

The National Institute for Public Health and the Environment (RIVM) and LEI Wageningen UR, have drawn up this report, commissioned by the Ministry of Economic Affairs, Agriculture and Innovation (EL&I), as well as on behalf of the Ministry of Infrastructure and the Environment (I&M). LEI is responsible for the information about agricultural practice and RIVM for the water quality data. RIVM is also the official secretary within this project.

This report provides an overview of agricultural practice in 2010 in respect of all the farms registered for derogation in the derogation monitoring network. This includes, among others, data on fertilising and nutrient surpluses realised. Information is also provided about the results of water quality monitoring in 2010 and 2011 at farms in the derogation monitoring network.

The present report covers virtually all the 300 farms participating in the derogation monitoring network. Due to changes in the sample population such as business termination, variations between participating farms occur throughout the years measured. Moreover, in retrospect, not each farm uses the derogation in practice. Consequently, the numbers of farms in the different regions can vary among years. The 300 farms were either already participating in the Minerals Policy Monitoring Programme (LMM) or were recruited and sampled during sampling campaigns.

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10 August 2012

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Summary

Background
The Nitrates Directive obliges member states to limit the use of livestock manure to a maximum of 170 kg of nitrogen per hectare per year. A member state can, under certain conditions, ask the European Commission if it may deviate from this obligation (derogation). In December 2005, the European Commission issued a derogation decision to the Netherlands for the period 2006-2009; in February 2010 this was extended until December 2013. Under this decision, grassland farms with 70 percent or more grassland may, under prescribed conditions, apply up to 250 kg nitrogen (N) per hectare to their land in the form of manure from grazing livestock. In return, the Dutch government is obliged to set up a monitoring network for derogation farms in accordance with the requirements stipulated in the derogation decision, and to provide annual reports in this respect to the European Commission.

The derogation monitoring network
In 2006, a new monitoring network was established to monitor the evolution in agricultural practice and water quality as a consequence of the derogation. This derogation monitoring network comprises 300 farms that registered for derogation. The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (LMM) of RIVM and LEI. By using a stratified random sampling method, the 300 farms are distributed as evenly as possible throughout the Netherlands in terms of region (sand, loess, clay and peat), farm type (dairy farms and other grassland farms) and economic size class. With this approach, the requirement that the derogation decision be representative for all soil types (clay, peat, sand and loess soils), cropping patterns and fertilisation practices – with the emphasis on the sand region – is effectuated.

Characteristics of farmland and farms in the derogation monitoring network
In 2010, the total agricultural area in the derogation monitoring network was 1.8 percent of the area used by all derogation farms that fulfilled the criteria for inclusion in the monitoring network (the sample population).

At 53 hectare (Table S1), the mean acreage of farms in the derogation monitoring network is larger than that of the average farm in the sample population (44 hectare). Dairy farms in the network also produced more milk per hectare, especially in the loess region. The percentage of farmland used as grassland (83 percent - Table S1) is slightly higher than in the sample population (82 percent).

Table S1 Characteristics of farms included in the derogation monitoring network for 2010, per region.

Characteristics	*Region*				
	Sand	*Loess*	*Clay*	*Peat*	*All*
Number of farms in the monitoring network	160	20	60	60	300
Number of farms with derogation and fully processed in FADN[1]	158	19	59	58	294
- of which specialised dairy farms	133	17	51	52	253
- of which other grassland farms	25	2	8	6	41
Descriptive characteristics					
Acreage of cultivated land (ha)	49	46	57	60	53
Percentage grassland	81	76	84	91	83
Milk production (kg FPCM[2]) per ha fodder crop	16,000	15,900	16,500	15,000	15,900

1: FADN: Farm Accountancy Data Network

2: FPCM = Fat and Protein Corrected Milk – this is a comparative standard for milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM). The means reported for the milk production only refer to the dairy farms (N = 253).

Use of fertilisers

In 2010, the farms in the derogation monitoring network used on average 246 kg of nitrogen from livestock manure per hectare of cultivated land (Table S2) and, with this, they complied exactly with the application standard for livestock manure at farm level. On arable land, an average of 166 kg per hectare was used, whereas on grassland an average of 260 kg nitrogen from livestock manure was applied.

The total use of nitrogen remained below the total nitrogen application standard. The use of phosphate remained some kg below the phosphate application standard.

Table S2 Mean use of fertilisers on farms in the derogation monitoring network in 2010, per region.

Characteristics		*Region*				
		Sand	*Loess*	*Clay*	*Peat*	*All*
Nitrogen from livestock manure (kg N/ha)	Farm level	245	233	251	247	246
	Arable land[2]	168	176	149	177	166
	Grassland	258	254	274	256	260
Total plant-available nitrogen[1] (kg N/ha)	Farm level	233	231	271	248	243
	Arable land[2]	115	174	120	121	122
	Grassland	259	254	304	264	269
Total phosphates[1] (kg P_2O_5/ha)	Farm level	89	86	90	90	89
	Arable land[2]	79	93	76	90	81
	Grassland	91	84	94	90	91

1: From livestock manure, other organic and inorganic fertiliser. The quantity of plant-available nitrogen from livestock manure and other organic fertiliser was calculated using the statutory availability coefficients determined for 2010.

2: Arable land on grassland farms is used mainly for the production of silage maize (average 88%).

Crop yield and nutrient surpluses at farm level

On average, yields of 183 kg per hectare of nitrogen and 71 kg per hectare of phosphate were estimated for silage maize, and yields of 257 kg per hectare of nitrogen and 85 kg per hectare of phosphate were calculated for grassland (Table S3). The mean nitrogen surplus on the soil surface balance in 2010 was calculated to be 185 kg per hectare. This surplus decreases in the sequence peat > clay > sand and loess (Table S3). The high surplus in the peat region was caused by an average of 75 kg of net nitrogen mineralisation per hectare being included in the calculation, whereas in the other regions the net nitrogen mineralisation was negligible. Nevertheless, the nitrogen surplus on the soil surface balance in the clay region is higher than in the sand and loess regions, due to higher use of inorganic fertilisers (Table S2). The phosphate surplus on the soil surface balance is on average 12 kg P_2O_5 per hectare, with little difference between the regions, although the phosphate surplus in the clay region is slightly lower.

Table S3 Mean estimated silage maize yield and calculated grassland yield on all farms that satisfied the selection criteria for applying the calculation method (Aarts et al., 2008) and nutrient surpluses on the soil surface balance on the farms in the derogation monitoring network in 2010, per region.

Characteristics	*Region*				
	Sand	*Loess*	*Clay*	*Peat*	*All*
Estimated silage maize yields[1]					
Kg dry matter/ha	15,600	17,600	15,100	15,200	15,600
Kg N/ha	183	205	177	179	183
Kg P_2O_5/ha	71	81	70	69	71
Calculated yield on grassland[1]					
Kg dry matter/ha	9200	9500	10,800	10,000	9700
Kg N/ha	245	249	283	272	257
Kg P_2O_5/ha	80	86	96	88	85
Nutrient surpluses per ha cultivated land					
Nitrogen surplus on the soil surface balance (kg N/ha)	166	166	193	233	185
Phosphate surplus on the soil surface balance (kg P_2O_5/ha)	13	11	9	13	12

1: The silage maize and grassland yields are based on 146 and 193 farms respectively. The other farms did not satisfy the selection criteria.

Comparison of agricultural practice for the years 2006 to 2010

The significant increase in the production of milk per farm, per hectare and per cow as opposed to an insignificant increase in acreage of cultivated land, indicates a slow ongoing increase in scale and intensification resulting in a higher production of milk per cow and more kg of milk per hectare. At the same time, the proportion of grassland remains more or less stable and the number of farms with grazing milk cows gradually diminishes (Table S4).

Table S4 Evolution of the average size and structure of farms and milk production on farms for grazing animals.

Characteristics	*2006*	*2007*	*2008*	*2009*	*2010*
Total acreage cultivated land (ha)	49	50	51	52	53
Proportion of grassland (%)	83	83	82	82	83
Proportion of farms with housed animals (%)	17	17	17	14	14
kg FPCM[1]/farm (x 1000)	686	723	775	811	860
kg FPCM[1]/milk cow (x 1000)	8.4	8.4	8.4	8.5	8.7
kg FPCM[1]/ha fodder crop (x 1000)	14	14	15	15	16
Proportion of dairy farms with grazing milk cows (%)	89	88	86	83	79

1: FPCM = Fat and Protein Corrected Milk – this is a comparative standard for milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM).

The nitrogen application standard for livestock manure is fully utilised (Table S5). There is a slight but significant increase in the use of plant-available nitrogen with livestock manure. This increase is caused mainly by the increased availability coefficient of nitrogen in livestock manure. Also as a result of this increase in the stipulated availability coefficient, the difference between the total nitrogen application standard and the use of plant-available nitrogen decreased from an average of 50 kg per hectare (2006) to an average of around 20 kg per hectare (2010) (Table S5). The difference between the use of phosphates per hectare and the phosphate application standard decreased from an average of around 10 kg per hectare (2006/2007) to 2 kg per hectare (2010), mainly as a result of the stricter regulations for use which were introduced in 2010. These regulations also take into account the phosphate condition of the soil. The use of phosphates as well as the phosphate application standard dropped significantly between 2006 and 2010 (Table S5). This went hand in hand with the decreased use of phosphate inorganic fertiliser.

Table S5 Evolution of mean use of nitrogen in livestock manure, total use of plant-available nitrogen and phosphate, and surpluses on the soil surface balance of nitrogen and phosphate on farms for grazing animals.

Characteristics	*2006*	*2007*	*2008*	*2009*	*2010*
Use of nitrogen livestock manure, excluding availability coefficient/ha	243	238	241	251	246
Application standard livestock manure/ha	243	241	243	244	246
Use of total of plant-available nitrogen, including availability coefficient/ha	226	225	243	251	243
Total nitrogen application standard for farms/ha	273	288	275	267	263
Mean nitrogen surplus on the soil surface balance/ha	195	183	192	202	185
Use of phosphate/ha	97	93	93	97	89
Phosphate application standard for farms/ha	106	103	98	98	91
Mean phosphate surplus on the soil surface balance/ha	25	17	16	20	12

The surpluses on the soil surface balance for nitrogen fluctuated somewhat across the years, but did not significantly decrease between 2006 and 2010, while the phosphate surplus did show a significant decrease between 2006 and 2010 (Table S5). In 2010, the farms in the 25 percent quartile realised a phosphate surplus of below 0 kg per hectare (0 kg/ha = balance). The lower surpluses for nitrogen and phosphate on the soil surface balance are virtually equal to the decrease in use of inorganic fertilisers.

The phosphate application standard at farm level for 2010 is lower than average in the period 2006-2009. This is caused by the fact that, starting in 2010, the phosphate condition of the soil is taken into account, which means that for soil with a neutral or high phosphate value the phosphate application standard was lowered compared to the previous year. The dry matter and phosphate values with regard to the estimated silage maize yields and the calculated yield on grassland did not deviate from the means in the years 2006-2009. These values were hardly influenced by the lower fertilisation rate. However, there is a downward trend in the yield measured in kg nitrogen, caused by the lower N-values in the crops. This applies to grassland as well as silage maize.

Water quality in measurement year 2010

The water quality measured in 2010 partly reflects the agricultural practice in the fourth year of derogation (2009) and in previous years. The mean nitrate concentration is higher in the sand and loess regions than in the other two regions, just as in previous years. One of the reasons for this is that the loess and sand regions have a relatively large share of soils prone to leaching.

In the sand, clay and peat regions, the nitrate and total nitrogen concentrations in water leaching from the root zone (Table S6) are on average higher than in the ditch water (Table S7). In the sand and clay regions, the phosphorus concentrations in the ditch water are comparable to those in the water leaching from the root zone. In the peat region, the phosphorus concentrations in the ditch water are lower than those in the water leaching from the root zone.

Table S6 Quality of the water leaching from the root zone in 2010; mean concentration of nitrate, total nitrogen and phosphorus[1] in mg/l and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	158	18	56	57
Nitrate (NO_3) (mg/l)	45	51	29	12
Nitrate % farms > 50 mg/l	39	44	12	4
Nitrogen (N) (mg/l)	13	12	8.5	9.5
Phosphorus (P) (mg/l)	0.13	<dt	0.21	0.43

1: Means below the detection limit of 0.062 mg/l are marked <dt.

Table S7 Quality of the ditch water in the winter of 2009/2010; mean concentration of nitrate, total nitrogen and phosphorus in mg/l and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.

Characteristic	*Region*		
	Sand	*Clay*	*Peat*
Number of farms	31	55	56
Nitrate (NO_3) (mg/l)	33	11	4
Nitrate % farms > 50 mg/l	19	0	0
Nitrogen (N) (mg/l)	9.6	4.6	3.9
Phosphorus (P) (mg/l)	0.13	0.24	0.14

Water quality in measurement year 2011, preliminary results
The preliminary results for the water quality in 2011 reflect the agricultural practice in 2010 (fifth year of derogation) and the previous years (Table S8 and S9). These figures can therefore be directly linked to the agricultural data that are stated in this report as well. The final results will be included in the report for 2013 (these are not expected to strongly deviate from the preliminary results).

Table S8 Quality of water leaching from the root zone in 2011; mean concentration of nitrate, total nitrogen and phosphorus in mg/l and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.

Character	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	158	*	57	59
Nitrate (NO_3) (mg/l)	38	*	20	7
Nitrate % farms > 50 mg/l	30	*	7	2
Nitrogen (N) (mg/l)	12	*	6.3	8.7
Phosphorus (P) (mg/l)	0.20	*	0.23	0.39

*: At the time of preparation of the present report, results from the loess region were not yet available; sampling was conducted between September 2011 and February 2012.

Table S9 Quality of the ditch water in the winter of 2010/2011; mean concentration of nitrate, total nitrogen and phosphorus in mg/l and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.

Characteristic	*Region*		
	Sand	*Clay*	*Peat*
Number of farms	31	56	58
Nitrate (NO_3) (mg/l)	25	8	4
Nitrate % > farms 50 mg/l	16	0	0
Nitrogen (N) (mg/l)	7.8	3.8	4.3
Phosphorus (P) (mg/l)	0.09	0.28	0.15

Comparison of water quality results for the period 2007 to 2011
This year results are available from five consecutive sampling years (except for the loess region).

The nitrate and total nitrogen concentrations measured in the water leaching from the root zone fluctuate over the years (Figure S1), and show a decrease in the sequence loess > sand > clay > peat. In recent years, the mean nitrate concentration was below the 50 mg/l EU target value.

In 2011, the nitrate and total nitrogen concentrations measured in the water leaching from the root zone in the sand region were significantly lower than the mean of the previous years. This is not the case in the other regions. In the sand and loess regions the concentrations decreased significantly between 2007 and 2011 (Table 4.9). These significant trends were possibly influenced by the strong fall between 2007 and 2008. After 2008, the decrease was minimal, particularly in the loess region. In the other regions no significant decreases occurred between 2007 and 2011.

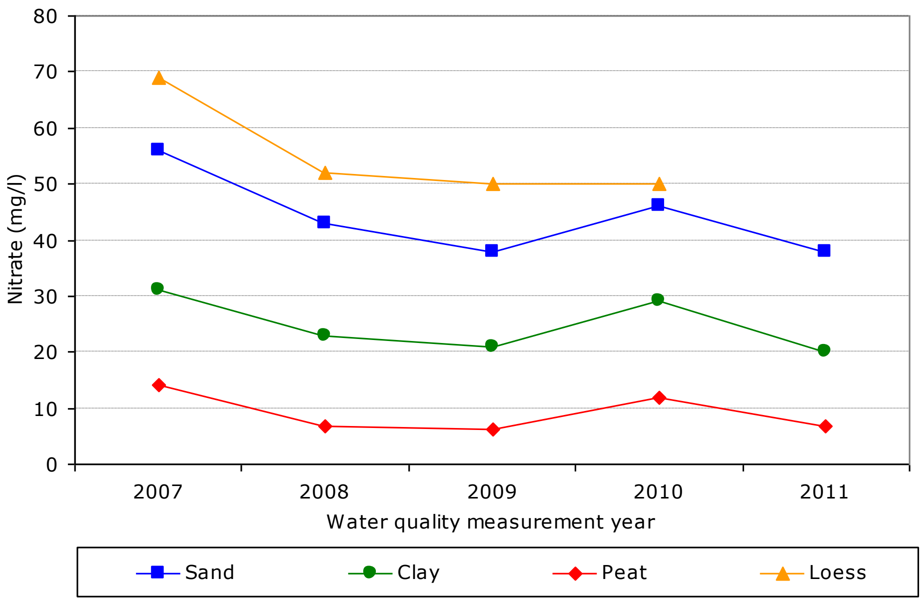


Figure S1 Evolution of nitrogen concentrations leaching in the root zone per region in successive measurement years.

The nitrate and total nitrogen concentrations measured in the ditch water also fluctuated (Figure S2). None of the regions showed a significant difference between the concentrations in 2011 and the mean of the previous years. The sand and clay regions, however, did show a significant drop in nitrate concentrations (Table 4.9).

In the clay, sand and peat regions the phosphorus concentration in the water leaching in the root zone fluctuated over the years (Table 4.9), and showed a decrease in the sequence peat > clay > sand > loess. In the ditchwater, the phosphorus concentrations decreased from clay to peat to sand. For both types of water, there was no significant difference between 2011 and previous years, nor were there any significant trends.

The final concentrations will be given in the progress report for 2013. In that report it will also become apparent if the trends have continued.

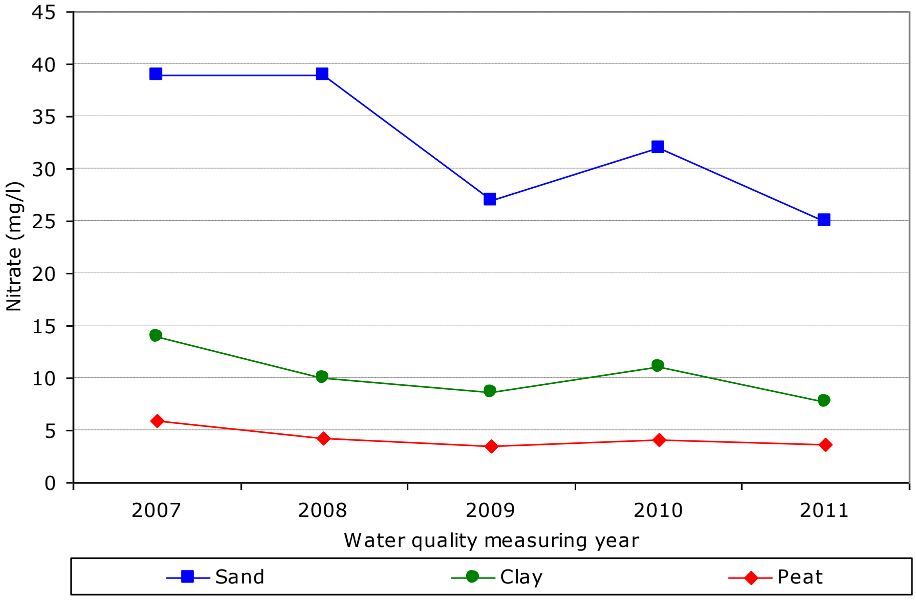


Figure S2 Evolution of nitrogen concentrations in the ditch water per region in successive measurement years.

Effect of agricultural practice on the water quality

Nitrogen

The nitrate concentration in the water leaching from the root zone showed a decrease in all regions in the period 2007-2009 (Figure S1). This decrease does not correspond to the evolution of the calculated nitrogen surplus in the same period (Figure S3). It is possible that the decrease is caused by the after-effects of drops in the nitrogen soil surplus before 2004. The calculated nitrogen surplus between 2006 and 2010 showed a slight fluctuation, but no further significant decrease. It is remarkable that the nitrogen surplus in the loess region rose significantly, while the nitrate concentration seemed to drop slightly.

Apart from the nitrogen surplus, there are other factors which play a part and which may have a diluting or concentrating effect on nitrate concentrations, such as weather conditions, sample adjustments, after-effects of nitrogen surpluses in previous years, reductions in the degree of grazing, and/or other factors. Farm management seems to move in the direction of further increase in scale and intensification in the dairy industry, whereby more and more entrepreneurs opt for full time housing of dairy cows, resulting in reduced grazing (Table S4). This reduction possibly partly explains the significant decrease in nitrate concentrations in the sand region.

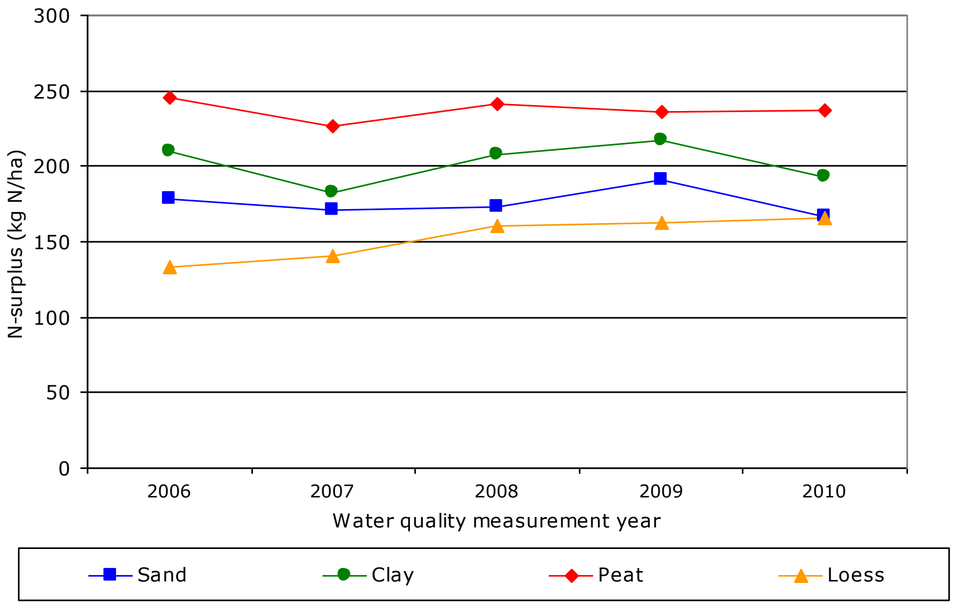


Figure S3 Evolution of the N-surplus per region in successive measurement years (agricultural practice year x influences the following water quality year x+1).

Phosphate

The phosphate surplus on the soil surface balance decreased during the measurement period from 25 kg per hectare in 2006 to 12 kg per hectare in 2010, with a peak in 2009. This decrease was caused mainly by a reduction in the use of inorganic fertiliser. The effect of the decrease is not observed in the water quality, probably because of the strong fixation of phosphate to the soil. The phosphorus concentration in the leaching water and the ditch water is therefore mainly determined by the hydrological conditions and the degree of surface runoff.

1 Introduction

1.1 Background

The EU Nitrates Directive obliges member states to limit the use of livestock manure to a maximum of 170 kg of nitrogen per hectare per year (EU, 1991). A member state can ask the European Commission if, under certain conditions, it may deviate from this obligation (derogation). In December 2005, the European Commission issued the Netherlands with a definitive derogation decision for the period 2006-2009 (EU, 2005). Under this decision, grassland farms cultivating at least 70 percent of their total area as grassland are allowed to apply up to 250 kg of nitrogen per hectare in the form of livestock manure originating from grazing livestock on their total area. The derogation decision was extended in February 2010 till end of December 2013 (EU, 2010). The Dutch government is obliged to collect a wide range of data regarding the effects of the derogation and to report these annually to the European Commission.

One of the obligations of the derogation decision (Appendix 1) concerns the formation of 'a monitoring network for the sampling of shallow groundwater, soil moisture, drainage water and ditches' on farms permitted an individual derogation (Article 8 of the decision, paragraph 2). The monitoring network must 'provide data on the nitrate and phosphorus concentrations in the water leaving the root zone and ending up in the groundwater and surface water system' (Article 8, paragraph 4). This monitoring network, which must cover at least 300 farms, should be 'representative for all types of soil (clay, peat, sand and sandy loess), fertilisation practices and crop rotations' (Article 8, paragraph 2). Within the monitoring network, the monitoring of the water quality on farms on sandy soils should be improved (Article 8, paragraph 5). The composition of the monitoring network should remain unchanged during the period (2006-2013) to which the decision applies (Article 8, paragraph 2). During the negotiations with the European Commission, it was agreed that the design of this monitoring network would tie in with the existing national network for monitoring the effectiveness of the minerals policy, the Minerals Policy Monitoring Programme (LMM), under which the water quality and the management of farms selected for this purpose have been monitored since 1992 (Fraters and Boumans, 2005). Additionally it was agreed that all participants in the LMM who satisfy the conditions could be regarded as participants in the monitoring network for derogation. Accordingly, the derogation monitoring network has become part of the LMM. For the LMM, the top metre of the phreatic groundwater, the soil moisture and/or the drainage water are sampled, as this is regarded as sampling the water leaving the root zone (Appendix 4). The ditch water is sampled as well, in order to get an impression of the quality of the surface water on farms.

Aside from the obligation to monitor, there is the requirement to report the evolution of the water quality. The report should be based on 'the monitoring of leaching from the root zone, the surface water quality and the groundwater quality, as well as on model-based calculations' (Article 10, paragraph 1). Furthermore, an annual report must be submitted 'for the different soil types and crops regarding the fertilisation and the yield on grassland farms on which derogation is permitted', to provide the European Commission with an understanding of the management on these farms and the degree to which this has been optimised (Article 10, paragraph 4). This report is intended to meet the aforementioned reporting requirements.

1.2 Previous reports

The first report (Fraters et al., 2007) was limited to a description of the derogation monitoring network, the progress made in 2006 in terms of setting this up, and the design and content of the reports for the years 2008 t/m 2010. Also a general description of the measurement and calculation methods to be used and the models to be applied was included.

In 2008, the second report was published. This contained the first results from the derogation monitoring network (Fraters et al., 2008). The first year of derogation was 2006. The figures on the agricultural practice concern farm management under derogation. The water quality data from 2006 relates to the agricultural practice from 2005 and are therefore not yet related to farm management under derogation.

The third progress report was published in 2009; it contains the data from 2007 (Zwart et al., 2009). In addition, a brief comparison is made between the results from 2006 and 2007, with the remark that water quality data from 2006 related to the agricultural practice in 2005. For this third progress report, there were insufficient measurement years available to be able to draw conclusions about trends.

The fourth progress report was published in 2010; this contains the data on the agricultural practice in 2008 and the data on the water quality in 2008 and, preliminary, 2009 (Zwart et al., 2010). Also, a brief comparison of the results from 2007, 2008 and 2009 is made, with the remark that the measurement series is too limited to draw solid conclusions about trends. For the first time, a limited analysis of the relationship between farm results and the associated water quality is conducted.

The fifth progress report was published in 2011; this contains the data on the agricultural practice in 2009 and the data on the water quality in 2009 and, preliminary, 2010 (Zwart et al., 2011). Additionally, the results from previous years are included, with a comparison for the agricultural practice between the mean of the period 2006-2008 and the measurement year 2009. For the water quality, this comparison is made for the period 2007-2009 and the measurement year 2010. Furthermore, a limited analysis is conducted of the relationship between farm results and the associated water quality.

1.3 Content of this report

This is the sixth annual report about the results of the derogation monitoring network. It reports on fertilisation, crop yields, nutrient surpluses and water quality. The nutrient surpluses are a major determinant for the quantity of nutrients that could potentially wash out.

The results in this report are based on the data as defined in the Farm Accountancy Data Network (hereafter referred to as FADN) of LEI. In the FADN, the actual situation on the farm is established according to the report offered by the farmer. These data need not necessarily correspond to the data used in enforcement checks. The area used may differ from the area recorded in the land registration system of the National Service for the Implementation of

Regulations (DR) of the Ministry of Economic Affairs, Agriculture and Innovation, since land which belongs administratively to the farm but which is not actually used for fertilisation is not recorded in the FADN. Also, there may be different numbers of animals, different figures for the import and export of products and different stocks. The DR-results are reported in Appendix 6, whereby a comparison is made with fertiliser use as compiled by the derogation monitoring network.

By relating the fertilisation, determined through using the data provided by FADN, to acreages actually used, the best possible insight is provided into the relationship between agricultural practice and water quality. However, these data cannot be used to assess compliance with the legislation, since this requires the data as recorded by the DR.

Both annual mean nitrate concentrations measured per region and the results of limited model calculations are included in the analysis of the data (Appendix 5). The calculations quantify the effect of confounding factors on the measured nitrate concentrations. Nitrate concentrations in the water leaching from the root zone are affected not only by fertilisation, but also by variations in the precipitation surplus (Boumans et al., 1997). A statistical model has been developed to analyse the effect of variations in the precipitation surplus on the nitrate concentration in the uppermost layer of ground water (Boumans et al., 1997, 2001). This model corrects the sample for the changes in the composition of the group of participating farms (Fraters et al., 2004). Participants sometimes have to be replaced during the course of the programme or changes occur in the acreage of the participating farms. As a result, the ratio between the soil types and/or drainage classes on the farms in the derogation monitoring network can change during the course of the programme. The soil type (sand, loess, clay, peat) and the drainage class (poor, moderate, well drained) affect the relationship between the nitrogen surplus and the nitrate concentration measured. A change in the nitrate concentration measured could therefore be caused by a change in the composition of the group of participating farms or by changes in the acreage within this group.

Chapter 2 contains a brief description of the design and realisation of the derogation monitoring network. It also details the agricultural characteristics of the participating farms and provides a description of how the water quality is sampled. Also, an explanation of the models and analyses is given. Chapter 3 presents and discusses the measurement results of the monitoring of the agricultural practice and the water quality in 2010 (Figure 1.1). The water quality data for 2010 are related to the agricultural practice data for 2009 and the preceding years. This chapter also contains the provisional results of the water quality monitoring for 2011, which are related to the agricultural practice data for 2010 and the preceding years. The data regarding the loess sampling carried out between the autumn of 2011 and the spring of 2012, are not included in this report. In chapter 4, developments in the agricultural practice and water quality are described, whereby statistics are studied to determine both the degree to which agricultural practice in 2010 deviated from previous years and trends since the beginning of derogation. Furthermore, a cautious evaluation is provided as to the effect of the agricultural practice on the water quality.

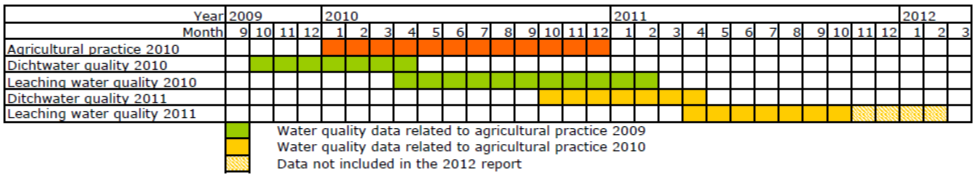


Figure 1.1 Overview of period of collecting the monitoring results as presented for the agricultural practice and the water quality.

The relevant articles from the derogation decision granted to the Netherlands by the European Commission (EU, 2005) have been included in Appendix 1. Appendix 2 provides further details about the design of the derogation monitoring network. The other appendices provide a detailed justification concerning the registration of data on the agricultural practice, the calculation of the fertilisation and the nitrogen and phosphate surpluses, the application of limits of probability (Appendix 3) and how the quality of the water is measured (Appendix 4). The methodology applied for precipitation correction and the calculation of the corrected nitrate concentration is provided in Appendix 5. Finally, in Appendix 6 a comparison is made between the use of fertilisers according to the data of DR and according to the data collected via the derogation monitoring network.

2 Design of the derogation monitoring network

2.1 Introduction

The design of the derogation monitoring network must satisfy the requirements of the European Commission, as stipulated in the derogation decision of December 2005 and the extension of the derogation in 2010 (Appendix 1). Previous reports provided extensive details about the composition of the sample and the choices this entailed (Fraters and Boumans, 2005; Fraters et al., 2007).

The setting up of the derogation monitoring network and the reporting of the results follows the segmenting of the Netherlands into regions, according to the action programmes for the Nitrate Directive (EU, 1991). Four regions are distinguished: the sand region, the loess region, the clay region and the peat region. The acreage of farmland in the sand region constitutes about 46 percent of the approximately 1.85 million hectares of farmland in the Netherlands (Baumann et al., 2012). The acreage of farmland in the loess region constitutes approximately 1.5 percent, in the clay region approximately 40 percent and in the peat region approximately 12.5 percent of the total farmland.

The sampling of the water quality for the measurement year 2010 was carried out during the winter of 2009/2010 in the Low Netherlands and in the summer and the winter of 2010/2011 in the High Netherlands (see also section 2.4.1). The Low Netherlands covers the clay and peat regions and those soils in the sand region that are drained via ditches, whether or not in combination with drainage pipes or surface drainage. The High Netherlands covers the other sand and loess soils. The sampling for determining the water quality for measurement year 2011 took place in the winter of 2010/2011 and in the summer of 2011 respectively. The associated sampling of the loess soils took place in the winter of 2011/2012. These latter data are not included in the report. Water sampling took place on 300 farms in the derogation monitoring network. Farms that (despite submitting an application) did not use the derogation were not included in this report, so as to ensure that the results concerning the effect of using derogation were not confounded. Consequently, the number of farms reported on deviates from the initial number of 300.

The water quality measured in 2010 partly reflects the agricultural practice in the year 2009 and the preceding years. The extent to which the agricultural practice in a previous year affects the measured water quality depends on factors such as the level and variation of the precipitation surplus in that year and the local hydrological circumstances. In the High Netherlands it is assumed that the agricultural practice is reflected in the water quality at least one year later. In the Low Netherlands the agricultural practice is reflected sooner. This difference in hydrology also explains the different sampling methods and periods employed in the Low and the High Netherlands.

As previously stated, all farm management data relevant for the derogation were registered for the 300 farms selected for derogation, according to the FADN-system (Poppe, 2004). A description of the monitoring of the agricultural characteristics and the methods of calculation of fertilisation and nutrient surpluses are to be found in Appendix 3. The water sampling on the farms was carried out in accordance with the standard LMM-procedures (Fraters et al., 2004). This sampling method is explained in Appendix 4.

2.2 Design and realisation of the sample

2.2.1 Number of farms in 2010

The derogation monitoring network is a permanent monitoring network. However, the loss of a number of farms is inevitable. Farms can drop out because:

- at the end of the year they indicate that they do not use the derogation;
- they no longer participate in the LMM because of termination of business, because cultivated land is no longer used or because of administrative problems.

Furthermore, although a farm has been processed in the FADN, it might have proved impossible to fully describe the nutrient flows. This could have been due to the presence on the farm of animals from other owners, as a result of which the import and export of feed, animals and manure is by definition incomplete, or because of administrative errors in the registration of imports and/or exports.

Of the 300 planned farms, 294 actually made use of derogation. The agricultural practice of 298 farms was successfully established and water sampling was successfully carried out at 290 farms (Table 2.1). In each region, a small number of farms dropped out or the information was incomplete. Compared to 2008, six farms did no longer participate in the FADN in 2009 and 2010. Therefore, these farms were replaced.

Table 2.1 Planned (design) and realised (realisation) number of dairy and other grassland farms per region in 2010.

Farm type	*Design/realisation*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Dairy	Design	140	17	52	52	261
	Realisation water quality	138	16	49	51	254
	Realisation agricultural practice	134	17	52	52	255
	Of which derogation	133	17	51	52	253
	Of which nutrient flows complete	130	17	50	52	249
Other grassland farms	Design	20	3	8	8	39
	Realisation water quality	21	2	7	6	36
	Realisation agricultural practice	25	3	9	6	43
	Of which derogation	25	2	8	6	41
	Of which nutrient flows complete	18	2	5	6	31
Total	Design	160	20	60	60	300
	Realisation water quality	159	18	56	57	290
	Realisation agricultural practice	159	20	61	58	298
	Of which derogation	158	19	59	58	294
	Of which nutrient flows complete	148	19	55	58	280

The various sections of this report detail the agricultural practice on the following numbers of farms:

- The description of general farm characteristics (section 2.3) concerns all farms that could be processed in FADN in 2010 and that made use of the derogation (= 294).
- The description of agricultural practice in 2010 (section 3.1) concerns all farms for which the nutrient flows could be fully completed in FADN (= 280).
- The comparison between the agricultural practice in the years 2006 to 2010 (section 4.2) includes all farms that participated in the derogation monitoring network in the respective years. Per year, this number varies. For 2006 this concerns 285 farms, for 2007 281 farms, for 2008 283 farms, for 2009 276 farms and for 2010 280 farms.

The report details the water quality on the following numbers of farms:

- The description of the water quality of measurement year 2010 (section 3.2) concerns all farms that could be processed in FADN 2010, that made use of derogation and where water quality measurements were carried out in 2010 (= 290).
- The description of the water quality of measurement year 2011 (section 3.2) concerns all farms in the derogation monitoring network 2010, except the loess farms, where the water quality was sampled in measurement year 2011 (n = 275).
- The evolution of the water quality for the years 2007 to 2011 (section 4.3) concerns all farms that in the agricultural practice year preceding the measurement year participated in the derogation monitoring network. The number varies per year. For 2007, data are available of 295 farms, for 2008 of 293 farms, for 2009 of 296 farms, for 2010 of 294 farms and for 2011 of 275 farms (except for the loess region).

2.2.2 *Representativeness of the sample*

In 2010 294 farms of the planned sample, with a total acreage of 15.387 hectare (1.8 percent of the Dutch agricultural acreage on grassland farms) registered for derogation (Table 2.2). The sample population covers 86.5 percent of the farms and 96.9 percent of the acreage of all farms that registered for derogation in 2010 and which satisfied the LMM selection criteria (the sample population, Appendix 2). Farms outside the sample population that did sign up for derogation are mainly other grassland farms with a size of less than 16 NGE (Netherlands units of magnitude). In the new farm definition this is 25,000 SO (Standard Output).

A minimum number of farms is needed to be able to make a reasoned statement per region. For loess, that minimum has been set at 15 (Fraters and Boumans, 2005). The loess region is relatively small, so it does not have many derogation farms in the sample populations. Consequently, a relatively large number of farms (16 percent) is included in the monitoring network. Furthermore, the dairy farms in all regions are more strongly represented in the acreage than the other grassland farms. This is because the desired number of sample farms per farm type is derived during the selection and acquisition process from the share in the total acreage of cultivated land, whereas the other grassland farms included were on average smaller than the dairy farms in terms of the acreage of cultivated land.

Table 2.2 Area of cultivated land (in ha) in the derogation monitoring network compared to the total area of cultivated land of farms with derogation in 2010 in the sample population, according to the Agricultural Census 2010.

		Sample population[1]	*Derogation monitoring network*	
Region	*Farm type*	*Area (ha)*	*Area (ha)*	*% of acreage sample population*
Sand	Dairy farms	359,188	6886	1.9%
	Other grassland farms	57,560	826	1.4%
	Total	416,747	7712	1.9%
Loess	Dairy farms	4838	814	16.8%
	Other grassland farms	782	66	8.5%
	Total	5620	880	15.7%
Clay	Dairy farms	202,118	3057	1.5%
	Other grassland farms	29,815	254	0.9%
	Total	231,932	3311	1.4%
Peat	Dairy farms	161,123	3336	2.1%
	Other grassland farms	19,063	149	0.8%
	Total	180,186	3484	1.9%
All	Dairy farms	727,267	14,093	1.9%
	Other grassland farms	107,219	1295	1.2%
	Total	834,486	15,387	1.8%

1: Estimate based on Statistics Agricultural Census 2010 processed by LEI. Further information on how the sample population was defined can be found in Appendix 2.

2.3 Description of the farms in the sample

The 294 farms which registered for derogation have an average of 53 hectare of cultivated land, of which 83 percent is grassland. The stocking density is 2.27 LSU (Phosphate Livestock Units) per hectare (Table 2.3). For comparison, data from farms in the 2010 Agricultural Census have been included, in so far as these farms are included in the sample population (Appendix 2).

An examination of the agricultural characteristics of the sample population and a comparison with the farms from the Agricultural Census (Table 2.3) reveal the following differences:

- The mean acreage of cultivated land of the sampled farms is on average 20 percent greater than that of the farms in the sample population. This applies to all regions.
- The acreage of natural habitat (1.1 hectare) is not included in the calculation of the environmental pressure per hectare of cultivated land (fertilisation, surpluses and the like).
- The proportion of grassland on the sampled farms (83 percent) is virtually the same as the mean of the sample population.
- 90 percent of the arable land on the farms sampled is used for silage maize.
- The stock density of grazing livestock on the farms sampled is on average 5 percent higher than the mean of the sample population.
- The proportion of farms sampled where grazing animals as well as housed animals are present is higher than the mean of the sample population.
- Dairy cattle and the associated young stock constitute almost 95 percent of the grazing livestock present. The group of other grazing livestock consists of beef cattle, sheep, goats, horses and ponies.

Table 2.3 Description of a number of general farm characteristics in 2010 of the farms in the derogation monitoring network (DM) compared to the mean of the sample population (Agricultural Census, LBT for short).

Farm characteristic[1]	*Population*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms DM	DM	158	19	59	58	294
Area grassland (ha)	DM	39	34	46	53	43
	LBT	31	29	42	41	36
Area silage maize (ha)	DM	9.3	9.9	8.6	7.4	8.8
	LBT	7.5	7.5	5.5	3.8	6.3
Area other arable land (ha)	DM	0.8	2.0	2.0	0.1	1.0
	LBT	1.3	2.9	2.3	1.1	1.5
Area cultivated land (ha)	DM	49	46	57	60	53
	LBT	40	39	50	46	44
Percentage grassland (%)	DM	81	76	84	91	83
	LBT	78	74	84	89	82
Area natural habitat (ha)	DM	0.5	2.3	2.5	0.9	1.1
	LBT	0.8	1.3	1.2	0.8	0.9
Phosphate livestock units	DM	2.29	2.26	2.40	2.11	2.27
(LSU/ha)[2]	LBT	2.28	2.14	2.03	1.98	2.16
Percentage farms with housed	DM	15	16	8	14	14
animals *%)	LBT	14	2	5	7	10
Specification stock density derogation monitoring network (LSU/ha)[2]						
Dairy cattle (including young stock)	DM	2.18	2.11	2.20	1.99	2.14
Other grazing animals	DM	0.11	0.15	0.20	0.11	0.13
Total housed animals	DM	0.85	0.08	0.51	0.25	0.62
Total all animals	DM	3.14	2.35	2.91	2.35	2.89

Source: Statistics Netherlands Agricultural Census 2010, processed by LEI, and FADN.

1: Areas are given in hectares of cultivated land and the acreage of natural habitat is not included.

2: LSU = Livestock Unit; this is a comparative standard for animal numbers based on the phosphate production forfeit (phosphate production forfeit dairy cow = 1 LSU).

The above comparison of the population of farms sampled with the Agricultural Census indicates that the population of farms sampled is a proper reflection of the Agricultural Census.

The dairy farms in the derogation monitoring network have an average of 15,900 kg of milk per hectare and produce 860,000 kg of milk per farm (Fat and Protein Corrected Milk, FPCM). Per cow, the milk production is 8,670 kg FPCM per year (Table 2.4). As the correct comparative material was not present in the Agricultural Census, for comparative purposes this table contains the weighted mean of the national sample from the FADN. In all regions, the dairy farms in the derogation monitoring network have a larger acreage and a higher milk production per farm than the weighted national mean. For loess, this comparison is not available, because for this type of region the number of farms in the FADN is too small.

Table 2.4 Mean milk production and grazing on dairy farms in the derogation monitoring network (DM) in 2010 compared to the weighted mean of dairy farms in the national sample (FADN).

Farm characteristic	*Population*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms in DM	DM	133	17	51	52	253
kg FPCM farm	DM	791,800	715,900	962,500	983,200	860,000
	FADN	694,700		775,900	738,300	712,300
kg FPCM/ha forage crop	DM	16,000	15,900	16,500	15,000	15,900
	FADN	16,200		15,200	14,200	15,500
kg FPCM/dairy cow	DM	8700	8510	8800	8530	8670
	FADN	8900		8600	8370	8700
Percentage farms with grazing	DM	80	82	76	76	79
	FADN	77		81	84	80

1: FPCM = Fat and Protein Corrected Milk; this is a standard used for comparing milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM).

An examination of the differences between the farms in the derogation monitoring network and the FADN-farms reveals the following:

- The mean milk production per farm on the dairy farms in the derogation monitoring network is on average 21 percent higher than the national mean. In the sand region the difference is the smallest (approximately 15 percent).
- The mean milk production per hectare and per milk cow present on the dairy farms in the derogation monitoring network hardly differ from the national mean in FADN (Table 2.4).

2.4 Monitoring of water quality

2.4.1 Sampling at farms

In measurement year 2010, water quality samples were carried out on 290 farms of the 294 farms in the derogation monitoring network that had applied for and used derogation in (agricultural practice year) 2010 (Table 2.5 and Figure 2.1). The difference of 4 farms is caused by the fact that these farms were new in the derogation monitoring network in measurement year 2010 and were sampled for water quality for the first time in measurement year 2011. Also, some farms in the derogation monitoring network were sampled while these farms did not use derogation in 2010 (3 farms) or switched to organic farming in 2010 (1 farm). These were not included in the results of the water quality and the agricultural practice. In 2011, 275 derogation farms were sampled in the sand, clay and peat regions. This concerns the sampling of the groundwater, drain water and/or soil moisture. On the participating farms in the Low Netherlands, the ditch water was also sampled. The number of farms sampled is stated in Table 2.5, as well as the mean sampling frequency. The results of the agricultural practice in the year 2010 are linked to those of the water quality in the following period (water quality year 2011).

The water quality sampling associated with the agricultural practice of 2009 took place in the period between October 2009 and February 2011 (Figure 2.1). The water quality sampling associated with the agricultural practice data of 2010 took place in the period between October 2010 and February 2012. The results of the water quality in the loess region, sampled from October 2011 to February 2012, are not available for this report because the required quality control has not yet been carried out. In this report, the water quality data for agricultural practice year 2010 are preliminary. Definite figures will be reported in 2013. The definite 2011/2012 data for the loess region will also be available in 2013. A detailed description of the sampled method per region is provided in Appendix 4.

Table 2.5 Number of sampled farms[1] per sub-programme and per region for 2010 and 2011, and the sampling frequency of the leaching (L) and ditch water (DW). The desired sampling frequency is stated in parentheses.

Year	*Sand*		*Loess*	*Clay*	*Peat*
	All farms	*Of which drained*			
2010	158	31	18	56	57
L-rounds	1.0 (1)	- (-)	1.0 (1)	3.2 (2-4[2])	1.0 (1)
DW-rounds	- (-)	4.0 (4)	- (-)	3.9 (4)	3.7 (4)
2011	158	31	*	57	59
L-rounds	1.0 (1)	- (-)	*	3.0 (2-4[2])	1.0 (1)
DW-rounds	- (-)	3.8 (4)	*	3.8 (4)	4.0 (4)

1: The difference between the total number of farms reported in the text and given in this table is caused by one sand farm where only ditch water and no leaching from the root zone was sampled.
2: In the clay region, groundwater is sampled up to 2 times and drainage water up to 4 times, depending on the type of farm. The average total number of samples will therefore always be between 2 and 4, depending on the proportion of farms with groundwater sampling and those with drainage water sampling.
*: In the loess region, 20 derogation farms were sampled in the period October 2011 to February 2012. The results of these samplings were not yet available when this report was compiled.

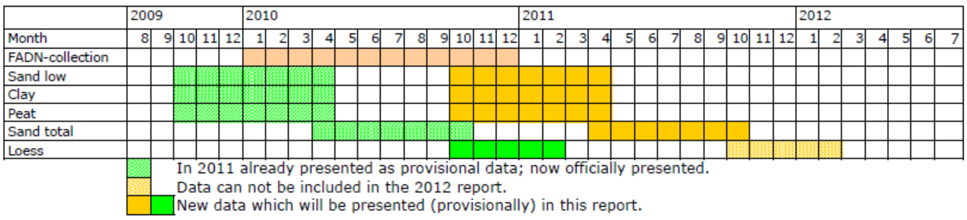


Figure 2.1 Sampling periods for water quality in 2010 (green) and 2011 (yellow) per region per programme.

Figure 2.2 shows the distribution of the sampled farms over the regions. Also, a distinction is made between dairy farms and other grassland farms. The distribution clearly shows that the focus of the derogation monitoring network lies with the farms in the sand region. Apart from this, a relatively large number of farms is located in Southern Limburg. The reason for this is that at least 15 farms must be sampled to be able to draw adequately substantiated conclusions (Fraters and Boumans, 2005).

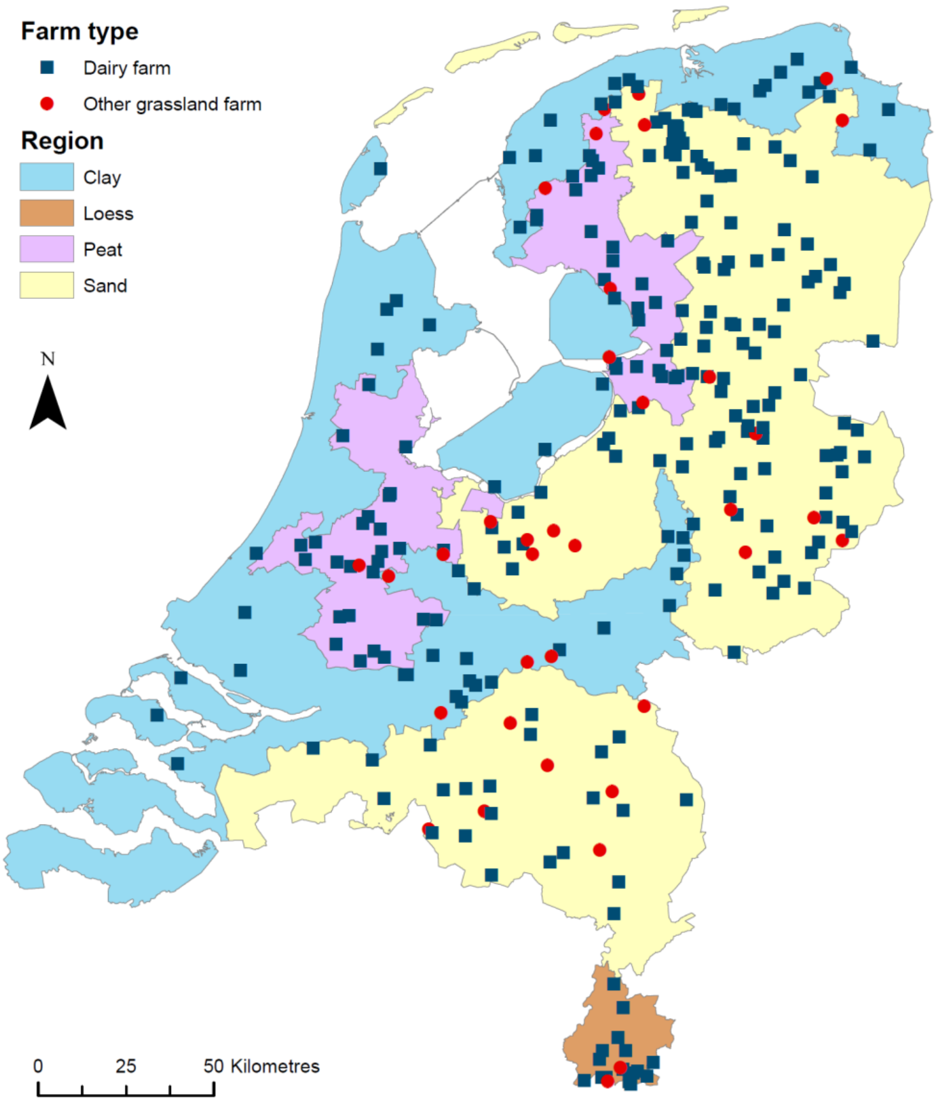


Figure 2.2 Location of the 290 grassland farms that participated in the water sampling for the derogation monitoring network in 2010.

The soil and drainage characteristics of the farms concerned are given per region in Table 2.6 and Table 2.7 for 2010 and 2011 respectively. Within a region, other soil types occur in addition to the main soil type for which the region is named. The loess region primarily consists of naturally good-draining soils and the peat region chiefly contains naturally poor-draining soils. The good-draining soils in the sand region are less well represented in the derogation monitoring network. Originally, the best soils (with a favourable drainage situation and nutrient status) were used for agriculture, while poorer (e.g. wetter) soils were used for dairy cows. Also, the driest soils in the sand region often have no agricultural function. Therefore, especially the wetter sand soils are represented in the derogation monitoring network. The differences in soil type and drainage class in the derogation monitoring network between 2010 and 2011 are minimal.

Table 2.6 Soil type and drainage class (in percentages) per region on derogation farms sampled in 2010.

Region	*Soil types*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	80	0	12	8	42	49	9
Loess	2	76	22	0	2	3	95
Clay	14	0	83	3	43	51	6
Peat	12	0	39	50	89	11	0

1: The drainage classes are linked to the groundwater regime classes. The class naturally poor draining contains Gt I to Gt IV, the class moderately draining Gt V, V* and VI, and the class good draining Gt VII and Gt VIII.

Table 2.7 Soil type and drainage class (in percentages) per region on derogation farms sampled in 2011.

Region	*Soil types*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	80	0	12	8	42	49	9
Loess	*	*	*	*	*	*	*
Clay	14	0	83	4	44	50	5
Peat	12	0	39	50	89	11	0

1: The drainage classes are linked to the groundwater regijme classes. The class naturally poor draining contains Gt I to Gt IV, the class moderately draining Gt V, V* and VI ,and the class good draining Gt VII and Gt VIII.

*: Results from the loess region were not yet available when this report was compiled.

2.4.2 *Chemical analyses and calculations*

The chemical analyses of the water samples were carried out in the accredited analytical laboratory of the RIVM. Table 2.8 provides an overview of the methods used for the different components. Further details can be found in Wattel-Koekkoek et al. (2008).

Table 2.8 Components analysed with analysis method and detection limit.

Component	*Analysis method*[1]	*Detection limit*
Nitrate (NO_3)	IC	0.31 mg l^{-1}
Ammonium (NH_4)	CFA	0.064 mg l^{-1}
Total nitrogen (N)	CFA	0.2 mg l^{-1}
Total phosphorus (P)	Q-ICP-MS	0.062 mg l^{-1}

1: Analysis method: Q-ICP-MS: Quadruple inductively coupled plasma mass spectrometry, IC: Ion chromatography and CFA: Continuous flow analyser.

An annual mean concentration per component was calculated for each farm. For this calculation, observations with a concentration lower than the detection limit were assigned a value of 0. This allows farm mean concentrations below the detection limit to be calculated. If in the results presented in this report values below the detection limit occur, this will be indicated by <dt.

3 Results for 2010

3.1 Agricultural characteristics

3.1.1 Nitrogen use via livestock manure

The use of nitrogen from livestock manure on farms in the derogation monitoring network in 2010 did not, on average, deviate from the application standard for livestock manure which can be specifically calculated for the farms (Table 3.1). For most of the farms, the manure production was calculated by means of forfeit standards. However, dairy farmers could also choose to deviate from these standards and to calculate a farm-specific manure production using the so-called Guidance (LNV, 2009). This farm-specific manure production was adopted for dairy farms that indicated they were using the Guidance and for which all of the necessary data were available (N = 76). On all other farms (N = 204) forfeits were used to determine the manure production. A more detailed explanation of the farm-specific and forfeit calculation methods for manure use is provided in Appendix 3.

Table 3.1 Mean nitrogen use via livestock manure (in kg N per ha) in 2010 on farms in the derogation monitoring network. Means per region.

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms	148	19	55	58	280
Produced on farm[1]	281	263	285	265	277
+ import	13	7	5	10	10
+ stock mutation[2]	-7	-11	-9	-7	-8
- export	42	26	31	22	34
Total	245	233	251	247	246
Application standard livestock manure	246	243	247	247	246
Use on arable land[3]	168	176	149	177	166
Use on grassland[3]	258	254	274	256	260

1: Calculated on the basis of forfeit standards with the exception of dairy farms that indicated they were using the Guidance farm-specific excretion dairy cattle (see Appendix 3).

2: A negative stock mutation is a stock increase and will correspond to export.

3: The mean use and the application standards on grassland and arable land are based on 274 farms and 201 farms respectively instead of 280 farms, as on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals and because 73 farms had no arable land.

The most important comments on the use of nitrogen from livestock manure are (Table 3.1):

- The mean application standard for livestock manure (246 kg per hectare) was below the derogation standard of 250 kg N from grazing livestock manure (derogation decision) because:
  - a number of farms had only applied for derogation on a part of their acreage;
  - a number of farms also applied manure from housed animals for which a standard of 170 kg per ha applies;
- For the farms in the derogation monitoring network the mean use of nitrogen from livestock manure (246 kg per hectare) was exactly in line with the mean application standard for livestock manure. The use of nitrogen from livestock manure on clay was a number of kg higher than the mean application standard.

- The use of nitrogen from livestock manure on arable land (mainly silage maize) was considerably lower in all regions than the use on grassland.

The use of animal manure in 2010, including rounding-off differences, was 7 kg N per hectare lower than the mean 253 kg N per hectare in 2009 (Zwart et al., 2011). The causes were:
- 13 kg N less use through a change in the stock mutation: a stock decrease of 5 kg N in 2009, a stock increase of 8 kg N in 2010;
- an increase in manure production of 9 kg N;
- a modest decrease of 2 kg N in manure import;
- a modest increase of 2 kg N in manure export.

The farms in the monitoring network both import and export livestock manure. As the average production was higher than the use allowed, the average manure export was higher than the import (including the stock mutation).
This is applicable for all regions (Table 3.2).

Table 3.2 Percentage of farms in the derogation monitoring network that imported and/or exported livestock manure in 2010. Means per region.

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All*
No import and export	23	16	34	36	28
Only export	36	47	44	34	38
Only import	23	26	10	21	20
Both import and export	17	11	12	9	14

Table 3.2 shows that on more than 25 percent of the farms in the monitoring network there was no import or export of manure. On more than a third of the farms manure was only exported, whereas on one fifth of the farms manure was only imported. It would seem that these farmers were of the opinion that the import of nutrients via livestock manure provided economic benefits as compared to using inorganic fertiliser. This may also apply to the farmers who both imported and exported manure (14 percent).

3.1.2 *Fertiliser use compared to the application standards (N and P)*

The quantity of plant-available nitrogen from livestock manure is calculated by multiplying the quantity of nitrogen in livestock manure used (produced on own farm or imported, Table 2.1) by the prevailing statutory plant-availability coefficients relevant to the specific situation (see Appendix 3). To allow a comparison of fertiliser use, these tables also contain the mean application standards per ha for arable land (mainly maize acreage) and grassland, from which the application standards at farm level have been derived. These mean application standards are based on the acreage of cultivated crops and the soil type classifications as registered in FADN and the statutory application standards determined for 2010 (National Service for the Implementation of Regulations, 2006, 2011).

In 2010, the use of nitrogen on the farms in the monitoring network was as follows (Table 3.3):
- In all regions, the calculated total (plant-available) nitrogen use at farm level was lower than the nitrogen application standard. This also applies for grassland and arable land separately, except for arable land in the loess region.

- In the clay region the calculated total (plant-available) nitrogen use at farm level was higher than in the other regions, partly due to a higher use of inorganic fertiliser. The nitrogen application standard for clay soils is higher than for other soils.
- In the sand region and the loess region, the calculated total (plant-available) nitrogen use was lower than in the other regions, due to a lower use of both livestock manure and inorganic fertiliser.
- In all regions, the nitrogen fertilisation on arable land (mostly silage maize) was lower than on grassland.

Table 3.3 Mean nitrogen use from fertilisers (in kg plant-available N per ha)[1] on farms in the derogation monitoring network in 2010. Means per region.

Description	*Category*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		148	19	55	58	280
Average statutory availability coefficient livestock manure in %		50	49	50	50	50
Fertiliser use	Livestock manure	122	115	126	123	123
	Other organic fertiliser	0	0	0	0	0
	Inorganic fertiliser	110	116	145	125	120
	Total mean	233	231	271	248	243
	Nitrogen application standard	251	239	286	280	263
Use of plant-available nitrogen on arable land[2]		115	174	120	121	122
Application standard arable land[2]		156	157	163	157	158
Use of plant-available nitrogen on grassland[2]		259	254	304	264	269
Application standard grassland[2]		272	267	310	293	284

1: Calculated according to the prevailing statutory availability coefficients (see Appendix 3).

2: The mean use and the application standards on grassland and arable land are based on 274 farms and 201 farms respectively instead of 280 farms, as on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals and because 73 farms had no arable land.

In 2010, the total use of phosphate on farms in the derogation monitoring network was as follows (Table 3.4):

- On average 2 kg per hectare lower than the phosphate application standard for these farms. The difference was slightly larger in the loess region.
- Specified according to application standard:
  - on grassland approximately 2 kg below the application standard for grassland. In the loess region the use on grassland was even 12 kg lower than the application standard for grassland;
  - on arable land 1 kg higher than the application standard for arable land. This was mainly due to its use in the loess and peat regions (14 kg and 13 kg per hectare respectively above the application standard for arable land);
- On average more than 95 percent of the phosphate was applied via livestock manure.

Regarding the use of phosphate on grassland and arable land in relation to the application standards, it must be mentioned that the use on arable land is reported by the dairy farmer**.** The use on grassland is calculated by deducting the use on arable land from the total use.

Table 3.4 Mean phosphate use (in kg P_2O_5 per ha) in 2010 on farms in the derogation monitoring network. Means per region.

Description	*Category*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		148	19	55	58	280
Fertiliser use	Livestock manure	86	82	88	87	86
	Other organic fertiliser	0	0	0	0	0
	Inorganic fertiliser	3	4	3	3	3
	Total mean	89	86	90	90	89
	Phosphate application standard	91	91	92	91	91
Use of phosphate on arable land[1]		79	93	76	90	81
Application standard arable land[1/2]		79	79	84	77	80
Use of phosphate on grassland[1]		91	84	94	90	91
Application standard grassland[1/2]		93	96	94	92	93

1: The mean use and the application standards on grassland and arable land are based on 274 farms and 201 farms respectively instead of 280 farms, as on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals and because 73 farms had no arable land.

2:Due to the fact that no classification is available, figures are based on the mean of the Combined Data Collection 2010. This shows that 10% of agricultural land has a low phosphate condition and that 20% has a neutral phosphate condition. Consequently, it must be concluded that 70% has a high phosphate condition ((Van den Ham et al, 2011, based on information from DR). In order to be considered for the application standard pertaining to the 'low' or 'neutral' classes, farmers must submit a soil analysis to the government. If no analysis is submitted, the (low) phosphate application standard pertaining to the 'high' phosphate class is automatically applied, based on the Fertilisers Act. A phosphate application standard of 120 is applied to low-phosphate and phosphate-fixation fields.

3.1.3 *Crop yields*

In 2010, the crop yields on the farms in the derogation monitoring network amounted to an average of 15,600 kg dry matter per hectare for silage maize and 9,700 kg dry matter per hectare for grassland (Table 3.5). These yields were estimated for silage maize and calculated for grassland on the farms in the derogation monitoring network that satisfied the criteria for applying the calculation method for crop yields. This calculation method is derived from Aarts et al. (2008). In this method, the yield from silage maize is estimated by measuring the quantity of ensilaged silage maize. The grass yield is calculated as the difference between the energy requirement of the cattle herd on the one hand and the energy uptake from farm-grown silage maize (and forage crops other than grass) and purchased feed on the other hand. Further information about this method is provided in Appendix 3.

The most important points with regard to the crop yields are (Table 3.5):

- The estimated mean dry matter yield for silage maize was 15,600 kg per hectare, whereby an estimated average of 183 kg N and 31 kg P (71 kg P_2O_5) was harvested. In the loess region the yield was well above and in the other regions around the national average.
- The calculated grassland yield in dry matter was almost two thirds of the estimated silage maize yield. Due to higher N and P levels in grass, both the N and P yield per hectare were, however, higher. The calculated grassland yields were highest in the clay region and lowest in the sand region.

Table 3.5 Average crop yield (in kg dry matter, N, P and P_2O_5 per ha) for silage maize (estimated) and grassland (calculated) in 2010 on farms in the derogation monitoring network that satisfy the criteria for applying the calculation method (Aarts et al., 2008). Means per region.

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Silage maize yields					
Number of farms	90	11	25	19	146
Kg dry matter per ha	15,600	17,600	15,100	15,200	15,600
Kg N per ha	183	205	177	179	183
Kg P per ha	31	35	30	30	31
Kg P_2O_5 per ha	71	81	70	69	71
Yields grassland					
Number of farms	110	113	36	33	193
Kg dry matter per ha	9200	9500	10,800	10,000	9700
Kg N per ha	245	249	283	272	257
Kg P per ha	35	37	42	38	37
Kg P_2O_5 per ha	80	86	96	88	85

3.1.4 *Nutrient surpluses*

The surplus on the soil surface balance for the farms in the derogation monitoring network amounted to an average of 185 kg per hectare for nitrogen in 2010 (Table 3.6), and an average of 12 kg per hectare for phosphate (Table 3.7). The surpluses on the soil surface balance were calculated using the calculation method described in Appendix 3.

Table 3.6 Nitrogen surplus on the soil surface balance (in kg N per ha) for farms in the derogation monitoring network in 2010. Means and 25% and 75% quartiles per region.

Description	*Category*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		148	19	55	58	280
Import farm	Inorganic fertiliser	110	116	145	125	120
	Livestock manure + other organic fertiliser	19	10	8	13	15
	Feed	190	161	170	140	174
	Other	11	5	14	7	10
	Total	330	292	336	285	319
Export farm	Milk and other animal products	76	68	74	74	75
	Animals	26	15	24	16	23
	Livestock manure	54	39	42	32	46
	Other	4	6	2	-3	2
	Total	160	128	143	118	146
Mean nitrogen surplus per farm		170	164	194	167	173
+ Deposition, mineralisation and organic N-fixation		45	44	43	112[1]	58
- Gaseous emissions[2]		47	42	44	45	46
Mean nitrogen surplus soil surface balance		167	166	193	233	185
Nitrogen surplus soil surface balance 25%-quartile		131	141	137	170	136
Nitrogen surplus soil surface balance 75%-quartile		196	191	234	299	221

1: Due to the assumption that on peat soil an additional 75 kg nitrogen mineralises from organic matter.

2: Gaseous emission from housing and storage, during application and grazing.

The variation in nitrogen surplus on the soil surface balance was considerable. The 25 percent of farms with the lowest surplus realised a surplus of less than 136 kg N per ha, whereas for the 25 percent of farms with the highest surplus, the surplus was in excess of 221 kg N per ha (Table 3.6). This could be explained by the fact that farmers with a low nitrogen surplus on the soil surface balance manage to integrate environmental aims well into their farm management (Van den Ham et al., 2010). Apart from that, farms with a low surplus might have relatively fertile soils, whereas farms with a high surplus might have soils producing relatively low yields.

For the 25 percent of farms with the lowest phosphate surpluses, the surplus was below 0 kg per hectare (0 kg/ha is balance), whereas for the 25 percent of farms with the highest surplus it was above 23 kg per hectare (Table 3.7). Just as in the case of the nitrogen soil surface surplus, this could be explained by the fact that farmers with a low phosphate surplus on the soil surface balance manage to integrate environmental aims well into their farm management (Van den Ham et al., 2010). Additionally, some of these farms might have relatively fertile soils, while farms with a high surplus might have soils producing relatively low yields.

Table 3.7 Phosphate surplus on the soil surface balance (in kg P_2O_5 per ha) for farms in the derogation monitoring network in 2010. Means and 25% and 75% quartiles per region.

Description	*Category*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		148	19	55	58	280
Import farm	Inorganic fertiliser	3	4	3	3	3
	Organic fertiliser	9	5	4	7	7
	Feed	68	55	58	53	62
	Other	5	3	6	3	5
	Total	85	66	70	66	77
Export farm	Milk and other animal products	30	27	29	28	29
	Animals	15	9	13	9	13
	Organic fertiliser	26	17	17	17	22
	Other	1	2	1	-1	1
	Total	72	55	61	53	65
Mean phosphate surplus soil surface balance		13	11	9	13	12
Phosphate surplus soil surface balance 25% quartile		1	0	-2	2	0
Phosphate surplus soil surface balance 75% quartile		24	19	20	21	23

3.2 Water quality

3.2.1 Leaching from the root zone, measured in 2010 (NO_3, N and P)

In 2010, the concentrations measured in water leaching from the root zone are related to the agricultural practices on the farms in 2009 and the previous years. The water quality reported here is therefore related to the fourth year and the previous years in which derogation was applied, and not to the results over 2010 presented in the previous section.

The nitrate concentrations in most regions were on average lower than the 50 mg NO_3 per litre stated in the Nitrate Directive (Table 3.8). Only in the loess region the nitrate concentrations were on average slightly higher than 50 mg NO_3 per litre. Although the nitrate concentration in the peat region was lower than in the clay region, the nitrogen concentration was higher. This was due to the higher ammonium concentrations in the groundwater. In 2010, the mean ammonium concentration in the peat region was 4.2 mg N per litre. In the clay and loess regions, the concentration was on average lower than 1 mg per litre. In the sand region, the mean concentration was 1.2 mg N per litre. The higher ammonium concentration is probably the consequence of nutrient-rich peat layers (Van Beek et al., 2004), whereby nitrogen is released in the form of ammonium or nitrate due to the breakdown of organic matter (Butterbach-Bahl and Gundersen, 2011). The groundwater that is, or has been, in contact with nutrient-rich peat layers often has a similarly high phosphate concentration (Van Beek et al., 2004). These nutrient-rich peat layers can also partly cause the measured higher mean phosphorus concentration in the peat and clay regions compared with the sand and loess regions. In addition, phosphate ions are easily absorbed by iron and aluminium (hydr)oxides and clay minerals, particularly in acidic circumstances, as occur in the sand region. Phosphate also easily precipitates in the form of (difficult to dissolve) aluminium, iron and calcium phosphates.

Table 3.8 Nutrient concentration (in mg/l) in water that leached from the root zone in 2010 on farms in the derogation monitoring network. Mean concentrations per region and number of observations lower than the detection limit for phosphorus.

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	158	18	56	57
Nitrate (NO_3)	45	51	29	12
Nitrogen (N)	13	12	8.5	9.5
Phosphorus[1] (P)	0.13 (63)	<dt (83)	0.21 (29)	0.43 (7)

1: If the mean is lower than the detection limit of 0.062 mg/l this is indicated with <dt. The percentage of the farms with an average lower than the detection limit is shown in parentheses.

In the sand region, 61 percent of the farms had a nitrate concentration lower than the 50 mg NO_3/l stated in the Nitrate Directive. In the loess region this was 56 percent (Table 3.9). In the clay and peat regions, the percentage of farms with a concentration lower than 50 mg per litre was 88 and 96 respectively. The lower number of farms in the sand and loess regions with a nitrate concentration below 50 mg/l compared to the clay and peat regions, is mainly due to a higher percentage of soils prone to leaching: these are soils where less denitrification occurs, partly due to deeper groundwater levels and/or a limited availability of organic material and pyrite (Biesheuvel, 2002, Fraters et al., 2007a, Boumans and Fraters, 2011).

Table 3.9 Frequency distribution of the mean farm nitrate concentrations (in mg NO_3/l) in water that leached from the root zone on farms in the derogation monitoring network per region in 2010, expressed as percentages per class.

Concentration class (mg NO_3 /l)	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	158	18	56	57
< 15	23	6	41	74
15-25	13	0	29	7
25-40	20	28	11	14
40-50	6	22	7	2
> 50	39	44	12	4

Fifty percent of the farms in the sand region had a nitrogen concentration of 11 mg N per litre or lower (Table 3.10). For the loess region the figures were more or less the same. For the peat and clay regions, the values were lower.

Table 3.10 Nitrogen concentrations (in mg /l N) in water that leached out from the root zone in 2010 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	158	18	56	57
First quartile (25%)	7.5	9.2	4.6	6.4
Median (50%)	11	12	6.4	7.5
Third quartile (75%)	17	14	9.4	12

The phosphorus concentration in the leaching water on more than 75 percent of the farms in the loess region was lower than the detection limit of 0.062 mg P per litre (Table 3.11). On three quarters of the farms in the sand region it was lower than 0.12 mg/l. In the clay region, the phosphorus concentrations on 50 percent of the farms were lower than 0.14 mg/l. In the peat region the concentrations were higher.

Table 3.11 Phosphorus concentrations (in mg/l P) in water leaching out of the root zone in 2010 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	158	18	56	57
First quartile (25%)	<dt	<dt	<dt	0.16
Median (50%)	<dt	<dt	0.14	0.30
Third quartile (75%)	0.12	<dt	0.31	0.48

1: If the mean is lower than the detection limit of 0.062 mg/l <dt is indicated.

3.2.2 *Ditch water quality, measured in 2009-2010 (N and P)*

The quality of the ditch water in the winter of 2009-2010 reported here reflects the agricultural practice in 2009 and the years prior to this, and is related to the fourth year of the derogation, not to the figures presented in section 3.1. The peat and clay figures were presented in 2011 as provisional figures (Zwart et al., 2010). The loess region has no derogation monitoring network farms with ditches or drains and is therefore not included in the tables below.

The nitrate concentration in the ditch water on the farms in the derogation monitoring network clearly differs per region. With a mean of 33 mg NO_3 per litre, the nitrate concentration is highest in the sand region and, with a mean of 4.3 mg/l, lowest in the peat region (Table 3.12). This also applies for the nitrogen concentration, although the difference between the clay and peat regions is small. The phosphorus concentration in the ditch water is relatively high in the clay region and relatively low in the sand and peat regions.

Table 3.12 Mean nutrient concentration (mg/l) per region in ditch water in the winter of 2009-2010 on farms in the derogation monitoring network.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms	31	0	55	56
Nitrate (NO_3)	33	*	11	4.3
Nitrogen (N)	9.6	*	4.6	3.9
Phosphorus (P)	0.13	*	0.24	0.14

*: There are no farms with ditches in the loess region.

1: In both the clay and peat regions one farm has no ditches.

In the sand region, 25 of the 31 farms (81 percent) had a nitrate concentration lower than 50 mg per litre in the ditch water (Table 3.13). In the clay and peat regions, none of the farms had a nitrate concentration percentage above 50 mg/l in the ditch water. Half of the farms in the sand region had a nitrogen concentration lower than 8.0 mg N per litre (Table 3.14). In the clay and peat regions 50 percent of the farms had a nitrogen concentration lower than 3.9 and 3.6 mg/l respectively in the ditch water.

Table 3.13 Frequency distribution of the mean farm nitrate concentrations (in mg NO_3/l) in ditch water on farms in the derogation monitoring network per region in the winter of 2009-2010, expressed as percentages per class.

Concentration class (mg NO_3 /l)	Region			
	Sand	Loess	Clay	Peat
Number of farms[1]	31	0	55	56
< 15	32	*	75	93
15-25	16	*	18	5
25-40	23	*	7	2
40-50	10	*	0	0
> 50	19	*	0	0

*: There are no farms with ditches in the loess region.

1: In both the clay and peat regions one farm has no ditches.

Table 3.14 Nitrogen concentrations (in mg N per litre) in ditch water on farms in the derogation monitoring network in the winter of 2009-2010. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms	31	0	55	56
First quartile (25%)	5.0	*	2.8	2.6
Median (50%)	8.0	*	3.9	3.6
Third quartile (75%)	12	*	5.8	4.9

*: There are no farms with ditches in the loess region.

1: In both the clay and peat regions one farm has no ditches.

More than 50 percent of the farms in the sand region had a phosphorus concentration in the ditch water lower than the detection limit of 0.062 mg P per litre (Table 3.15). In the peat region, 50 percent of the farms had a phosphorus concentration below 0.08 mg/l. The highest concentrations were found in the clay region, where 50 percent of the farms had a phosphorus concentration below 0.15 mg/l. In both the clay and the peat regions the concentrations were higher than in the sand region.

Table 3.15 Phosphorus concentrations[1] (in mg/l P) in ditch water in the winter of 2009-2010 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms[2]	31	0	55	56
First quartile (25%)	<dt	*	<dt	<dt
Median (50%)	<dt	*	0.15	0.08
Third quartile (75%)	0.12	*	0.37	0.17

*: There are no farms with ditches in the loess region.

1: If the mean is lower than the detection limit of 0.062 mg/l <dt is indicated.

2: In both the clay and peat regions one farm has no ditches.

Comparison with the provisional figures for 2010 as reported in 2011
The figures are virtually unchanged from those reported as preliminary figures in 2011 (Zwart et al., 2011). Differences that do occur are due to a small variation in the selection of the derogation farms. It emerges that not all the farms in the monitoring network made use of derogation for the year in question. This was not known until after rounding off the agricultural practice report in the subsequent year.

3.2.3 *Provisional figures for the measurement year 2011 (N and P)*

For the fifth water quality measurement year (2011), only provisional results are available – with the exception of the loess region where no results were available at the time of drafting this report. 'Provisional' means that the results carry a reasonable certainty, although various cross-checks have not yet been carried out. This could mean that several concentrations might change in the final results presented in 2013.

Table 3.16 shows the frequency distributions in the mean farm nitrate concentrations (mg NO_3/l) over the concentration classes. Tables 3.17 and 3.18 show the frequency distribution per quartile for the nitrogen concentration and the phosphorus concentration. Both the water leaching from the root zone and the ditch water are shown, expressed in percentages, for all farms in the derogation monitoring network per region in 2011.

In the sand region, the mean nitrate concentration in water leaching from the root zone was 38 mg/l (Table 3.16), and 70 percent of the farms had a concentration lower than 50 mg/l. This is a higher percentage than in 2010 (Table 3.9). The mean nitrate concentration in the water leaching from the root zone in the clay region in 2011 was 19 mg/l. Of the participating farms, 93 percent had a nitrate concentration lower than 50 mg/l (Table 3.16). The mean nitrate concentration on farms in the peat region was 7 mg/l. In the clay and peat regions, the percentage of farms with concentrations lower than 50 mg/l was also higher than in 2010.

The mean nitrate concentration in the ditch water in 2011 in the clay and peat regions was 8 mg/l and 4 mg/l respectively, which was well below 50 mg/l (Table 3.16). In the sand region it was 25 mg/l, which was higher than in the clay and peat regions; however, the mean concentration was lower than in 2010.

Table 3.16 Frequency distributions of the mean nitrate concentrations (in mg/l NO_3) in water that leached from the root zone and in the ditch water per region in 2011, expressed in percentages per concentration class and mean nitrate concentration for all farms.

Concentration class (mg NO_3/l)	*Water type*						
	Leaching from root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	158	*	57	59	31	56	58
Mean concentration all farms	38	*	20	7	25	8	4
< 15	27	*	63	83	45	88	98
15-25	15	*	16	8	23	7	0
25-40	20	*	11	5	13	4	0
40-50	8	*	4	2	3	2	2
> 50	30	*	7	2	16	0	0

*: Data from the loess region were not yet available when this report was drafted.

The nitrogen concentration in the leaching water in the sand region was also higher than in the clay and peat regions (Table 3.17). What is noticeable here is that the nitrogen concentration in the peat region was higher than in the clay region. This was due to a higher concentration of ammonium nitrogen in the peat region (Van Beek et al., 2004). The nitrogen concentrations in the ditch water show a similar pattern to those in the leaching water, but with lower concentrations.

Table 3.17 Nitrogen concentrations (in mg/l N) in the water leaching from the root zone (left) and in the ditch water (right) in 2011 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	*Water type*						
	Leaching from root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	158	*	57	59	31	56	58
Mean	12	*	6.3	8.7	7.8	3.8	4.3
First quartile (25%)	7.3	*	3.3	5.8	4.0	2.4	3.0
Median (50%)	11	*	4.3	8.3	7.1	3.3	4.3
Third quartile (75%)	16	*	7.7	10	9.2	4.7	5.4

*: Data from the loess region were not yet available when this report was drafted.

Contrary to nitrogen, the phosphorus concentrations in the leaching water were higher in the peat region than in the clay and sand regions (Table 3.18). As in the case of nitrogen, the phosphorus concentrations in the ditch water were lower than in the leaching water, with the exception of the clay region, where the phosphorus concentration in the ditch water was higher than in the leaching water.

Table 3.18 Phosphorus concentrations[1] (in mg/l P) in the water leaching from the root zone (left) and in the ditch water (right) in 2011 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	*Water type*						
	Leaching from the root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	158	*	57	59	31	56	58
Mean	0.20	*	0.23	0.39	0.09	0.28	0.15
First quartile (25%)	<dt	*	<dt	0.11	<dt	<dt	<dt
Median (50%)	<dt	*	0.21	0.27	<dt	0.14	0.08
Third quartile (75%)	0.11	*	0.29	0.53	0.13	0.47	0.19

*: Loess farms in the monitoring network do not have ditches

1: If the mean is lower than the detection limit of 0.062 mg/l, <dt is indicated.

4 Changes in the monitoring network since the derogation

4.1 Introduction

This chapter first of all describes the trends in the agricultural practice in the derogation monitoring network, followed by the evolution of the water quality. Trend changes since the start of the derogation are established, as well as the extent to which agricultural practice year 2010 statistically differs from the preceding years. Finally, a link is made between the evolution of the agricultural practice and of the water quality. This includes results both from this report and from the previous reports on the derogation monitoring network (Fraters et al., 2008; Zwart et al., 2009, 2010 and 2011). For both the agricultural practice and the water quality, five measurement years are available. When establishing relationships, it should be realised that a series of five successive years is still rather limited.

4.1.1 Selection of farms for comparison of results

In order to compare the results of successive years, previous reports used only those farms that participated in the derogation monitoring network and actually used the derogation in the measurement year concerned as well as in the preceding years. Because each year some farms dropped out and new farms were not used for the trend analyses, the number of farms that had participated each year diminished in successive years. To guarantee the quality of the results in the long run, a sufficient number of large groups is required. Therefore, starting with this report a different method for the selection of farms is used. Per measurement year, all farms are included that participated in the derogation monitoring network in that year and actually used derogation. By using this method, a larger group of farms is available to determine averages per year and the number of farms per year remains constant in successive reports. Consequently, the results of preceding years will no longer change, with the exception of the corrected nitrate concentrations (section 4.3.2), because with the statistical method applied nitrate concentrations in previous years might be slightly affected by the concentrations in the most recent measurement year.

Because starting with this report a different method of farm selection is used, the figures in this chapter for the preceding years may differ slightly from the figures reported by Zwart et al. (2009; 2010; 2011).

4.1.2 Statistical method determination of differences and trends

When preparing this report, data for five consecutive years were available. For the agricultural practice this includes the years prior to 2010 (2006, 2007, 2008 and 2009) and for the water quality the years prior to 2011 (2007, 2008, 2009 and 2010).

Determination of deviation of measurement year concerned
The purpose of the comparison is to determine whether there is a significant difference between the measurement year and the average of the preceding years. The significance was determined by using the Restricted maximum likelihood procedure (REML method). The REML method is suitable for unbalanced data sets and therefore takes into account that for a large part the same farms were monitored during a number of years. For the data on agricultural practice, calculations were made using SPSS (IBM SPSS Statistics,

version 19), whereby the REML method is to be found in the linear mixed effects models procedure (MIXED method). For the water quality data, calculations were made using the GenStat REML method (14th edition; VSN International Ltd.).

Calculations were made with unweighted annual farm averages, which means that these are not corrected for farm acreage, size, etc. The annual farm averages available were divided into two groups: all the averages of the measurement year in group 1 and those of the preceding years in group 2. The difference between group 1 and group 2 is estimated as a so-called 'fixed effect', taking into account that the data for a large part come from the same farms ('random effect'). Information on fixed and random effects can be found in standard statistical manuals on variance analysis, see for example Kleinbaum et al. (1997) and Payne (2000). Estimations made with such models are explained by Welham et al. (2004).

If the most recent measurement year (agricultural practice year 2010, water quality measurement year 2011) differs significantly from the average of the preceding years ($p<0.05$), the direction of the difference between the most recent measurement year and the preceding years is indicated by '+' or '-'. If there is no relevant difference ($p>0.05$), this is indicated by '≈'. This indication is listed in the column 'difference' in the summarising tables (see for example Table 4.1). In some situations when outliers occurred, the required results could not be obtained via the REML method. In such cases the ANOVA method was used. This is a simpler method for variance analysis (Field, 2005), which does not take into account the fact that for a large part the same farms were sampled.

Determination of trends
Furthermore, it was determined whether trend changes took place during the measurement period. Here again the REML method was used, with groups per year. Only significant trend changes ($p<0.05$) are dealt with in the text. If the REML method was not satisfactory because of outliers, linear regression analysis was used (Field, 2005), which does not take into account the fact that for a large part the same farms were sampled.

4.2 Trends in the agricultural practice

Table 4.1 includes all farms (dairy and other grassland) that in the years 2006-2010 participated in the derogation monitoring network and actually used derogation (293 to 296 farms per year). On a number of these farms (varying from 9 to 17 farms per year) the nutrient flows were incomplete. Therefore, Table 4.2 to 4.4 and Table 4.6 to 4.8 are based on the results from a lower number of farms than indicated in Table 4.1. These numbers are reported in the tables. The calculated crop yields (Table 4.5) are based on data from even fewer farms. Not all farms have farmland. Besides, the yields of the farms cannot always be calculated reliably, because some farms did not satisfy the criteria for calculating crop yields.

4.2.1 Classification of the farms

The changes in the general farm characteristics in the course of time, such as acreage of cultivated land and percentage of grassland, are generally limited (Table 4.1). The quantity of milk produced, expressed as FPCM per farm and per hectare, has increased. This can be explained by purchase and lease and by the expansion of the milk quota from the European Union (by 0.5 percent in 2007,

2.5 percent in 2008, 1 percent in 2009 and 1 percent in 2010). The increase in the milk production in 2010 was not associated with a comparable increase in the area of cultivated land per farm. This means an increase of milk production (FCPM) per hectare. The milk production per cow was higher in 2010 than the average for
2006-2009. The number of farms where dairy cows were grazed (79 percent) was significantly lower in 2010 than the average for 2006-2009. For the years 2006-2010, there is a significant trend towards a decrease in the percentage of farms with grazing dairy cows.

Table 4.1 General operating characteristics of the farms in the derogation monitoring network in the years 2006 to 2010, the average for the years 2006 to 2009, the difference between 2010 and the average for the years 2006 to 2009 and the trend for the years 2006 to 2010.

Farm characteristic	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Number of dairy farms	263	257	259	256		257		
Number of other grassland farms	31	38	37	37		37		
Total area cultivated land (ha)	49	50	51	52	51	53	≈	≈
Percentage grassland	83	83	82	82	82	83	≈	≈
Percentage farms with housed animals	17	17	17	14	16	14	≈	≈
Total livestock density (LSU/ha)[1]	3.0	3.1	2.7	2.8	3.0	2.9	≈	≈
Kg FPCM per farm (x 1000)	686	723	775	811	785	860	+	+
Kg FPCM per dairy cow (x 1000)	8.4	8.4	8.4	8.5	8.4	8.7	+	+
Kg FPCM/ha forage crop (x 1000)	14	14	15	15	15	16	+	+
Percentage dairy farms with grazing dairy cows	89	88	86	83	87	79	-	-

1: LSU = Livestock Unit. 1 dairy cow = 41 kg phosphate = 1 LSU, 1 young animal 1-2 yr. = 18 kg phosphate = 0.44 LSU, 1 young animal 0-1 yr. = 9 kg phosphate = 0.22 LSU.
Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).

For the period 2006-2010, there is a significant trend towards an increase in the production of milk (FCPM) per farm, per hectare and per cow. This does not apply to the number of farms with housed animals and the area of cultivated land per farm. For the dairy industry the trend indicates a slow, but steadily ongoing increase in scale and intensification of the production of milk per hectare. Also, farmers increasingly opt for full time housing of dairy cows.

4.2.2 *Livestock manure*

Despite an increase of only a few kg per hectare in the use of nitrogen in livestock manure in the years 2006-2010, a trend was set. The stock mutation rate is significantly higher in 2010 than in the period 2006-2009 (Table 4.2). The use of nitrogen from livestock manure on arable land was significantly lower in 2010 than the average for 2006-2009. Here again a trend was set. On grassland, the use did not increase in 2010 compared to the average for 2006-2009, but there was a significant trend towards an increase in use between 2006 and 2010. Here too, it was a matter of only a few kg of nitrogen per hectare.

Table 4.2 Average nitrogen use via livestock manure (in kg N/ha) on farms in the derogation monitoring network in the years 2006 to 2010, the average for the years 2006 to 2009, the difference between 2010 and the average for the years 2006 to 2009, and the trend for the years 2006 to 2010.

Description	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Number of farms	285	281	283	276		280		
Use of nitrogen in livestock manure								
Produced on farm	266	262	268	266	266	277	≈	≈
+ Import	9	11	12	12	11	10	≈	≈
+ Stock mutation[1]	-5	-7	-6	3	-4	-8	-	≈
- Export	28	28	32	30	30	34	≈	≈
Total use	243	238	241	251	243	246	≈	+
Application standard livestock manure	243	241	243	244	243	246	+	+
Use on grassland[2]	258	251	257	269	259	261	≈	+
Use on arable land[3]	179	184	177	178	180	166	-	-

Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).
1: A negative stock mutation is a stock increase and will correspond to export of manure.
2: The mean use and the application standards on grassland are based on the following numbers of farms: 277 (2006), 279 (2007), 276 (2008), 268 (2009) ans 274 (2010), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.
3: The mean use and the application standards on arable land are based on the following numbers of farms: 205 (2006), 204 (2007), 210 (2008), 203 (2009) and 201 (2010), as a number of farms, besides falling outside the confidence intervals for the allocation of fertilisers to arable land, had no arable land. On arable land or grassland, the allocation of fertilisers fell outside the confidence intervals on the following numbers of farms: 8 (2006), 2 (2007), 7 (2008), 5 (2009) and 6 (2010), while 72 (2006), 75 (2007), 66 (2008), 65 (2009) and 73 (2010) farms had no arable land.

4.2.3 Use of fertilisers compared to the application standards

The total use of plant-available nitrogen is still lower than the total application standard, but the difference is decreasing (Table 4.3). Where the difference between the use and the total application standard for plant-available nitrogen in 2006 was almost 50 kg per hectare, this was reduced to 20 kg per hectare in 2010. Partly this is due to higher statutory availability coefficients for grazing livestock manure, and partly to more stringent nitrogen application standards (Table 4.3).

The use of inorganic nitrogen fertiliser was fairly constant from 2006 to 2009, but was significantly lower in 2010 than the average over the 2006-2009 period. Therefore, the total amount of plant-available nitrogen in 2010 barely deviated from the average over the four preceding years. However, there is an increase in the total use of nitrogen, mainly due to the increase of the statutory availability coefficient.

Table 4.3 Average nitrogen use (in kg plant-available N/ha) on farms in the derogation monitoring network in the years 2006 to 2010, the average for the years 2006 to 2009, the difference between 2010 and the average for the years 2006 to 2009, and the trend for the years 2006 to 2010.

Description	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Number of farms	285	281	283	276		280		
Livestock manure excl. availability coefficient	243	238	241	251	243	246	≈	+
Availability coefficient	40	41	49	49	45	50	+	+
Livestock manure incl. availability coefficient	98	97	118	124	109	123	+	+
+ other organic fertiliser	0	0	0	0	0	0	≈	≈
+ inorganic fertiliser	128	128	124	127	127	120	-	≈
Total use	226	225	243	251	236	243	≈	+
Farm's nitrogen application standard	273	288	275	267	276	263	-	-
Use on grassland[1]	253	253	273	282	265	269	≈	+
Nitrogen application standard grassland	318	313	298	289	304	284	-	-
Use on arable land[2]	109	116	127	127	120	122	≈	+
Nitrogen application standard arable land	164	171	167	162	166	158	-	-

Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).
1: The mean use and the application standards on grassland are based on the following numbers of farms respectively: 277 (2006), 279 (2007), 276 (2008), 268 (2009) and 274 (2010), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.
2: The mean use and the application standards on arable land are based on the following numbers of farms respectively: 205 (2006), 204 (2007), 210 (2008), 203 (2009) and 201 (2010), as a number of farms, besides falling outside the confidence intervals for the allocation of fertilisers to arable land, had no arable land. On arable land or grassland, the allocation of fertilisers fell outside the confidence intervals on the following numbers of farms respectively: 8 (2006), 2 (2007), 7 (2008), 5 (2009) and 6 (2010), while 72 (2006), 75 (2007), 66 (2008), 65 (2009) and 73 (2010) farms respectively had no arable land.

From 2006 to 2010, the use of phosphate fertilisers on the farms in the monitoring network decreased by about 8 percent and the phosphate application norm by 14 percent. This resulted in a reduction of the difference between the use of phosphate and the phosphate application standard from approximately 10 kg/ha in 2006/2007 to 2 kg/ha in 2010. In 2010, the use of phosphate fertilisers decreased compared to 2009 (Table 4.4).

Table 4.4 Average phosphate use (in kg P_2O_5/ha) on farms in the derogation monitoring network in the years 2006 to 2010, the average for the years 2006 to 2009, the difference between 2010 and the average for the years 2006 to 2009, and the trend for the years 2006 to 2010.

Description	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Number of farms	285	281	283	276		280		
Livestock manure	87	85	87	93	88	86	≈	≈
+ other organic fertiliser	0	0	0	0	0	0	≈	≈
+ inorganic fertiliser	10	7	6	4	7	3	-	-
Total use	97	93	93	97	95	89	-	-
Farm's phosphate application standard	106	103	98	98	101	91	-	-
Use on grassland[1]	98	92	93	100	96	91	-	≈
Phosphate application standard grassland	111	106	101	101	104	93	-	-
Use on arable land[2]	100	101	99	93	98	81	-	-
Phosphate application standard arable land	96	92	86	85	90	80	-	-

Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).
1: The mean use and the application standards on grassland are based on the following numbers of farms respectively: 277 (2006), 279 (2007), 276 (2008), 268 (2009) and 274 (2010), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.
2: The mean use and the application standards on arable land are based on the following numbers of farms respectively: 205 (2006), 204 (2007), 210 (2008), 203 (2009) and 201 (2010), as a number of farms, besides falling outside the confidence intervals for the allocation of fertilisers to arable land, had no arable land. On arable land or grassland, the allocation of fertilisers fell outside the confidence intervals on the following numbers of farms respectively: 8 (2006), 2 (2007), 7 (2008), 5 (2009) and 6 (2010), while 72 (2006), 75 (2007), 66 (2008), 65 (2009) and 73 (2010) farms respectively had no arable land.

Some important developments are:

- Between 2006 and 2010, the phosphate application standards were lowered from an average of 106 kg per hectare to an average of 91 kg per hectare. This means that the difference between the use and the standard was largely eliminated, which also resulted in a reduction in the use of inorganic phosphate fertiliser.
- Both in 2009 and in 2010, more phosphate was used on grassland than on arable land. The opposite was the case in the years 2006-2008.
- Between 2006 and 2010, there was a significant trend towards a reduction of both the total phosphate use and the use of phosphate on arable land. This is not the case for grassland. However, the total use of phosphate, as well as the use on grassland and on arable land separately, was significantly lower in 2010 than the average of the four preceding years.
- The phosphate application standards for 2010 were significantly lower than the average for the years 2006-2009, because starting in 2010 the phosphate condition of the soil was taken into account in the application standards, lowering the phosphate application standard for soil with a neutral phosphate condition and soil with a high phosphate condition compared to 2009. Farmers must submit a soil analysis to the government in order to be considered for the (higher) phosphate application standard

pertaining to the 'neutral' or 'low' phosphate classes. If no soil analysis is submitted, then on the basis of the Fertilisers Act, the (low) phosphate application standard pertaining to the 'high' phosphate class is automatically applied. Because 70 percent was placed in the 'high' phosphate class (Van den Ham et al., 2011, based on data of the National Service for the Implementation of Regulations), the mean phosphate application standard in 2010 was 7 kg per hectare lower than in 2009. Besides, there was a downward trend in the phosphate application standards from 2006 to 2010.

4.2.4 *Crop yields*

The crop yields are calculated according to the method described by Aarts et al. (2008). A more detailed explanation of this calculation method is provided in Appendix 3.

The mean grassland and silage maize yields show no significant difference between 2010 and the means in the years 2006-2009, nor is there a trend to be seen in the yields of the years 2006 tot 2010. This applies to tonnes of dry matter as well as kg P. However, there is a trend towards a decrease in yields measured in kg N with regard to both grassland and silage maize. This is caused by lower N levels in both grass and maize (Table 4.5).

Table 4.5 Calculated crop yield (in tonnes dry matter and kg N, P and P_2O_5/ha) for grassland and estimated yield for silage maize on farms in the derogation monitoring network that satisfy the criteria for applying the method for calculating grassland yield (Aarts et al., 2008) for the years 2006 to 2010, the average for the years 2006 to 2009, the difference between 2010 and the average for the years 2006 to 2009, and the trend for the years 2006 to 2010.

Description	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Estimated yield silage maize								
Number of farms	136	128	135	145		146		
Tonnes dry matter/ha	16	15	16	16	16	16	≈	≈
Kg N/ha	205	172	182	185	186	183	≈	-
Kg P/ha	34	31	32	41	34	31	≈	≈
Kg P_2O_5 /ha	78	70	73	94	79	71	≈	≈
Calculated yield grassland								
Number of farms	158	168	165	182		193		
Tonnes dry matter/ha	9.1	11	9.7	9.7	9.8	9.7	≈	≈
Kg N/ha	265	290	265	261	270	257	-	-
Kg P/ha	36	41	39	38	38	37	≈	≈
Kg P_2O_5/ha	81	95	88	86	88	85	≈	≈

Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).

4.2.5 *Nutrient surpluses on the soil surface balance*

The nitrogen surpluses in the soil surface balance fluctuate somewhat over the years. The average N surplus in the soil surface balance in 2010 was not significantly different from the average for the years 2006-2009, nor was there a trend towards a reduction (Table 4.6). The soil types in the different regions show no significant differences either, except for the loess region, where there is a trend indicating a significant increase (Table 4.7).

Table 4.6 Nitrogen surplus on the soil surface balance (in kg N/ha) on farms in the derogation monitoring network for the years 2006 to 2010, the average for the years 2006 to 2009, the difference between 2010 and the average for the years 2006 to 2009, and the trend for the years 2006 to 2010.

Description	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Number of farms	285	281	283	273		280		
Import of (inorganic) fertiliser, feed, animals and other products	308	304	322	320	313	319	≈	≈
Export of milk, animals, feed, manure and other products	129	136	145	133	136	146	≈	≈
Deposition, mineralization and N fixation	60	60	59	59	60	58	≈	≈
Gaseous emission from housing and storage, during grazing and application	44	43	44	43	44	46	≈	≈
Mean surplus soil surface balance	195	183	192	202	193	185	≈	≈
Surplus soil surface balance 25% quartile[1]	144	133	145	150	144	136		
Surplus soil surface balance 75% quartile[2]	233	232	231	233	233	221		

1: Upper limit of the 25% farms with the lowest surplus on the soil surface balance.
2: Lower limit of the 25% farms with the highest surplus on the soil surface balance.
Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).

Table 4.7 Nitrogen surplus on the soil surface balance (in kg N/ha) on farms in the derogation monitoring network for the years 2006 to 2010, the relative difference between 2010 and the average for the years 2006 to 2009, and the trend for the years 2006 to 2010.

Region	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Sand (n = 145-154)	178	171	173	191	178	167	≈	≈
Loess (n = 17-20)	133	141	161	163	150	166	≈	+
Clay (n = 52-56)	210	183	208	217	204	193	≈	≈
Peat (n = 57-59)	245	227	241	236	237	233	≈	≈
All farms (n = 273-285)	195	183	192	202	193	185	≈	≈

Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).

Table 4.8 shows that the phosphate surplus on the soil surface balance in 2010 was significantly lower than the average for the years 2006-2009. It also shows a decreasing trend between the years 2006 and 2010, caused by a significant drop in the import of inorganic fertiliser (Table 4.4) and a (not significantly) higher export. The farms in the first quartile realised a mean phosphate surplus of 0 kg per hectare (balance) in 2010.

Table 4.8 Phosphate surplus on the soil surface balance (in kg P_2O_5/ha) on farms in the derogation monitoring network for the years 2006 to 2010, the average for the years 2006 to 2009, the difference between 2010 and the average for the years 2006 to 2009, and the trend for the years 2006 to 2010.

Description	*2006*	*2007*	*2008*	*2009*	*Average 06-09*	*2010*	*Difference*	*Trend*
Number of farms	285	281	283	273		280		
Import of (inorganic) fertiliser, feed, animals and other products	84	79	82	79	81	77	-	≈
Export of milk, animals, feed, manure and other products	59	61	66	59	61	65	≈	≈
Mean surplus soil surface balance	25	17	16	20	20	12	-	-
Surplus soil surface balance 25% quartile[1]	12	5	6	8	8	0		
Surplus soil surface balance 75% quartile[2]	36	30	26	29	30	23		

1: Upper limit of the 25% farms with the lowest surplus on the soil surface balance.
2: Lower limit of the 25% farms with the highest surplus on the soil surface balance.
Difference: direction and significance of difference between 2010 and the average of previous years.
≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).
Trend: direction and significance of the trend for the years 2006-2010. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).

4.2.6 *Summarised*

Comparison of the results for the years 2006 to 2010 reveals a significant increase of milk production per farm, per hectare and per cow, accompanied by a rise in the production of livestock manure. Between 2006 and 2010 there was a trend towards a slight but significant increase in the use of plant-available nitrogen in livestock manure, mainly caused by the higher statutory availability coefficient for grazing. In 2010, the use of livestock manure was not higher than the application standard. In 2009 it was slightly higher, but that does not apply to the average for 2006-2009.

In 2010, the use of inorganic nitrogen fertilisers was significantly lower than the average in the four preceding years. Between 2006 and 2010, the total use of plant-available nitrogen increased significantly. Here again, the main reason for this was the higher statutory availability coefficient for nitrogen in livestock manure. The total use of plant-available nitrogen remained about 20 kg per hectare below the total application standard in 2010. Due to the more stringent application standard and the higher statutory availability coefficient for nitrogen in livestock manure, the difference has diminished in the course of the years. For the years 2006-2009, the mean use of plant-available nitrogen was 40 kg per hectare lower than the total application standard. The surpluses on the soil surface balance for nitrogen fluctuated somewhat over the years, but no significant trend was determined.

The use of phosphate via fertilisation was significantly lower in 2010 than the average for the years 2006-2009, mainly caused by a decrease in the use of inorganic fertiliser. Partly as a result of this, the phosphate surplus was significantly lower in 2010 than the average for the years 2006-2009. The farms in the 25 percent quartile realised a mean phosphate surplus of less than 0 kg per hectare (0 kg/ha is balance) in 2010. Both the use of phosphate and the phosphate surplus showed a significant decreasing trend between 2006 and 2010. Between 2006-2007 and 2010, the difference between the phosphate application standard and the phosphate use was reduced from approximately 10 kg to 2 kg per hectare. The phosphate application standard for 2010 was significantly lower than the average for the period 2006-2009, due to the fact that starting in 2010 the phosphate condition of the soil was taken into account, which means that for soil with a neutral phosphate condition and soil with a high phosphate condition the phosphate application standard was lowered compared to 2009.

The estimated silage maize yield and the calculated grassland yield, both in kg dry matter per hectare and in kg phosphate per hectare, did not differ from the average in the years 2006-2009. Measured in kg N per hectare there is, however, a significant reduction in the yields between 2006 and 2010, both for grassland and silage maize. This is caused by the lower N levels in grass and maize.

In conclusion, it can be said that the mean use of nitrogen in livestock manure was not higher than the application standard in 2010. There is however a slight but significant rise in the use of plant-available nitrogen in livestock manure. The main reason for this is the higher statutory availability coefficient for nitrogen in livestock manure for grazing. The total use of plant-available nitrogen and phosphate was lower than the total application standards for nitrogen and phosphate. There was a slight but significant increase in the total use of plant-available nitrogen between 2006 and 2010, while the use of phosphate showed a decreasing trend.

The surplus for nitrogen on the soil surface balance did not decrease significantly between 2006 and 2010, while the phosphate surplus showed a trend towards decrease. The farms in the 25 percent quartile realised a phosphate surplus lower than 0 (balance) in 2010.

4.3 Evolution of the water quality

In this section, the evolution of the water quality in the derogation years 2006-2010 is reported. The water quality is roughly determined in the year following the use of derogation in the agricultural practice, in this case the period 2007-2011. The comparison between the water quality in 2006 (no relationship yet with derogation) and 2007 (related to 2006, the first year of derogation) is described in Zwart et al. (2009).

The evolution of the water quality in the years 2007 to 2011 is determined for all the farms that participated in the derogation monitoring network and that actually used derogation in the agricultural practice year preceding the measurement year. This means that the numbers of farms reported on in chapter 4 differ from the numbers in chapter 3. For 2011, only preliminary results are reported. For the loess region, data for 2011 are not yet available.

4.3.1 *Development average concentrations 2007-2011*

Nitrate and nitrogen

The average nitrate concentration in the water leaching from the root zone on the derogation farms dropped between 2007 and 2009. In the period following this, the concentration fluctuated, showing a limited increase in 2010 and a comparable decrease in 2011 (Figure 4.1). These fluctuations were due partly to a lower precipitation surplus in 2007 and in 2010, resulting in a rise in the nitrate concentrations in the leaching water.

The average nitrate concentrations are the highest in the loess region and show a reduction in the sequence loess > sand > clay > peat. In the clay and the peat regions, the average concentrations were lower than 50 mg nitrate per litre for all years (Figure 4.1). In the sand region this has been the case from 2008. In the loess region the average nitrate concentration was according to the standard of 50 mg/l in 2009 and 2010. The higher nitrate concentrations in the loess and the sand regions are caused mainly by a higher percentage of soils prone to leaching; these are soils where less denitrification occurs, partly due to deeper groundwater levels (Fraters et al., 2007, Boumans and Fraters, 2011).

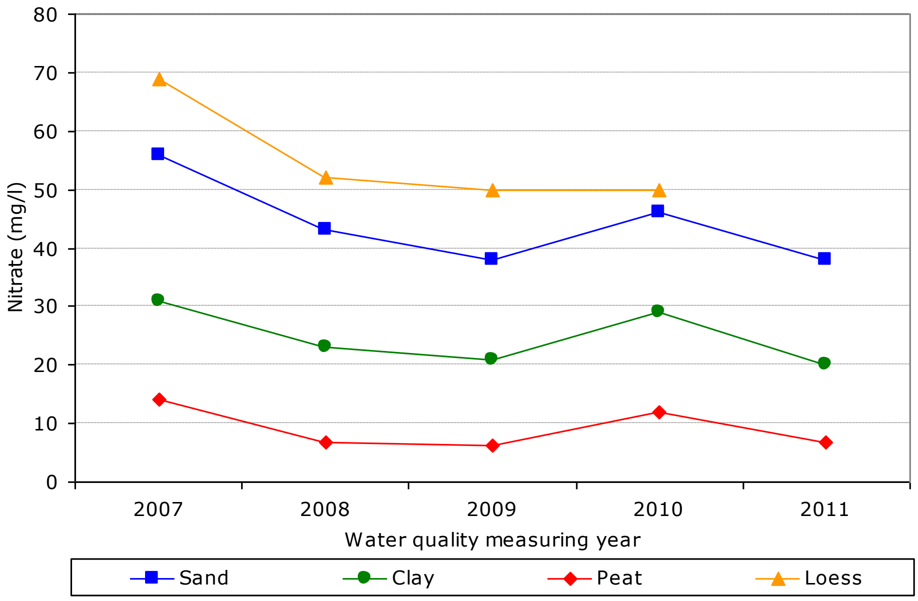


Figure 4.1 Mean nitrate concentration in water leaching from the root zone on derogation farms in the four regions during the period 2007-2011.

In general, the concentrations in the water leaching from the root zone were not significantly different in 2011 from the average concentration in the preceding years (Table 4.9). Only in the sand region, the nitrate and nitrogen concentrations in the leaching water were significantly lower in 2011 than the average in the preceding years.

In the clay and the peat regions, there is no trend towards either a rise or a fall of the concentrations in the water leaching from the root zone, but rather towards fluctuations over the years. In the loess and the sand regions, however, the nitrate concentration did drop significantly between 2007 and 2011. These significant trends are affected by the sharp fall between 2007 and 2008 (Figure 4.1). Particularly in the loess region, after 2008 the decrease is minimal. The future will tell to what extent these decreasing trends will remain significant in the course of a longer term measurement series.

The report for water quality year 2009 showed a reduction in the nitrate and nitrogen concentrations in the loess region (Zwart et al., 2010). In 2010, the nitrate and nitrogen concentrations in the loess region did not decrease any further, but remained stable at 50 mg nitrate per litre.

The nitrate concentrations in the ditch water of the derogation farms in the peat and the clay regions showed the same picture as the water leaching from the root zone (Figure 4.2), but with lower concentrations. The results for the ditch water in the sand region were similar to those for the water leaching from the root zone, but dropped more sharply between 2008 and 2009 and still seem to be decreasing, albeit with fluctuations. In all the regions and the years, the mean nitrate concentrations in the ditch water were less than 50 mg/l. The mean nitrate concentrations were highest in the sand region and decreased in the sequence sand > clay > peat. The nitrate and nitrogen concentrations in the ditch water in 2011 did not differ significantly from the mean concentrations in the preceding years (Table 4.9). In the clay region, there was a significant decrease in the nitrate concentration in the ditch water between 2007 and 2011. The decrease in the nitrate concentration in the ditch water in the sand region was significant for nitrate (as determined by regression analysis).

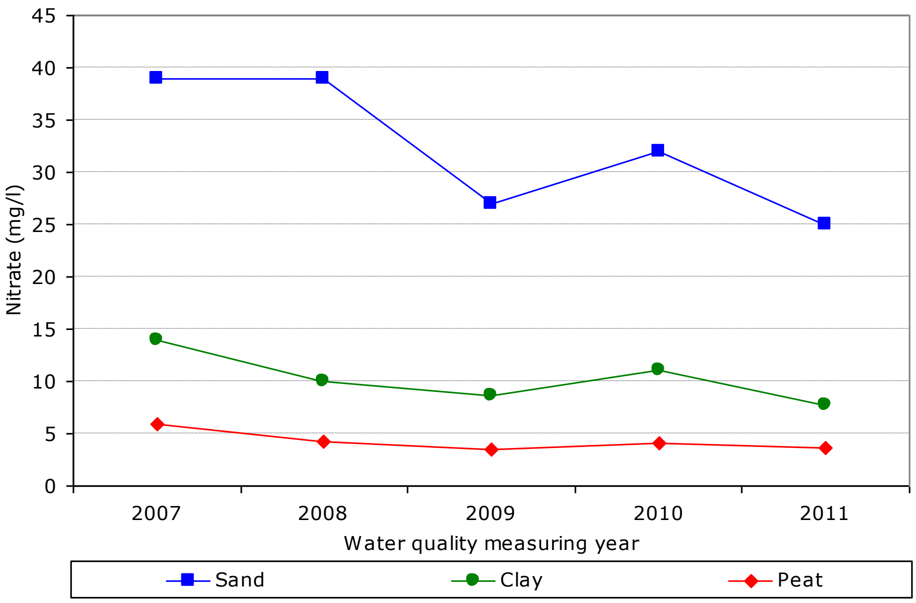


Figure 4.2 Mean nitrate concentration in ditch water on derogation farms in the three regions during the period 2007 to 2011.

Table 4.9 Average nutrient concentrations (mg/l) in the water leaching from the root zone (leaching) and the ditch water in 2007 to 2011, the difference between 2011 and the average for the years 2007 to 2010, and the trend for the years 2007 to 2011.

	2007	*2008*	*2009*	*2010*	*Average 07-10*	*2011*	*Difference*	*Trend*
				Clay leaching				
Number	57	57	57	57		57		
Nitrate	31	23	21	29	26	20	≈	≈
Phosphorus	0.27	0.22	0.26	0.20	0.24	0.23	≈	≈
Nitrogen (N)	9.3	7.2	6.6	8.4	7.9	6.3	≈	≈
				Clay ditch water				
Number	56	56	56	56		56		
Nitrate	14	10	8.7	11	11	7.7	≈	-
Phosphorus	0.32	0.34	0.37	0.22	0.31	0.28	≈	≈
Nitrogen (N)	4.8	4.4	4.1	4.5	4.5	3.8	≈	≈
				Sand leaching				
Number	160	157	159	159		158		
Nitrate	56	43	38	46	46	38	-	-
Phosphorus	0.11	0.17	0.14	0.13	0.14	0.20	≈	≈
Nitrogen (N)	16	13	11	13	13	12	-	-
				Sand ditch water				
Number	23	25	30	30		31		
Nitrate	39	39	27	32	34	25	≈	-
Phosphorus	0.12	0.12	0.10	0.13	0.12	0.094	≈[1]	≈[1]
Nitrogen (N)	10	11	8.0	9.6	9.7	7.8	≈	≈[1]
				Peat leaching				
Number	60	61	60	60		59		
Nitrate	14	6.7	6.2	12	9.6	6.9	≈	≈
Phosphorus	0.53	0.44	0.39	0.42	0.45	0.39	≈	≈[1]
Nitrogen (N)	12	8.9	7.6	9.5	9.6	8.7	≈	≈
				Peat ditch water				
Number	61	60	59	59		58		
Nitrate	5.9	4.2	3.5	4.1	4.4	3.7	≈[1]	≈[1]
Phosphorus	0.22	0.16	0.22	0.14	0.18	0.15	≈	≈
Nitrogen (N)	3.6	4.0	4.2	4.0	3.9	4.3	≈	≈
				Loess leaching[2]				
Number	17	18	20	18		#		
Nitrate	69	52	50	50	57	#	≈	-
Phosphorus[3]	<dt	<dt	<dt	<dt	<dt	#	≈	≈
Nitrogen (N)	17	13	12	12	14	#	≈	-

Difference: direction and significance of difference between 2011 and the average of previous years.

≈ : difference not relevant (p>0.05), +/- : a significant difference (p<0.05).

Trend: direction and significance of the trend for the years 2007-2011. ≈ : trend not relevant (p>0.05), +/- : a significant trend (p<0.05).

1: Use of alternative statistical method instead of REML. In order to calculate the difference ANOVA was used; for the trend the regression analysis (linear) was used.

2: The difference was determined based on the comparison of the data for 2010 with the data for 2007-2009. The data for 2011 are not yet available (#).

3: If the mean P concentration is lower than the detection limit of 0.062 mg/l this is indicated with <dt.

Phosphorus
In the clay, sand and peat regions, the phosphorus concentration in the water leaching from the root zone has been fluctuating over the years (Table 4.9). The mean concentration in the loess region was under the detection limit in all years. The concentrations were highest in the peat region, followed by the clay region and the sand region. The concentration was lowest in the loess region. There was no significant difference between the measurement year 2011 and the average of the preceding years, nor were there any significant trends to be seen.

The report for the water quality year 2010 showed a reduction of phosphorus levels in the leaching water in the clay region (Zwart et al., 2010). In 2011, the concentration rose somewhat when compared with 2010, but this rise does not seem to persist.

The phosphorus concentrations in the ditch water in the clay, sand and peat regions have also been fluctuating over the years (Table 4.9). The phosphorus concentrations in the ditch water decreased in the sequence clay > peat > sand. There is no significant difference between the measurement year 2011 and the average of the preceding years, nor were there any significant trends to be seen.

The report for the water quality year 2010 showed a reduction of phosphorus levels in the ditch water in the clay and peat regions (Zwart et al., 2010). In 2011, this reduction did not persist in the clay region, where the phosphorus concentration slightly increased again. In the peat region, the phosphorus concentration in the ditch water remained fairly stable.

4.3.2 *Influence of environmental factors and sample on nitrate concentrations*

The nitrate concentration in the leaching water is not only influenced by the agricultural practice, but also by environmental factors such as the precipitation surplus and changes in the groundwater level (Boumans et al., 2005; Fraters et al., 2005; Zwart et al., 2009, 2010, 2011). Changes in the farms participating in the sample can also have an effect, because the soil type and the groundwater level vary per farm (Boumans et al., 1989).

For the sand region, a statistical method was developed to make corrections for the influence of weather conditions, groundwater level and changes in the sample of the nitrate concentration in the leaching water (Boumans and Fraters, 2011). This method uses the relative evaporation as a measure for the impact of annual fluctuations in the precipitation surplus (Table 4.10). As the values for the evaporation and the groundwater level rise, the nitrate concentration will also rise as long as the other factors do not change. A further explanation of the method is provided in Appendix 5.

The mean corrected nitrate concentrations in the sand region dropped significantly from approximately 55 mg/l in 2007 to approximately 35 mg/l in 2011, a reduction of 20 mg/l (Table 4.10 and Figure 4.3). Although the decrease is significant (decrease of 5 mg NO_3 per year, s.e. 0.48, $p<0.001$), the results must be dealt with carefully. The method used is not all-inclusive and does not take all the processes into consideration. However, it can be concluded that if factors such as weather conditions, changes in groundwater levels and effects of sample changes are not taken into account, the nitrate concentration would drop significantly, with fluctuations. If these factors are taken into account the concentration also shows a significant decrease, but with far fewer fluctuations.

In recent years the nitrate concentrations, both measured and corrected, have been under the 50 mg/l standard and have shown a trend towards a significant decrease. Therefore, it can be concluded that the weather, the groundwater level and the sample are not the reason that concentrations are under 50 mg/l.

Table 4.10 Mean nitrate concentration (mg/l), measured and corrected, in the leaching water in the sand region. The average relative evaporation and the groundwater level are also given.

Year	*Number of farms*	*Relative evaporation*	*Groundwater level*[1]	*Nitrate Measured*	*Nitrate Corrected*
2007	160	1.3	136	56	55
2008	157	0.93	144	43	50
2009	159	1.0	158	39	42
2010	159	1.4	145	46	40
2011	158	1.3	149	38	35

1: Mean groundwater level in centimetres below surface level.

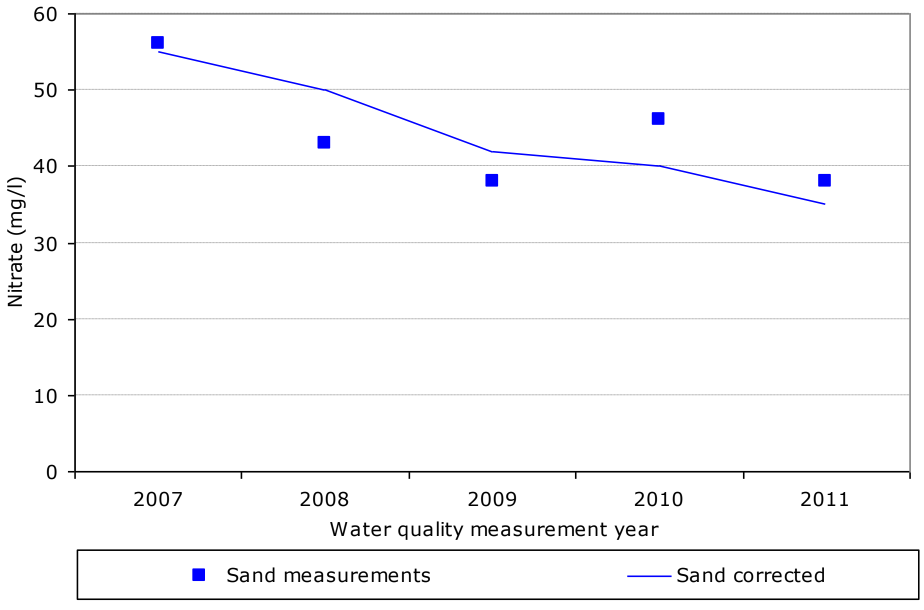


Figure 4.3 Evolution of nitrate concentrations leaching from the root zone in the sand region in the successive measurement years, and the corrected nitrate concentration.

For leaching in the clay region, using the correction method originally developed for the sand region, no clear relationship was found with the precipitation surplus and the groundwater level. This was due partly to the low nitrate concentrations, resulting in a less clear picture of relationships. Besides, data on groundwater levels were not available for all the farms, so that it was not possible to provide corrected concentrations. In the peat region, nitrate concentrations were still lower, making it even more difficult to establish relationships. In the loess region, the sample was too small to be able to carry out a well-founded correction.

4.3.3 *Summarised*

The mean nitrate concentrations were highest in the loess region and decreased in the sequence loess > sand > clay > peat (Table 4.9, Figure 4.1 and Figure 4.2). In recent years, the mean concentrations in the leaching water and the ditch water were either lower or in line with the standard of 50 mg nitrate per litre. The concentrations fluctuated, which was caused partly by the different precipitation surpluses across the years (dry versus wet years) and changes in the sample. In 2011, the measured nitrate and nitrogen concentrations in the leaching water in the sand region were significantly lower than the average for the previous years. This was not the case in the other regions. In the sand and loess regions, the nitrate and nitrogen concentrations dropped significantly between 2007 and 2011, but showed distinct fluctuations. These significant trends were possibly affected by the sharp decrease between 2007 and 2008. After correcting the results for the sand region taking into account weather and sample effects, the fluctuations were no longer visible (Table 4.10 and Figure 4.3). Both the measured and the corrected nitrate concentrations showed a significant trend towards a decrease in the sand region. In the clay and peat regions, there was no significant trend with regard to the leaching water.

In none of the regions did the mean nitrate and nitrogen concentrations in 2011 in the ditch water differ significantly from the average in the previous years (Table 4.9). In the clay and the sand regions, however, the decrease in the nitrate concentration between 2007 and 2011 was significant.

In the previous report, the nitrate concentrations in the loess region also seemed to show a decrease (Zwart et al., 2011). This trend does not seem to persist, but the concentrations did remain stable.

In the clay, sand and peat regions, the phosphorus concentrations in the water leaching from the root zone and in the ditch water have been fluctuating over the years (Table 4.9). In the loess region, the mean phosphorus concentration remained below the detection limit in all years. There was no significant difference between the measurement year 2011 and the average of the preceding years, nor were there any significant trends. The same applied to the concentrations in the ditch water.

In the previous report, the phosphorus concentrations in the leaching water in the clay region and in the ditch water in the clay and peat regions seemed to be decreasing (Zwart et al., 2011). This decrease did not persist in 2011.

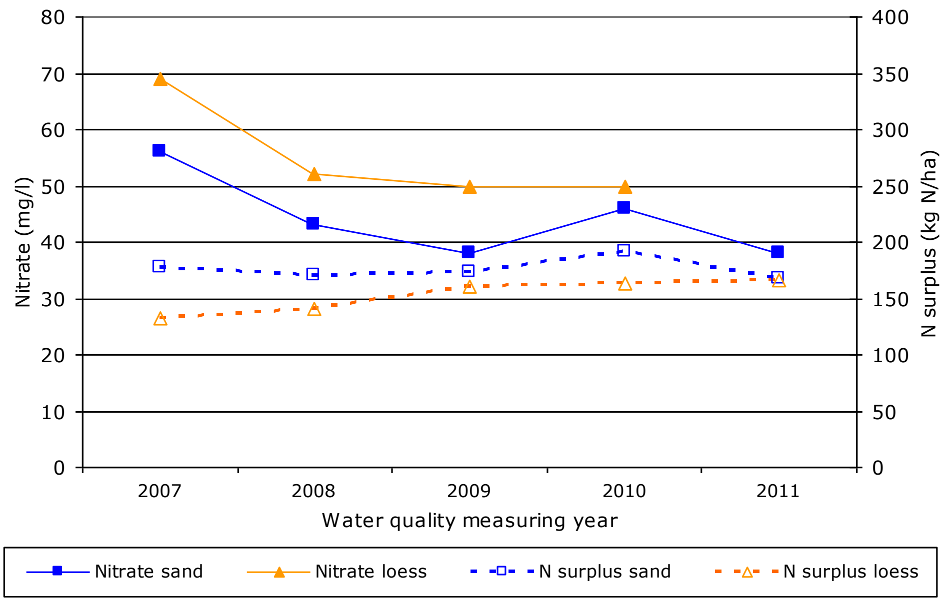
4.4 Effect of agricultural practice on the water quality

This section provides a qualitative consideration of the trend in the water quality on the derogation farms in relation to the developments in the agricultural practice. Due consideration should be given to the fact that a measurement series of five years is not enough to draw well-founded conclusions about developments. Therefore, the following text is indicative in nature and should be assessed, and where necessary adapted, in subsequent years.

Nitrogen
The water quality measured in 2007 was influenced by the agricultural practice in 2006 and previous years, the water quality in 2008 by the agricultural practice in 2007, and so on. In Figure 4.4, the trend lines for both the nitrate

concentration in the leaching water and the N surplus from the agricultural practice are shown.

A



B

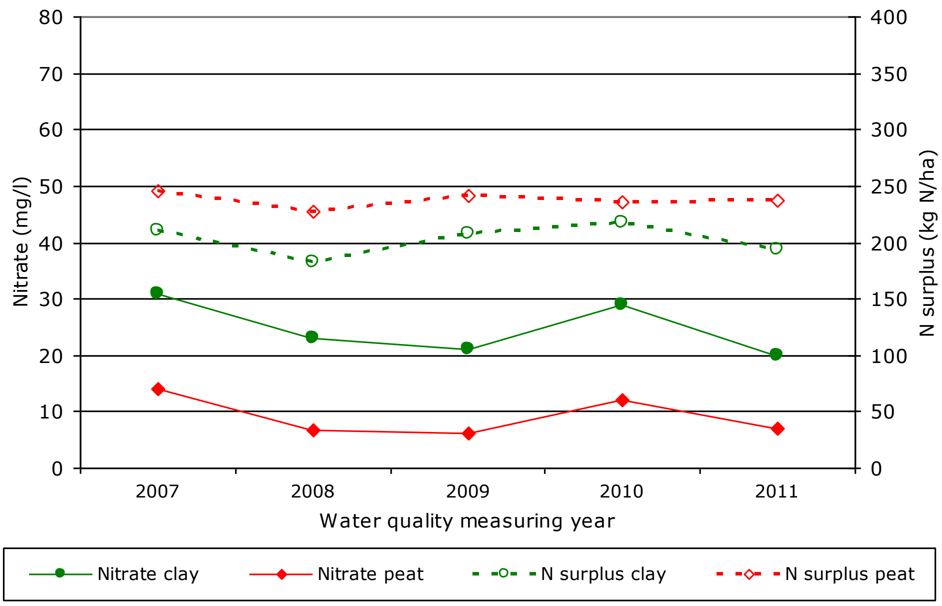


Figure 4.4 Evolution of mean nitrate concentrations leaching from the root zone for the sand and loess regions (A) and for the clay and peat regions (B) in the successive measurement years, with the N surplus from the agricultural practice of the previous year added.

In the period 2007 to 2009, the nitrate concentration in the leaching water in the sand region showed a decrease. This decrease did not reflect the evolution of the measured nitrogen surplus during the same period, which did not show a visible decrease. In the years before 2004, a decrease in the nitrogen surplus was visible (Zwart et al., 2008). The after-effects of these decreases in the nitrogen surplus in the soil surface balance may have played a role in the decrease of the nitrate concentration in 2007 and 2008. The calculated nitrogen surplus fluctuated slightly between 2006 and 2010, but did not show a significant decrease. In 2010, the nitrate concentration in the leaching water in the sand region showed an increase. As 2010 was a very dry year, the measured nitrate concentration in the leaching water showed an increase between 2009 and 2010, followed by a decrease between 2010 and 2011. The nitrate concentration is sensitive to weather influences (Boumans and Fraters, 2011). After correction for weather conditions and other factors, the nitrate concentration in the sand region showed a decrease in the measurement period from approximately 55 mg/l to approximately 35 mg/l.

In the dairy industry a trend was set towards continuing increase in scale and intensification of the production of milk per hectare and per cow. Also, farmers have increasingly been opting for full-time housing of dairy cows, resulting in a decreasing number of farms with grazing dairy cows (Table 4.1 and section 4.2.1). This trend in grazing might partly explain the decreasing nitrate concentrations in the sand region (Boumans and Fraters, 2011). The percentage of dairy farms with grazing dairy cows in the monitoring network decreased from 89 percent in 2006 to 79 percent in 2010.

In the clay and peat regions, the measured nitrate concentration was lower, but here again there was no trend to be seen in the evolution of the nitrogen surpluses in the soil surface balance. It is remarkable that the nitrogen surplus in the loess region increased significantly, while the nitrate concentration tended to decrease somewhat. There is no clear explanation for this development.

Apart from the nitrogen surplus, there are more factors that play a part and that may have a diluting or concentrating effect on the nitrate concentrations, such as weather conditions, changes in the sample, after-effects of nitrogen surpluses in previous years, reductions in grazing, and so on.

Phosphate
The phosphate surplus on the soil surface balance showed a decreasing trend. The effect of this decrease was not reflected in the water quality, where the concentration fluctuated. The cause of this lack of a clear relationship is possibly the strong fixation of phosphate to the soil, which causes changes in phosphate surplus to generate less effect in the phosphorus concentrations. Another possibility is that the phosphorus concentration in the leaching water and the ditch water increased as a result of high groundwater levels and/or more surface runoff.

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Websites

- Website CBS, Landbouwtelling: http://statline.cbs.nl.
- Website Koeien & Kansen: http://www.koeienenkansen.nl

Appendix 1 The derogation decision, relevant articles

This appendix contains the literal texts of the articles from the derogation decision of the European Commission (EU, 2005) with respect to the monitoring and reporting. These are complemented with the texts of the relevant articles from the prolongation of the derogation decision until 31 December 2013 by the European Commission, dated 5 February 2010. The present report concerns the years carried out under the first decision, complemented with the first year under the new derogation decision.

Relevant articles of the derogation decision (EU, 2005)

Article 8 Monitoring

1. Maps showing the percentage of grassland farms, percentage of livestock and percentage of farmland covered by an individual derogation in each municipality, shall be drawn by the competent authority and shall be updated every year. Those maps shall be submitted to the Commission annually and for the first time in the second quarter of 2006.
2. A monitoring network for sampling of soil moisture, streams and shallow groundwater shall be established and maintained as derogation monitoring sites. The monitoring network, comprising at least 300 farms to which an individual derogation has been consented, shall be representative of each soil type (clay, peat, sand and sandy loessial soils), fertilisation practice and crop rotation. The composition of the monitoring network shall not be modified during the period of applicability of this decision.
3. The surveys and continuous nutrient analyses shall provide data on local land use, crop rotations and agricultural practices on farms benefiting from an individual derogation. Those data can be used for model-based calculations of the magnitude of nitrate leaching and phosphorus losses from fields where up to 250 kg nitrogen per ha per year in manure from grazing livestock is applied.
4. Shallow groundwater, soil moisture, drainage water and streams in farms belonging to the monitoring network shall provide data on nitrate and phosphorus concentrations in water leaving the root zone and entering the groundwater and surface water system.
5. A reinforced water monitoring shall address agricultural catchments in sandy soils.

Article 9 Controls

1. The authorized national authority shall carry out administrative controls of all farms benefiting from an individual derogation for the assessment of compliance with the maximum amount of 250 kg nitrogen per ha per year from grazing livestock manure, with total nitrogen and phosphate application standards and conditions on land use.
2. A programme of inspections shall be established based on risk analysis, results of controls of the previous years and results of general random controls of legislation implementing Directive 91/676/EEC. Specific inspections shall address at least 5 percent of farms benefiting from an individual derogation with regard to land use, livestock number and manure production. Field inspections shall be carried out in at least 3 percent of the farms in respect of the conditions set out in Articles 5 and 6.

Article 10 Reporting

1. The authorized national authority shall annually submit the results of the monitoring to the Commission, together with a concise report on evaluation practice (controls at farm level, including information on non-compliant farms based on results of administrative and field inspections) and water quality evolution (based on monitoring of root zone leaching, surface and groundwater quality and model-based calculations). The report shall be submitted to the Commission annually in the second quarter of the year following the year the report concerns.
2. In addition to the data referred to in paragraph 1 the report shall include the following:
   a. data related to fertilisation for all farms which benefit from an individual derogation;
   b. trends in livestock numbers for each livestock category in the Netherlands and at derogation farms;
   c. trends in national manure production as far as nitrogen and phosphate in manure are concerned;
   d. a summary of the results of controls related to excretion coefficients for pig and poultry manure at country level.
3. Results obtained in this manner will be taken into consideration by the Commission with regard to a possible new request for derogation by the Dutch authorities.
4. In order to obtain insights regarding management on grassland farms for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the authorized authority and submitted to the Commission.

Supplement to the extension of the derogation decision (EU, 2010)

Article 10, section 1, second paragraph, is replaced by:

'The report is to be submitted to the Commission annually in the second quarter of the year subsequent to the year to which it applies.'

References

- EU (2005). Beschikking van de Commissie van 8 december 2005 tot verlening van een door Nederland gevraagde derogatie op grond van Richtlijn 91/676/EEG van de Raad inzake de bescherming van water tegen verontreiniging door nitraten uit agrarische bronnen. Publicatieblad van de Europese Unie, L324: 89-93 (10.12.2005).
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Appendix 2 Selection and recruitment of participants for the derogation monitoring network

A2.1 Introduction
This appendix explains the selection and recruitment of the 300 dairy and other grassland farms in the derogation monitoring network in detail. As indicated previously in the main text, the derogation monitoring network has become part of the Minerals Policy Monitoring Network (LMM). The selection and recruitment of farms for the derogation monitoring network is comparable to that of participants in other parts of the LMM. Based on the – then most recent – Agricultural Census data (2005), a sample population was defined for each of the 4 regions. The sample populations were then divided into groups of farms (the strata) having the same groundwater body, farm type and economic size. From this distribution, the desired number of farms for the sample was derived per stratum, which not only considered the proportion of the total surface area of cultivated land in a given stratum (the greater the area of cultivated land in a stratum, the greater the number of farms required in the random sample) but also a minimum representation per groundwater body.

The recruitment of farms was initially targeted at farms in the Farm Accountancy Data Network (FADN; report year 2006). For this, all suitable FADN farms were approached that had applied for derogation in 2006. Once the recruitment under FADN farms had been completed, it was determined which strata needed additional farms. Additional farms were selected from a database, compiled by the National Service for the Implementation of Regulations (DR) of the Ministry of Agriculture, Nature and Food Quality, which contains all farms that had applied for derogation in 2006. Of the additional participants chosen, 15 are also participating in the research project *Koeien & Kansen* (www.koeienenkansen.nl).

Replacements for farms that dropped out between 2006 and 2009 were preferably selected from farms that already participate in the LMM and FADN. With this approach, water quality samples from previous years were also available for farms newly admitted to the derogation monitoring network.

A2.2 Definition of the sample population
Just as with the LMM, a limited number of farms from the Agricultural Census database that had registered for derogation were not considered for the sample. The first group of farms excluded from participation in the derogation monitoring network were either very small (economic size smaller than 16 NGE), or extremely large (larger than 800 NGE in size). Farms using organic practices were also excluded as, by definition, organic farms (irrespective of the type of grassland or fertiliser) may not use more than 170 kg nitrogen from livestock manure per ha. Also, a minimum farm size of 10 hectares of cultivated land was adhered to, to guarantee a certain level of representativeness in the total area. Finally, in the LMM the farm type without livestock contains only arable farms. Market garden enterprises, farms with permanent cultivations and farms with crop combinations are therefore not included in the LMM.

The consequences of the aforementioned selection criteria are illustrated in Tables A2.1 and A2.2. In these tables, the farms (Table A2.1) and the acreages (Table A2.2) in the sample population have been derived from data from the Agricultural Census 2010 and a database from the National Service for the Implementation of Regulations, which contains more than 22,600 farm relation numbers (BRS) of farms which applied for derogation for the year 2010. As 441 BRS numbers were missing from the Agricultural Census 2010 it has been decided not to include absolute numbers of farms and hectares in the tables. Instead, the numbers of excluded farms and hectares of cultivated land have been expressed as a percentage of the more than 22,000 farms for which data were available in the Agricultural Census of 2010.

Table A2.1 Percentage derivation of the number of farms represented in the sample population of the derogation monitoring network in 2010.

	Distribution number of farms		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2010	71%	29%	100%
Farms <16 NGE	0.2%	11%	11%
Farms > 800 NGE	0.0%		0.0%
Organic farms	0.3%	0.2%	0.5%
Farms < 10 hectare	0.5%	1.1%	1.7%
Farms outside LMM		0.2%	0.2%
Sample population	70%	16%	87%

Source: Statistics Netherlands Agricultural Census 2010, processed by LEI

Table A2.2 Percentage derivation of the acreage of cultivated land represented in the sample population of the derogation monitoring network in 2010.

	Distribution acreage cultivated land		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2010	85%	15%	100%
Farms <16 NGE	0.0%	2.0%	2.1%
Farms > 800 NGE	0.2%		0.2%
Organic farms	0.4%	0.1%	0.5%
Farms < 10 hectare	0.1%	0.2%	0.3%
Farms outside LMM		0.1%	0.1%
Sample population	84%	12%	97%

Source: Statistics Netherlands Agricultural Census 2009, processed by LEI

Tables A2.1 and A2.2 reveal that more than 70 percent of the derogation farms registered in 2010 and 85 percent of the associated acreage of cultivated land concerned specialised dairy farms. Furthermore, most of the dairy farms also satisfied the selection criteria for the sample population for the derogation monitoring network. The farms excluded are mainly other grassland farms with a small size in terms of NGE and cultivated land. As a consequence of the selection criteria adopted, almost 14 percent of the farms registered for derogation (yet only 3.1 percent of the acreage on which derogation has been applied for) fell outside of the sample design.

A2.3 Explanation per stratification variable
The derogation decision demands a monitoring network that is not only representative for all soil types but also for all fertilisation practices and crop rotations (Article 8 of the derogation decision). Accordingly, the stratification took place not only per region but also per farm type, economic size (size class) and groundwater body. These variables are explained in this section.

A2.4 Classification according to farm type
For the classification of farms according to farm type, use was made of the classification based on the NEG classification (Poppe 2004). The NEG classification is a slightly modified version of the EC classification of farms that was introduced by Statistics Netherlands (CBS) for the Netherlands. This classification has retained its name despite the EC having become the EU. The NEG profile of a farm is determined by the extent to which the farm produces specific types of crops and/or keeps certain types of animals. For this, all crop acreages and numbers of animals per animal species present are converted into so-called standard gross margins (SGM). A farm is characterised as 'specialised' when a relative proportion (often at least two-thirds) of the total farm volume comes from a certain type of production (for example, dairy, arable or pigs). Within the NEG profile, eight main farm types can be distinguished of which five are pure and three combined. The five pure, main farm types are: arable, market gardening, permanent cultivation (fruit growing and tree nurseries), grazing livestock and housed animals (intensive livestock farming). Combined farms are classified as crop combinations, livestock combinations and crop and livestock combinations. Each main farm type is further divided into several subtypes. For example, within the grazing animal farms, specialised dairy farms are distinguished.

The main farm types market gardening, permanent cultivations and crop combinations are not represented in the LMM. A total of 0.2 percent of the farms with derogation (Table A2.1) with 0.1 percent of the cultivated land acreage do, however, belong to these main farm types. These farms (in total 40 with more than 1000 ha cultivated land) are therefore between 16 and 800 NGE in size, are not organic and have at least 10 ha cultivated land. Farms of these main farm types cannot per definition be dairy farms and therefore the relevant cells in Tables A2.1 and A2.2 are empty.

Within the group of farms that applied for derogation, dairy farms form a large homogenous group (that use almost 85 percent of the acreage of cultivated land as can be seen from Table A2.2). A good 15 percent of the acreage is situated on farms of a different type. These farms were also included in the monitoring network so as to gain as representative a sample as possible in terms of crop rotations and fertilisation practices. The roughly 29 percent non-dairy farms (Table B2.1) can be of various types, but in this publication are described as other grassland farms, as at least 70 percent of the cultivated land acreage must consist of grassland: otherwise the farm would not be eligible for derogation.

A2.5 Classification according to economic size
Other than farm type, farms are also classified according to economic size, for which three size classes are distinguished. This prevents farms of a smaller or larger economic size from being overrepresented.

The economic size is also determined using the standard gross margins. The total standard gross margins at farm level are converted into NGEs by means of a scaling factor (De Bont et al., 2003).

A2.6 Classification according to groundwater body per region

For the Water Framework Directive, a total of twenty groundwater bodies are distinguished in the Netherlands (Verhagen et al., 2006). During the setting up of the derogation monitoring network, a fair distribution (and minimal representation) was strived for in each region to cover the most important groundwater bodies measured in terms of cultivated land area. The municipality in which the farm receives post formed the basis for determining the groundwater body per farm. In municipalities where several groundwater bodies are found, all farms were attributed to the largest groundwater body.

Within the sand region, five groundwater bodies were distinguished as sub-regions, namely: Eems, Maas, Rhine Central, Rhine North and Rhine East. The other farms (in other groundwater bodies within the region) were attributed to the sixth sub-region termed 'other'. The loess region only contains the 'Chalk' groundwater body and was therefore not classified further. The peat region was divided into four sub-regions, namely the groundwater bodies Rhine North, Rhine East, Rhine West and 'other'. Five sub-regions were eventually distinguished in the clay region. As several groundwater bodies are situated in the south-western sea clay area (without clear domination) this entire clay area was classified as a separate sub-region. A further three groundwater bodies were distinguished as separate sub-regions: Eems, Rhine North and Rhine West (in so far as this is located outside of the south-western sea clay area). The fifth sub-region concerned the farms in other, not further classified, municipalities.

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Appendix 3 Monitoring of farm characteristics

This appendix provides an explanation of how the data about the agricultural practice in FADN (Farm Accountancy Data Network of LEI) were monitored and how fertiliser usage, crop yields (Section A3.2), probability limits (Section A3.3) and nutrient surpluses (Section A3.4) were calculated from these data.

A3.1 Introduction

The LEI is responsible for monitoring the data on agricultural practices as part of FADN. The FADN is a stratified sample of approximately 1500 farms and horticultural enterprises, for which a detailed set of financial-economic and environmental data is maintained. The FADN represents almost 95 percent of the total agricultural production in the Netherlands (Poppe, 2004). Approximately 45 full-time LEI employees are responsible for collecting and recording the operational data in FADN. They process all the invoices of the participating farms. They also make inventories of initial and final stocks and of additional data such as the crop rotation, the grazing system and the composition of the livestock population. Participants receive a participants report from LEI, which largely contains annual totals (such as a profit and loss account and a balance). When the data are processed into information for participants or researchers, the outcomes are of course checked for inconsistencies, as in addition to financial flows, physical flows are registered as well.

Most of the data in FADN are converted into annual totals, which are corrected for stock mutations. The feed concentrate use per year therefore emerges from the sum of all purchases between two balance dates, minus all sales, plus the initial stock, minus the final stock. The use of fertilisers is known not just on an annual basis but also on the basis of the growing season, which runs from the moment that the preceding crop is harvested until the harvest of the crop.

Fertilisation, yield and nutrient surpluses are expressed per surface unit. For this, the total acreage of the cultivated land is used. This is the acreage that the farm actually fertilises and uses for crop production. Rented land, natural habitat, ditches, built-up land and paved surfaces are not included in this acreage.

A3.2 Calculation of fertilisation and crop yields

According to the derogation decision (EU, 2005) the report should include details regarding the fertilisation and crop yield (Article 10, paragraph 4). This Article states (see Appendix 1): 'In order to provide elements regarding management on grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the authorized authority and submitted to the Commission'.

For the presentation about fertiliser use, a distinction is made between the four regions (the clay region, the peat region, the sand region and the loess region). Fertilisation at farm level is reported, and a distinction is also made between fertilisation on arable land and on grassland.

A3.2.1 Calculation of fertiliser use

Nitrogen in livestock manure

For the calculation of the use of nutrients via livestock manure, the production of manure on the farm is calculated first. For nitrogen, this is the net production after subtraction of gaseous nitrogen losses from housing and storage. The manure production from grazing livestock is calculated by multiplying the mean number of animals present by the statutory excretion forfeits (National Service for the Implementation of Regulations, 2006). An exception to this are those farms that make use of the so-called Guidance (see header 'Farm-specific use of livestock manure' that follows in this appendix). For the manure production from housed animals, the number of animals concerned is multiplied by the national excretion forfeits, as stipulated by the Working Group Uniformisation Manure Figures (Van Bruggen, 2007). This is in contrast to the statutory calculation of manure production on housed animal farms in which a housing balance method is used whereby the manure production is calculated as import feed and animals minus export animals and animal products.

Furthermore, the quantity of nutrients is registered for all fertilisers and stocks (inorganic fertiliser, livestock manure and other organic fertilisers) imported and exported. In principle, the quantity of nitrogen and phosphate in all imported and exported fertilisers is recorded by means of sampling. If sampling has not taken place, forfeit levels per fertiliser type are used (National Service for the Implementation of Regulations, 2006). Initial and final stocks are always calculated using forfeits (National Service for the Implementation of Regulations, 2006).

The total quantity of fertiliser used at farm level is subsequently calculated as:

Fertiliser use farm = Production + Initial stock - Final stock + Import - Export.

The quantity of fertilisers used on arable land is directly registered in . Besides the type and quantity, the time of application is also recorded. The fertiliser use on grassland is subsequently calculated as:

Fertiliser use on grassland = Fertiliser use farm - Fertiliser use on arable land.

This use on grassland consists of manure that is spread and manure that is directly excreted onto the grassland by grazing livestock (grassland manure). The quantity of nutrients in grassland manure is calculated per type of animal by multiplying the percentage of time on an annual basis that the animals graze by the excretion forfeits (National Service for the Implementation of Regulations, 2006).

Farm-specific use of livestock manure

Since measurement year 2007, the calculation of the manure production has been modified for farms that make use of the Guidance farm-specific excretion dairy cattle. On these farms, the manure production is not calculated on the basis of forfeits, but farm-specifically if the following criteria are satisfied:

- The farm is a specialised dairy farm (according to NEG classification).
- The dairy herd is at least 67 percent of the total LSU quantity of grazing livestock.
- No pigs and/or poultry are present on the farm.
- At least 80 percent of the acreage consists of fodder crops.
- The farm-specific calculation gives a real advantage (i.e. lower excretion) compared to the calculation using forfeits.

From 1 January 2009, the Guidance farm-specific excretion dairy cattle is used as the starting point for the calculation of the farm-specific excretion of the dairy herd (LNV, 2009). All of the sections in this Guidance are adhered to, except for the calculation of the VEM uptake from grass (grass silage and fresh grass) and from fresh grass (meadow grass and zero-grazing) and for the empirical relationship between the uptake from grass silage and from fresh grass. VEM is the Dutch standard for the net energy content of feeds. For the calculation of the uptake from grass, feed losses from purchased feed (feed concentrate, wet by-products, milk products) have been included in accordance with Aarts et al. (2008).

Nitrogen use
The total nitrogen use is expressed in kg plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficients as stated in Table A3.1.

Table A3.1 Applied availability coefficients (in %) for determination of nitrogen use.

Type fertiliser	*Condition*	*Availability coefficient*
Autumn application livestock manure on arable land on clay or peat soil	Liquid manure	30 (2006) 40 (2007) 50 (2008) Ban (2009)
	Solid manure	25 (2006/2007) 30 (2008/2009/2010)
Manure produced by livestock on own farm	Farm with grazing	35 (2006/2007) 45 (2008/2009/2010)
	Farm without grazing	60
Other fertilisers and conditions	Thin fraction and slurry	80
	Liquid manure Liquid manure pigs clay/peat Liquid manure pigs sand and loess Liquid manure other animal species	60 (2006-2009) 60(2010) 70 (2010) 60 (2010)
	Solid manure from pigs, poultry and minks	55
	Solid manure other animal species	40
	Mushroom compost	25
	Compost	10
	Sewage sludge	40
	Other organic fertilisers	50

(National Service for the Implementation of Regulations, 2006, 2011)

The availability coefficient is lower (35 percent instead of 60 percent in 2006 and 2007, 45 percent instead of 60 percent since 2008) for all livestock manure produced and applied on the farm if grazing is applied on the farm. A lower availability coefficient is calculated for the fertilisation of arable land during the autumn on clay and peat soil. In all other cases, the availability coefficient depends solely on the type of fertiliser.

Phosphate use
Phosphate use is expressed in kg phosphate. The calculation of the use includes all fertilisers, with the exception of a part of the phosphate which is applied via compost and defecation scum.

A3.2.2 Calculation grass and silage maize yield
Design calculation module
The design of the calculation module for determining the grass and silage maize yield in FADN is largely similar to the procedure described in Aarts et al. (2005, 2008). The calculation module starts by determining the energy requirement of the dairy herd based on the milk production and growth realised. In FADN all transactions and stock mutations for feed products are registered. This first of all shows what proportion of the energy requirement is covered by purchased feed. Then the energy uptake from farm-produced silage maize and other forage crops (other than grassland) is determined by measurements and levels of the silage supplies insofar as these are available. Otherwise for the farm-produced silage maize and other forage crops an estimate from the farmers and/or their advisors is used. Finally, it is assumed that the remaining energy requirement is satisfied by means of grass produced on the farm. The number of days in the grazing season registered in FADN is used to hypothesise a ratio between the energy uptake from fresh grass and that from grass silage. The aforementioned procedure clarifies how much VEM is obtained by the herd from farm-produced feed. The N and P uptake are then calculated by multiplying this VEM uptake by the N:VEM and P:VEM ratios. Finally, the N, P, kVEM and kg dry matter yields for silage maize and grassland are calculated by increasing the uptakes with the quantity of N, P, kVEM uptake and kg dry matter lost on average during feed production (only grass) and conservation.

Selection criteria
The calculation module used is not applicable for all farms. On mixed farms it is often difficult to clearly separate the product flows between different production units. Therefore, in accordance with Aarts et al. (2008) the method is only used on farms that satisfy the following criteria:
- It is a specialised dairy farm according to the NEG classification.
- The dairy herd is at least 67 percent of the total LSU quantity of grazing livestock.
- No pigs and/or poultry are present on the farm.
- At least 80 percent of the acreage consists of fodder crops.
- The countryside premium per ha grassland is no more than 100 euro.

The following selection criteria for the use of the method were not adopted from Aarts et al. (2008):
- at least 15 ha forage crop;
- at least 30 dairy cows;
- at least 4500 kg milk corrected for fat and protein (FPCM) per cow per year;
- non-organic production method.

These criteria were not considered because in the study of Aarts et al. (2008) they were used to make statements about the population of 'typical' dairy farms. In the Derogation Monitor the population has already been determined (permanent monitoring network of 300 farms) and therefore these criteria can be ignored. Additionally, with respect to the outcomes, the following confidence intervals for yields were used in accordance with Aarts et al. (2008):

- silage maize yield: 5000 - 22,000 kg dry matter per ha;
- grassland yield: 4000 - 20,000 kg dry matter per ha.

For yields that do not fall within this range, it is assumed that this must have been caused by an error in the registration. The farms concerned are also excluded from the report.

Deviations from Aarts et al. (2008)

In a number of cases, the procedure described by Aarts et al. (2005, 2008) is deviated from, because more detailed information was available or because the procedure could not be incorporated in FADN in a comparable manner. It concerns the following items:

- composition of grass silage and silage maize;
- supplement for grazing based on the actual number of days in the grazing season;
- ratio of silage grass to fresh grass based on the actual number of days in the grazing season;
- conservation and feeds losses.

Ad 1)

In Aarts et al. (2008) the composition of grass silage and silage maize pits is based on provincial averages of the Netherlands Laboratory for Soil and Crop Research (BLGG, 2011). A slightly different method was used in FADN. Since 2006, the composition of the grass silage and maize silage per farm has also been recorded in FADN. In the FADN calculation procedure, this farm-specific composition is used if at least 80 percent of all silage pits obtained has been fully sampled. If that is not the case (in one of the silage pits one of the parameters – dry matter, VEM, N or P – is missing), then the national average composition is used. This average composition of silage maize and grass is detailed in Table A3.2.

Table A3.2 National average composition of grass silage and silage maize in 2010 (BLGG).

Silage type	*Dry matter (gram / kg)*	*VEM (/ kg dry matter)*	*N (gram / kg dry matter)*	*P (gram / kg dry matter)*
Silage maize	350	975	12	2.0
Grass silage	466	899	28	3.9

Ad 2)

For the calculation of the energy requirement, a so-called mobilisation charge has been incorporated. This mobilisation charge is, for example, dependent on the grazing. In Aarts et al. (2008) a distinction was made between three types of grazing, namely 0 days, less than 138 days and more than 138 days. Since 2004, the exact number of days in the grazing season has been registered in FADN and it was decided to use these data in the calculation. For every day of unlimited grazing, 533 VEM (16,000/30) extra mobilisation charge was incorporated per cow, and for each day of limited grazing 400 VEM (12,000/30), in accordance with Appendix 2 from the notes Guidance 2009 (LNV 2009).

Ad 3)
In addition, the ratio of the energy uptake from fresh grass and silage grass is, in contrast to Aarts et al. (2008) based on the number of days in the grazing season and/or zero-grazing registered in FADN. For zero-grazing the percentage of fresh grass varies between 0 and 35 percent, in the case of unlimited grazing between 0 and 40 percent and in the case of limited grazing between 0 and 20 percent. This calculation is also performed in accordance with Appendix 2 from the notes Guidance (LNV, 2009).

Ad 4)
The information in Appendix III in Aarts et al. (2008) is not totally complete with respect to the percentages adopted for conservation losses. To prevent misunderstandings, all percentages used in FADN for the calculation of conservation and feeds losses are shown in Table A3.3.

Table A3.3 Percentages used for conservation and feeds losses.

	Conservation losses				*Feed losses*
Category	*Dry matter*	*VEM*	*N*	*P*	*Dry matter, VEM, N and P*
Wet by-products	4	6	1.5	0	3
Additional forage crops consumed	6	8	2	0	5
Feed concentrate	0	0	0	0	2
Milk products	0	0	0	0	2
Silage maize	4	4	1	0	5
Grass silage	10	15	3	0	5
Meadow grass	0	0	0	0	0

Demonstration calculation for grassland and silage maize yield
In Table A3.4 the yields for grassland and silage maize are calculated for a demonstration farm. The calculation of the VEM requirement is not explained further. This is described in detail in Appendix III of the report by Aarts et al. (2008).

Table A3.4 Demonstration calculation for determination of grassland and silage maize yields.

Demonstration of calculation				
Grazing	183 days limited grazing			
Ha grassland	40			
Ha sil. Maize	10			
	quantity	kVEM	N	P
Total VEM uptake = 1.02 * VEM requirement		750,000		
	quantity	kVEM	N	P
Composition feed concentrates	per kg	960	28.0	5.0
Use feed concentrates[1]	200,000	192,000	5,600	1,000
Feed losses	4,000	3,840	112	20
Net uptake feed concentrates	196,000	188,160	5,488	980
	quantity	kVEM	N	P
Comp. wet by-products	per kg dm	1,020	12.0	2.0
Use wet by-products[1]	20,000	20,400	240	40
Conservation losses	800	1,224	4	0
Fed wet by-products	19,200	19,176	236	40
Feed losses	576	575	7	1
Net uptake wet by-products	18,624	18,601	229	39
	quantity	kVEM	N	P
Comp. additional roughage	per kg dm	700	10.2	2.5
Use additional roughage[1]	600	420	6	2
Conservation losses	36	34	0	0
Fed additional roughage	564	386	6	2
Feed losses	28	19	0	0
Net uptake additional roughage	536	367	6	1
		kVEM	N	P
Total use purchased feed **(= sum feed concentrates + wet by-products +**		207,128	5,723	1,020
	quantity	kVEM	N	P
Comp. own silage maize	per kg dm	960	11.1	2.2
Production own silage maize **(= estimate yield by**	150,000	144,000	1,665	330
Conservation losses	6,000	5,760	17	0
Fed own maize silage	144,000	138,240	1,648	330
Feed losses	7,200	6,912	82	17
Net uptake own silage maize	136,800	131,328	1,566	314
	per kg dm	kVEM	N	P
Net uptake from grass products **(=net total uptake - uptake purchased feed - uptake own maize silage)**		411,544		
Factor fresh grass **(based on recorded grazing sytem)**		0		
Composition fresh grass	per kg dm	990	35.0	4.8
Net uptake from fresh grass **(= factor fresh grass * net uptake from grass products)**		82,309	2,910	399
	quantity	kVEM	N	P
Composition grass silage	per kg dm	900	32.0	4.5
Net uptake from grass silage **(=net uptake from grass products - net uptake from fresh grass)**	365,817	329,235	11,706	1,646
Conservation losses	18,291	16,462	585	82
Fed grass silage	384,108	345,697	12,291	1,728
Feed losses	38,411	51,855	369	0
Grass yield (leaving field)	422,519	397,552	12,660	1,728
	kg dm	kVEM	N	P
Yield silage maize per ha	15,000	14,400	167	33
Yield grassland per ha	10,563	9,939	317	43

[1] Use = purchase - sale + initial stock - closing stock

A3.3 Confidence intervals

On the LMM farms, fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers separately, both for nitrogen and for phosphate, as well as total fertilisation (inorganic fertilisers, livestock manure and other organic fertilisers) must fall within the confidence intervals for the LMM. Table A3.5 shows these intervals.

Table A3.5 Confidence intervals for use of inorganic fertilisers, livestock manure, other organic fertilisers and total of inorganic fertilisers + livestock manure + other organic fertilisers in kg nitrogen per ha and kg phosphate per ha

Nutrient + type	*Lower/upper limit*	*Condition*	*Kg per ha*
Nitrogen			
Inorganic fertilisers	Lower limit	None	<0
Inorganic fertilisers	Upper limit	None	>400
Livestock manure	Lower limit	LSU/ha > 1	<100
Livestock manure	Lower limit	LSU/ha <= 1	<0
Livestock manure	Upper limit	None	>500
Other organic fertilisers	Lower limit	None	<0
Other organic fertilisers	Upper limit	None	>400
Total fertilisers	Lower limit	None	<30
Total fertilisers	Upper limit	None	>700
Phosphate			
Inorganic fertilisers	Lower limit	None	<0
Inorganic fertilisers	Upper limit	None	>160
Livestock manure	Lower limit	None	<0
Livestock manure	Upper limit	None	>250
Other organic fertilisers	Lower limit	None	<0
Other organic fertilisers	Upper limit	None	>200
Total fertilisers	Lower limit	None	<0
Total fertilisers	Upper limit	None	>350

A3.4 Calculation of nutrient surpluses

In addition to fertilisation and crop yield, the surplus of nitrogen and phosphate on the soil surface balance (in kg N per ha and in kg P_2O_5 per ha respectively) is also reported on. These surpluses are calculated by applying a method derived from the approach used and described by Schröder et al. (2004, 2007). This means that in addition to the imported quantities of nitrogen and phosphate in organic and inorganic fertilisers, and the exported quantities of nitrogen and phosphate in crops, consideration is also given to other import categories such as net mineralisation of organic matter in the soil, nitrogen fixation by legumes, and atmospheric deposition. The calculation of nutrient surpluses on the soil surface balance assumes an equilibrium situation. It is assumed that in the longer term, the import of organic nitrogen in the form of crop residues and organic fertiliser, is equal to the annual decomposition. An exception to this rule is made for peat and reclaimed soils, for which an import for mineralisation is calculated of 160 kg N per ha for grassland on peat and 20 kg N per ha for grassland on reclaimed soil and other crops on peat and reclaimed soils. For these soils it is known that net mineralisation occurs as a consequence of the groundwater level management which is necessary to use these soils for agricultural purposes. Schröder et al. (2004, 2007) calculated the surplus on the soil surface balance by using the release of nutrients to the soil as the starting point. In this study, a balance method is used to calculate the surplus on the soil surface balance from the farm data.

The calculation method used for determining the nitrogen surplus is summarised in Table A3.6. Initially, the surplus on the farm gate balance is calculated by summing the import and export of nutrients registered in the bookkeeping. This surplus is calculated with the inclusion of stock mutations. For nitrogen, the surplus calculated on the farm gate balance is then corrected for import and export categories on the soil surface balance. Similarly, for phosphate the surplus on the soil surface balance is the same as the surplus on the farm gate balance. A more detailed explanation of the calculation methods can be found in the footnotes below, with reference to the table.

a) Purchase – sale + initial stock – final stock
b) Purchase + stock decrease
c) Sale – purchase + final stock – initial stock
d) Sale + stock increase
e) N-levels inorganic fertiliser, feed concentrate and single feeds via annual reviews supplier. If these are not available then standards are used
f) N-levels for forage crops via annual reviews or forfeit standards (CVB, 2003)
g) N levels crops and plant products according to Van Dijk (2003)
h) N levels livestock manure and compost according to National Service for the Implementation of Regulations (2006)
i) N levels animals according to Beukeboom (1996).
j) The N-level of milk is calculated as the farm-specific protein level/6.38. Other N level animal products according to Beukeboom (1996).
k) For grass on peat: 160 kg N per ha per year, other crops on peat as well as reclaimed soil (irrespective of crop): 20 kg N per ha per year, all other soil types: 0 kg. For FADN farms the areas are established according to the four soil types used by the National Service for the Implementation of Regulations (sand/clay/peat/loess). For the estimation of the mineralisation of reclaimed soil, use was made of global soil classifications per farm (based on the postal code) according to De Vries and Denneboom (1992).
l) The atmospheric deposition is differentiated each year per province and varied in 2006 between 23 and 40 kg N per ha per year (MNP/CBS/WUR, 2007).
m) N fixation in kg N per ha per year (Schröder, 2006).
    - for grass clover: for clover proportion <5 percent: 10 kg, in the case of clover proportion between 5 and 15 percent: 50 kg, in the case of clover proportion >15 percent: 100 kg, proportion of clover according to figures submitted by the participant;
    - for lucerne: 160 kg;
    - for peas, broad beans, kidney beans and snap peas: 40 kg;
    - for other legumes: 80 kg.
n) Volatilisation from housing and storage as a function of the animal species, housing system and grazing system according to Oenema et al. (2000).
o) Volatilisation in the case of grazing: 8 percent of the N total excreted on grassland (Schröder et al., 2005). In the case of mechanical application on grassland: trailing foot spreader, 10 percent of N total; trussed beam plough, 6.5 percent of N total; shallow grassland injector, 3 percent of N total; aboveground spreading of solid manure, 14.5 percent. On arable land, incorporation in the soil 8.5 percent of N total; injection, 1 percent of N total; aboveground spreading of solid manure, 14.5 percent (Van Dijk et al., 2004, Table 1).

Table A3.6 Calculation method used for determining the nitrogen surplus on the soil surface balance (kg N, per ha-1 per year-1).

Description categories		Calculation method
Import farm	Inorganic fertiliser	Quantity [a] * level [e]
	Livestock manure and other organic fertiliser	Quantity [b] *level [h]
	Feed	Quantity [a] * level [e,f]
	Animals	Quantity [b] * level [i]
	Plant products (sowing seed, young plants and seed potatoes)	Quantity [b] * level [g]
	Other	Quantity [b] * level
Export farm	Animal products (milk, wool, eggs)	Quantity [c] * level [j]
	Animals	Quantity [d] * level [i]
	Livestock manure and other organic fertiliser	Quantity [d] * level [h]
	Crops and other plant products	Quantity [d] * level [g]
	Other	Quantity [d] * level
N surplus on the farm gate balance	Import farm - Export farm	
Import soil surface balance	+ Mineralisation	160 kg N for peat soil and 20 kg for reclaimed soil [k]
	+ Atmospheric deposition	Differentiated per province[l]
	+ N fixation by legumes	All legumes [m]
Export soil surface balance	- Volatilisation from housing and storage	Based on animal species, housing system and grazing system[n]
	- Volatilisation application and grazing	Inorganic fertiliser and livestock manure, based on actual manure production, grazing and application method[o]
N surplus on the soil surface balance	N surplus farm + import soil surface balance - export soil surface balance	

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Appendix 4 Sampling of water on farms in 2010

A4.1 Introduction

The derogation decision (EU 2005, see Appendix 1) states that a report must be produced concerning the evolution of water quality based on, for example, regular monitoring of leaching from the root zone and checking of surface and groundwater quality (Article 10, paragraph 1). For this, the monitoring of the quality of the 'shallow groundwater layers, soil moisture, drainage water and watercourses on farms that are part of the monitoring network' must provide data about the nitrate and phosphorus concentrations in the water leaving the root zone and ending up in the groundwater and surface water system (Article 8, paragraph 4).

A4.1.1 Water sampling

In the Netherlands, the groundwater level is often present just beneath the root zone; the mean groundwater level in the sand region is approximately 1.5 metres below surface level. In the clay and peat regions, the groundwater levels are, on average, shallower. Only on the push moraines of the sand region and in the loess region is the groundwater level mostly deeper than 5 metres beneath the surface. Therefore, in the majority of situations, leaching from the root zone or leaching into groundwater can be measured by sampling the uppermost metre of the phreatic groundwater. In situations where the groundwater level is deeper (more than 5 metres below the surface) and the soil retains sufficient moisture (loess region), the soil moisture below the root zone is sampled. There is little agriculture on the push moraines in the sand region with a deep groundwater level. Where this does occur, the soil moisture below the root zone is sampled if possible.

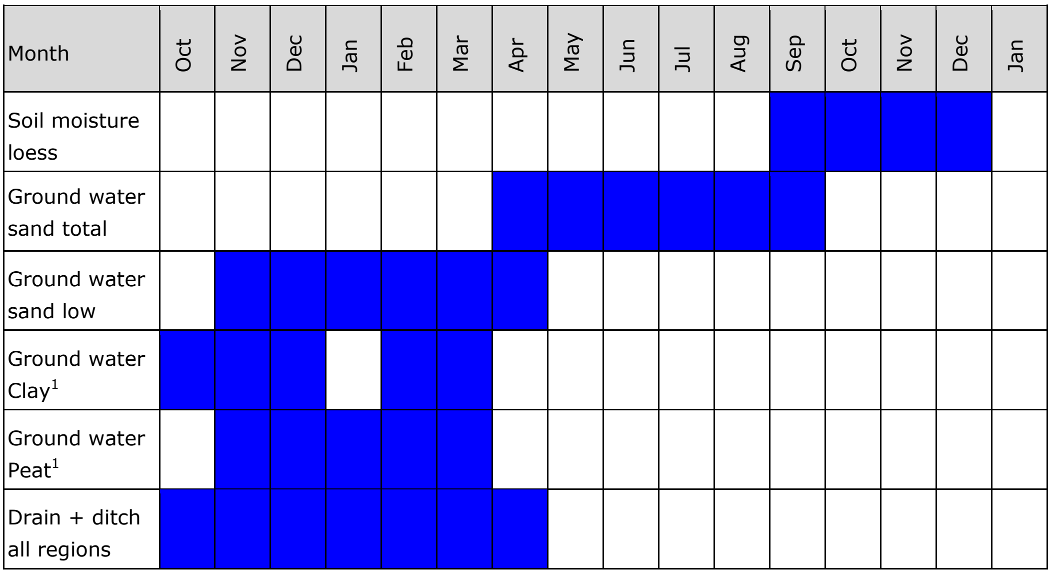
The loading of surface water with nitrogen (N) and phosphorus (P) takes place via run-off and groundwater, in which the travel times are usually longer. In the High Netherlands, only the leaching from the root zone is monitored by sampling the uppermost metre of groundwater or by sampling soil moisture under the root zone. In the Low Netherlands, in areas drained via ditches, whether or not in combination with pipe drainage, the travel times are shorter. Here, the loading of surface water is visualised by sampling ditch water in combination with sampling of the uppermost metre of groundwater or water from the drainage pipes (drain water).

A4.1.2 Number of measurements per farm

On each farm groundwater, drain water and soil moisture are sampled at sixteen locations and ditch water at maximum eight locations. The number of measurement locations is based on the results of previous research carried out in the sand region (Fraters et al., 1998; Boumans et al., 1997), in the clay region (Meinardi and Van den Eertwegh, 1995, 1997; Rozemeijer et al., 2006) and in the peat region (Van den Eertwegh and Van Beek, 2004; Van Beek et al., 2004; Fraters et al., 2002).

A4.1.3 The measurement period and measurement frequency

Sampling takes place in the winter in the Low Netherlands. During the winter, the precipitation surplus is largely transported via shallow groundwater flows to the surface water. In the dry season, especially in low-lying peat and clay polders, water from outside the polder can be let in, to maintain high ditch and groundwater levels. Sampling in sand and loess soils in the High Netherlands can take place in both the summer and the winter. As the available sampling capacity must be spread over the year, the sand region is sampled in the summer and the loess region in the autumn. The measurement period (Figure A4.1) has been chosen in such a manner that the measurements represent leaching from the root zone and with this provide as good a picture as possible of the agricultural practices in the previous year. Weather conditions can cause a delay in sampling or retard initiation of a new sampling campaign.



1 The exact starting date of the sampling depends on the quantity of precipitation. Sufficient precipitation must have fallen before leaching to the groundwater can take place. Under the current regulations sampling never starts later than 1 December.

Figure A4.1 Overview of standard sampling periods for determining the water quality per region.

In the High Netherlands soil moisture and groundwater are measured once per year on each farm. The yearly precipitation surplus in the Netherlands is approximately 300 mm per year. This quantity of water spreads throughout a soil with a porosity of 0.3 (typical for sandy soil) over a layer of around 1 metre in the soil (saturated soil). Therefore, the quality of the uppermost metre gives a good picture of the annual leaching from the root zone and the loading of groundwater. Other types of soil (clay, peat, loess) generally have a greater porosity. In other words, a sample from the uppermost metre will contain, on average, water from more than just the previous year. A measuring frequency of once per year is therefore sufficient. Previous research has demonstrated that the variation in the nitrate concentration within one year, as well as the variation between years, disappears if dilution effects and variations in the groundwater level are taken into account (Fraters et al., 1997).

From the start of the first sampling season in the Low Netherlands following granting of derogation (1 October 2006), the frequency of the sampling of drain water and ditch water was increased from two to three rounds per winter (LMM sampling frequency realised up until then) to approximately four rounds per winter (intended LMM sampling frequency). By this, a better spread over the leaching season could be achieved. The feasibility of four rounds depends upon the weather conditions. Too little precipitation or frost can lead to drains not being sampled. The intended LMM sampling frequency was based on research carried out by Meinardi and Van den Eertwegh in the early 1990s (Meinardi and

Van den Eertwegh, 1995, 1997; Van den Eertwegh, 2002). The evaluation of the LMM-programme in the clay areas, in the period 1996-2002, led to the conclusion that there was no reason to change the existing relationship between the number of sampling rounds per farm and year (realised sampling frequency), and the number of drains sampled per farm and per sampling round (Rozemeijer et al., 2006). The intensification emerges from the European Commission's request for an increased sampling frequency. A frequency of four times per year is equivalent to the proposed sampling frequency for operational monitoring of vulnerable phreatic groundwater that has a relatively fast and shallow run-off (EU, 2006).

Besides the compulsory components of nitrate, total nitrogen and total phosphorus, the chemical analysis of the water samples also included the determination of other water quality characteristics. This was performed to explain the data for the measurements of the compulsory components. These additional components include ammonium nitrogen, ortho-phosphorus and several general characteristics such as conductivity, pH and dissolved organic carbon. The results of these additional measurements have not been included in this report.

The following sections describe the sampling per region in greater detail. The activities were performed according to work instructions. The text below refers to the work instructions used by stating the relevant document number. At the end of this appendix an overview of the work instructions concerned is provided.

For the sampling in the Low Netherlands, a severe period of frost in the months of December, January and February meant that not all drain water and ditch water sampling could be carried out according to plan. In many cases this resulted in sampling extending into April and even May. The minimum period between two samplings was also reduced to two weeks from March onwards, to be able to complete the desired number of rounds in the limited time available.

A4.2 The sand and the loess regions

A4.2.1 Standard sampling

The groundwater sampling of the derogation farms in the sand region occurred in the period April 2010 to October 2010 (Figure A4.2). One farm in the sand region was not sampled until December 2010. This farm was a participant in the special programme ‘Koeien & Kansen’ (Van Vliet et al., 2010) and, in addition, a participant in the derogation monitoring network. The management of the Koeien & Kansen-project decided to sample this farm in the winter. In the loess region sampling was carried out in the period September 2010 – February 2011 (Figure A4.2) In these periods, each farm was sampled once.

The sampling was carried out according to the standard sampling method. On each farm, samples were taken from bore holes made at 16 locations. The number of locations per field depended on the size of the field and the number of fields on a farm. Within the field, the locations were chosen randomly. Selection and positioning took place according to a protocol (BW-W-021). The uppermost metre of groundwater was sampled using the open bore hole method (BW-W-015). In the field, the groundwater level and nitrate concentration were determined (Nitrachek-method, BW-W-001). The water samples were filtered and stored in a cool dark place for transport to the laboratory (BW-W-008).

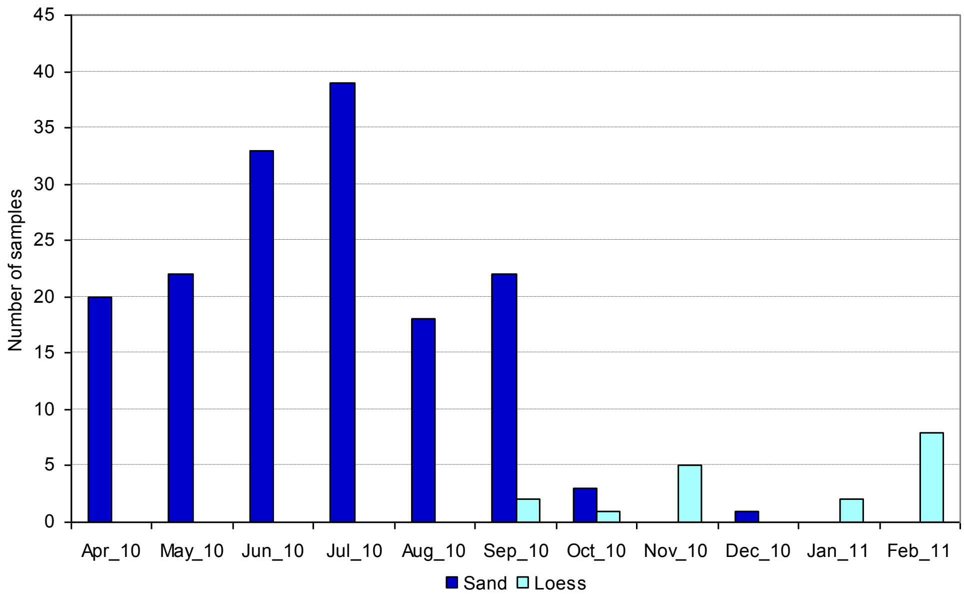


Figure A4.2 Number of samples for groundwater and soil moisture in the sand and loess regions per month during the period April 2010 to February 2011.

Acidification, as a means of conservation, has taken place since 1 November 2010 by using sampling bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification used to be effected in the field by means of sulphuric acid or nitric acid (BW-W-009). Soil moisture sampling was carried out by collecting drill cores between depths of 150 and 300 cm with the aid of an Edelman drill, after which the samples were transported to the laboratory, untreated in tightly sealed containers (BW-W-014). In the laboratory the samples were centrifuged to collect the soil moisture. In the laboratory, 2 mixed samples were prepared (8 samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

A4.2.2 The additional sampling in the low-lying areas
On farms in the sand region, additional ditch water samples were taken during the period November 2009 to April 2010 (Figure A4.3). This was performed according to the standard method. On each farm two types of ditch sample were distinguished. In principle, there are two ditch types: farm ditches and local ditches. Farm ditches only discharge water originating from the farm. Local ditches carry water from elsewhere; the water leaving the farm is therefore a mixture.

If farm ditches were present, samples were taken downstream (where the water leaves the farm or the ditches) in four of these ditches. Furthermore, in four local ditches, samples were taken downstream to gain an impression of the local ditch water quality. If there were no farm ditches, then samples were taken both upstream and downstream from four local ditches. This provided an impression of the local water quality and the effect of the farm on this. The ditch water sampling types are therefore farm ditch, local ditch upstream and local ditch downstream. The selection of locations for the ditch water sampling was protocolled (BW-W-021). The selection is aimed at gaining an impression of the effect of the farm on ditch water quality and excluding effects external to the farm as much as possible.

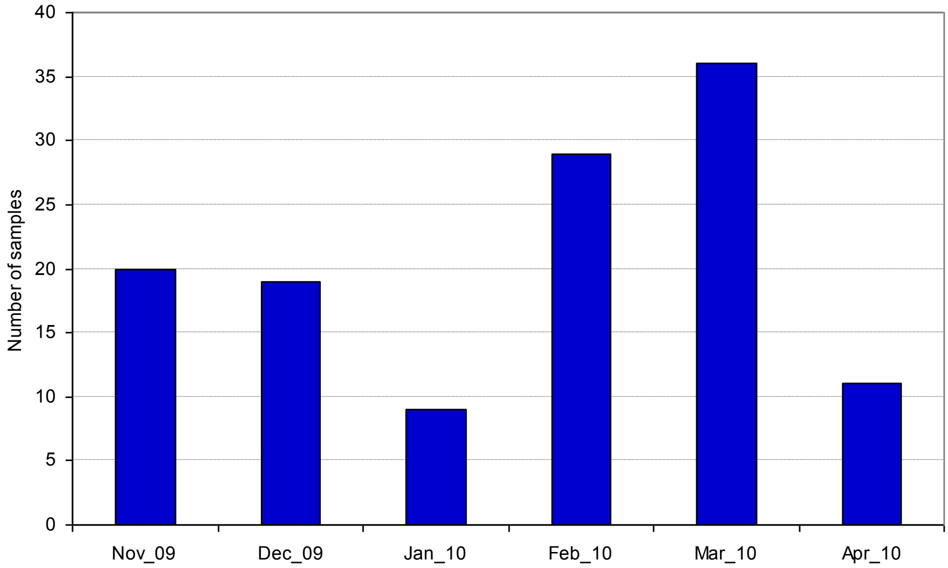


Figure A4.3 Number of samplings of ditch water in the sand region per month during the period November 2009 to April 2010.

During the winter of 2009-2010 ditch water was sampled between three and four times on the farms.

The ditch water samples were taken with a measuring beaker attached to a stick or 'fishing rod' (BW-W-011). Water samples were stored in a cool, dry place for transport to the laboratory (BW-W-008). In the laboratory the next day, two mixed samples were prepared from these ditch water samples (one per ditch sample type). The individual ditch water samples were analysed for nitrate and the mixed samples were also analysed for total nitrogen and total phosphorus.

A4.3 The clay region

In the clay region, a distinction is made between farms on which the soil is drained with drainage pipes and farms where that is not the case. If less than 25 percent of a farm's acreage is drained with drainage pipes, or if less than 13 drains can be sampled, then the farm is considered not to be drained. The sampling strategy on drained farms differs from that on non-drained farms.

A4.3.1 Drained farms

On the drained farms, drain water and ditch water were sampled in the period October 2009 to May 2010 (see Figure A4.4). On each farm, 16 drainage pipes were selected for sampling. The number of drainage pipes to be sampled per field depended on the size of the field. Within the field the drains were selected on the basis of a protocol (BW-W-021). On each farm 2 types of ditch sample were distinguished. For each type of ditch sample, maximal 4 sampling locations were selected (section B4.2). The selection was performed in accordance with the aforementioned protocol and was aimed at gaining an impression of the effect of the farm on ditch water quality and excluding effects external to the farm as much as possible.

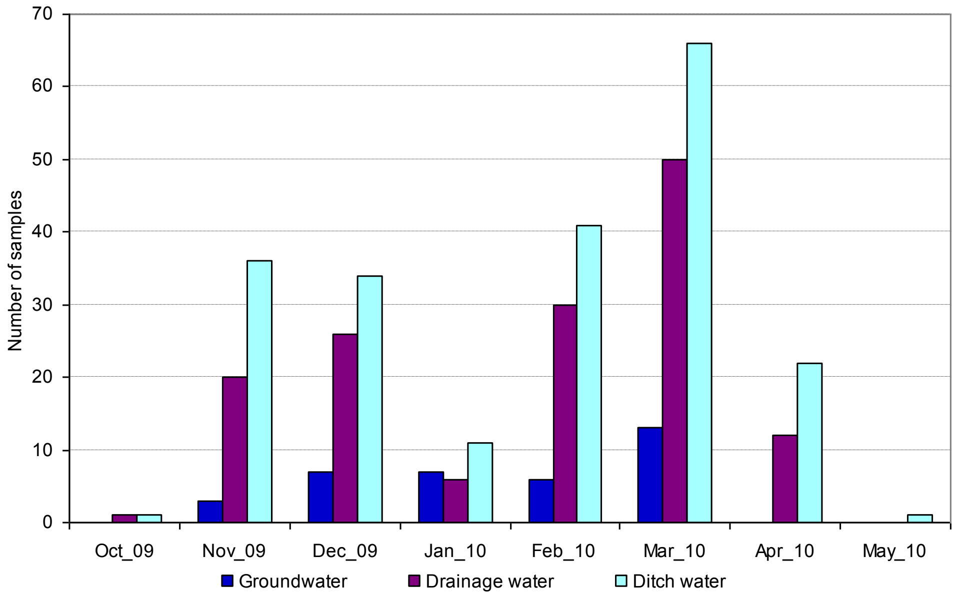


Figure A4.4 Number of samplings of ground-, drain and ditch water in the clay region per month during the period October 2009 to May 2010.

During this winter, the drain water and ditch water were sampled between one and four times as described in the previous section. The sampling was spread over the winter and the period between two samples was at least three weeks.

Water samples were stored in a cool, dry place for transport to the laboratory (BW-W-008). In the laboratory, a single mixed sample was prepared on the following day for the drain water samples, and two of the ditch water samples (one per type of ditch sampled). The individual drain water and ditch water samples were analysed for nitrate and the mixed samples were also analysed for total nitrogen and total phosphorus.

A4.3.2 Non-drained farms

On the non-drained farms, the uppermost metre of the groundwater and ditch water were sampled in the period November 2009 to April 2010 (BW-W-021) (Figure A4.4). On these farms, the groundwater was sampled between one and two times and the ditch water between one and four times.

The sampling of the groundwater was similar to that in the sand region, with the exception that the groundwater is sampled twice in the clay region. However, instead of the open bore hole method, the closed bore hole method was occasionally used (BW-W-015). In the field, the nitrate concentration was determined at each of the 16 locations (Nitrachek method BW-W-001).
The water samples were filtered and stored in a cool, dark place for transport to the laboratory (BW-W-008). Acidification, as a means of conservation, has taken place since 1 November 2010 by using sampling bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification used to be effected in the field by means of sulphuric acid or nitric acid (BW-W-009). In the laboratory, 2 mixed samples were prepared (8 samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

The ditch water sampling was similar to that of the drained farms, two types of ditch samples each with maximal four locations. However, an important difference was that sampling took place with a filter lance (BW-W-011) and water samples were filtered straightaway in the field and analysed for nitrate (Nitrachek method BW-W-001). As well as being filtered, the individual samples were also conserved (BW-W-009) and stored in a cool dark place for transport to the laboratory (BW-W-008). In the laboratory, one mixed sample was prepared per ditch type. The mixed samples were analysed for nitrate, total nitrogen and total phosphorus.

A4.4 The peat region

In the peat region the uppermost metre of groundwater was sampled once on all farms in the period November 2009 to May 2010 (Figure A4.5). In the same period ditch water was sampled on three to four occasions.

The sampling of groundwater was similar to that in the sand and clay regions. However, instead of an open or closed bore hole method, a reservoir tube method was usually used (BW-W-015). In the field, the nitrate concentration was determined at each of the 16 locations (Nitrachek method BW-W-001). The water samples were filtered and stored in a cool, dark place for transport to the laboratory (BW-W-008). Acidification, as a means of conservation, has taken place since 1 November 2010 by using sampling bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification used to be effected in the field by means of sulphuric acid or nitric acid (BW-W-009). In the laboratory, 2 mixed samples were prepared (8 samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

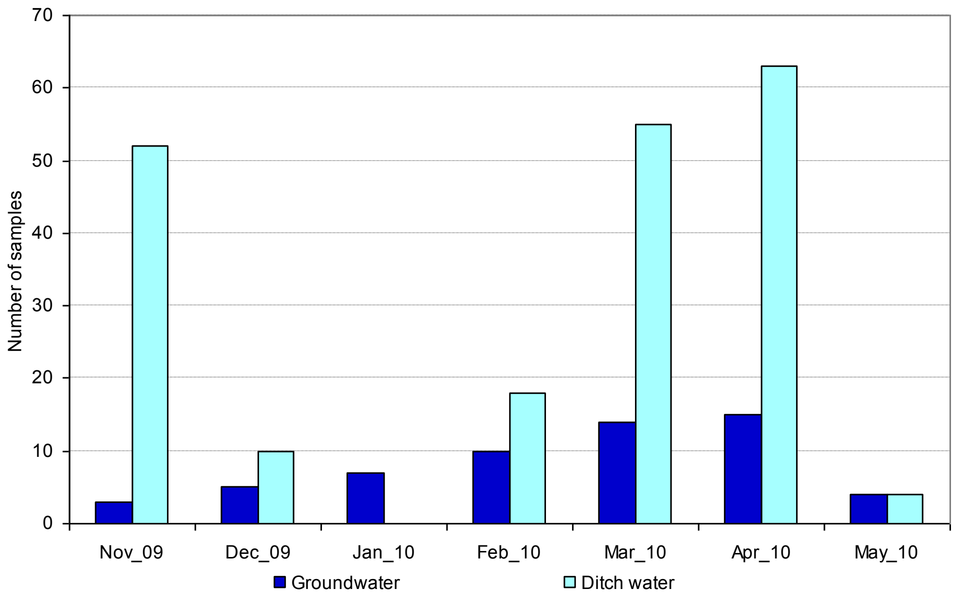


Figure A4.5 Number of samples from groundwater and ditch water in the peat region per month during the period November 2009 to May 2010.

Ditch water sampling, carried out at the same time as groundwater sampling, was similar to that of non-drained farms in the clay region. The sampling therefore took place with a filter lance (BW-W-011). There were always two types of ditch samples, each with maximal four locations. Water samples were analysed for nitrate straightaway in the field (Nitrachek method, BW-W-001).

The water samples were filtered and stored in a cool, dark place for transport to the laboratory (BW-W-008). Acidification, as a means of conservation, has taken place since 1 November 2010 by using sampling bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification used to be effected in the field by means of sulphuric acid or nitric acid (BW-W-009). In the laboratory, two mixed samples were prepared from these ditch water samples (one per ditch type). The mixed samples were analysed for nitrate, total nitrogen and total phosphorus.

The additional ditch water samples were taken at the same locations as the samples that were taken at the same time for the groundwater sampling. However, the sampling method deviated, as it followed the method used on drained farms in the clay region. Sampling therefore took place with a fishing rod and measuring beaker. No analyses took place in the field and the samples were stored in a cool, dry place for transport to the laboratory (BW-W-011), but not filtered and conserved. The following day, in the laboratory one mixed sample per ditch type was prepared and analysed for nitrate, total nitrogen and total phosphorus. Per ditch type, a maximum of four individual samples is used for a mixed sample.

Overview of the RIVM work instructions used:

BW-W-001	The measurement of the nitrate concentration in an aqueous solution with the aid of a Nitracheck-reflectometer (type 404).
BW-W-008	Temporary storage and transport of samples.
BW-W-009	Method for conserving water samples by adding an acid.
BW-W-011	Sampling ditch water or surface water with a modified sampling lance and hose pump.
BW-W-014	Soil sampling with an Edelman drill to obtain soil moisture analyses.
BW-W-015	Groundwater sampling with a sampling lance and hose pump on sand, clay or peat soils.
BW-W-021	Determination of the location of the sampling points.

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Appendix 5 Method corrected nitrate concentration

The method for calculating the corrected nitrate concentration consists of two parts. Firstly, the fluctuations in concentrations in the leaching water caused by fluctuations in the precipitation surplus are calculated. Secondly, an indexed trend line for nitrate is determined by estimating the annual average nitrate concentrations for the situation without fluctuations in the precipitation surplus and other confounding factors.

Effect of the precipitation surplus
The nitrate concentration of the upper groundwater, which is sampled by LMM, exhibits fluctuations that cannot be clarified by variations in the agricultural practice alone. Fraters et al. (1998) showed that fluctuations in the precipitation surplus cause fluctuations in the nitrate concentration. For example, it was demonstrated that the 50 percent reduction in the nitrate concentration between 1993 and 1994 was mostly caused by greater dilution and/or more denitrification arising from a higher precipitation surplus. Below, a description of the method demonstrating the effect of the precipitation surplus is given.

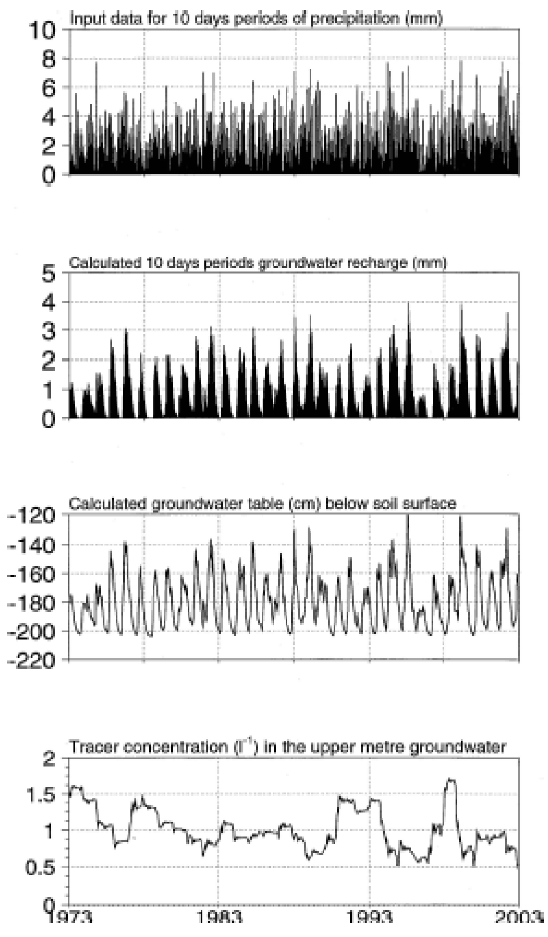

Figure A5.1 Trend over a period of 30 years of precipitation, groundwater recharge, groundwater level and tracer concentration.

The effect of a variable precipitation surplus on the nitrate concentration is determined by calculating a ‘precipitation surplus’ variable and then including this variable as an explanatory variable in a statistical model (see below). The relationship between nitrate and the ‘precipitation surplus’ variable in the statistical model can be caused by both greater dilution of the nitrate and greater denitrification.

The ‘precipitation surplus’ variable is calculated in two steps:

Step 1. First, the leaching from a virtual tracer is calculated by means of a soil simulation model ONZAT (OECD, 1989) using nationally available data about precipitation and evaporation from 16 weather districts.

The virtual tracer is applied each day to the soil surface of a standard soil profile with grass, for 8 different drainage situations. The result is a trend in the groundwater level and a tracer concentration for 15 x 8 = 120 situations. Figure A5.1 shows the trend over a period of 30 years for a given situation of the precipitation, groundwater recharge, groundwater level and tracer concentration.

From the figure it can be concluded that variations in the precipitation surplus can cause a two-fold or even a three-fold variation in the tracer concentration between years. The tracer concentration is inversely proportional to the precipitation surplus.

Step 2. For each temporary drill hole the weather district, the sampling date and the groundwater level measured are used to find an associated tracer concentration in the simulation results (Boumans et al., 2001). Then the tracer concentrations are averaged per farm, so that a farm-averaged tracer concentration (= precipitation surplus variable) is obtained for the farm-average nitrate concentration, that is measured in a mixed sample of groundwater from the same temporary drill holes.

Indexed trend line for nitrate
The indexed trend line estimates the annual average nitrate concentrations for the situation *without* the influence of confounding factors such as weather variability and the sample.

The water quality can be affected by people, by the weather and because old farms are no longer included and new farms are added to the monitoring network. Nitrate reacts the fastest and most clearly to changes in soil load and the nitrate concentration is in general high in the sand region. In the peat region, nitrate is hardly present. The clay region occupies an intermediate position. The indexation will improve as more observations become available. Far fewer observations are available from the loess region than from other regions. Due to the above-mentioned complications, the method delivers no conclusive results for the clay, peat and loess regions. Therefore, no correction will be introduced for these regions.

The sand region is the most susceptible to nitrate leaching, so that the human impact and the influence of the weather are most noticeable here. Besides this, many observations are available. To separate the influence of the agricultural practice as much as possible from the other influences, the REsidual Maximum Likelihood (REML) technique is applied (chapter 4, Table 4.10). This technique allows for the fact that the sample contains similar farms monitored in several years but also different farms in several years. The REML technique was also used to investigate whether a difference in the precipitation surplus and a difference in the groundwater level could have affected the concentrations found (Table 4.10). The use of the REML method is described in greater detail in Fraters et al. (2004), Annex 2.

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Appendix 6 Economic indicators fertiliser use National Service for the Implementation of Regulations

A6.1 Introduction

In the years 2006 to 2009, the National Service for the Implementation of Regulations (further to be referred to as DR) reported on fertiliser use, based on its own data. This calculated fertiliser use based on DR data and the calculated fertiliser use based on data from farms in the derogation monitoring network (DM farms) of the Minerals Policy Monitoring Programme (LMM) were at times quite different, particularly in 2009. At the end of 2011, LEI conducted an investigation and succeeded in identifying virtually all of the differences. Because, for example, the defining methods of DR and LMM differ, the results forthcoming from the DR data and the LMM data will not always match exactly. Thereupon it was decided that LEI, in an appendix to the Derogation Report to be drawn up by RIVM and LEI, will present the DR figures on the basis of DR material. In this context, LEI will also examine the differences between fertiliser use calculated on the basis of DR data and fertiliser use calculated on the basis of LMM data.

Table A6.1 shows fertiliser use on farms with derogation in the year 2010, based on DR data and according to the results of derogation monitoring by LMM.

Table A6.1 Fertiliser use on farms in the derogation monitoring by LMM in kg/ha, fertiliser use in kg/ha on farms with derogation according to DR and the differences between these sources in the year 2010 for both nitrogen and phosphate.

			Difference LMM – DR	
Category	*LMM*	*DR*	*In kg/ha*	*In %*
Nitrogen from livestock manure	246	218	27	13
Nitrogen from inorganic fertiliser	121	131	-10	-7.9
Nitrogen from other organic fertilisers	0	4	-4	-100
Total nitrogen	366	353	13	3.8
Phosphate from livestock manure	86	81	5	6.5
Phosphate from inorganic fertilisers	3	2	1	53
Phosphate from other organic fertilisers	0	1	-1	-73
Total phosphate	89	84	5	6.2

A6.2 Summary analysis of differences

A6.2.1 Nitrogen from livestock manure

The calculated volume of nitrogen from livestock manure is 27 kg per ha higher in LMM than based on DR data.

Table A6.2 Composition of the difference in the use of livestock manure on farms with derogation according to DR and on farms in the derogation monitoring by LMM in the year 2010 for nitrogen.

	Nitrogen	
Category	*Kg N/ha*	*Percentage*
Value reported by LMM	246	
Value reported by DR	218	
Difference	27	
Caused by		
DR population: all versus >=10 ha within LMM confidence intervals and between 16 and 800 NGE	14	52
DR population >=10 ha within LMM confidence intervals and between 16 and 800 NGE versus LMM derogation farms with DR data	-3.7	-14
Stocks	-6.4	-23
Import and export	0.9	3
Use of BEX*	-9.1	-33
Excretion forfeit dairy cows	15	54
Excretion forfeit other cattle	9.6	35
Excretion forfeit other grazing animals	1.7	6
Excretion forfeit housed animals	5.4	20

Source: processed data DR and FADN LEI

*: BEX is farm-specific excretion (National Service for the Implementation of Regulations, 2010).

Table A6.2 summarises the reasons for these differences:

1. Slightly over half the difference shown in Table A7.1 (14 kg per hectare) is associated with differences in populations. Within LMM, farms smaller than 10 hectare, smaller than 16 NGE or larger than 800 NGE are excluded, which is not the case in the DR data. Besides, LMM applies confidence intervals (see Appendix 3), whereby farms with improbably high or low amounts of fertilisers are excluded. The amounts of fertilisers as calculated on the excluded farms are substantially lower.
2. Furthermore, the use of livestock manure in LMM, as calculated on the basis of DR data, deviates almost 4 kg from that of the DR population >= 10 hectare and between 16 and 800 NGE. The 280 LMM observations can be regarded as a sample from the much larger DR population.
3. This difference is partly compensated by the fact that stocks and imports and exports registered by LMM differ from those registered by DR. Participants in the FADN are requested to report the actual situation, which might differ from the DR registration. In 2010, the net effect was that the calculated fertiliser amounts in LMM were 6 kg per hectare lower than in DR. In 2009 still the opposite was the case.
4. The difference in acreage between LMM and DR, calculated on the basis of DR data, is 0.13 hectare. This does not affect the differences.
5. The remaining difference (22 kg per hectare) is caused by the differences in the method for calculating the excretion, whereby the following applies:
   a. The excretion forfeit in LMM is defined more precisely than in the DR data, for a number of reasons. It appears that the DR cannot always calculate the excretion of dairy cows because it lacks data on milk supplies or urea levels. Also, in more than 300 DR observations milk supplies, urea levels and numbers of dairy cows were known, but the excretion for the dairy cows was nevertheless not calculated. Furthermore, LMM takes the housing system into account when determining the forfeit, while in DR the housing system is not known, so

the lower solid manure forfeit is selected. On the other hand, the DR does not regard the excretion of hobby animals as excretion, but as other organic fertilisers. It is also possible that a different method for calculating the excretion of housed animals is applied.

b. In LMM, BEX (farm-specific excretion) is applied for a much larger number of farms, resulting in a use of livestock manure which is over 9 kg N per hectare lower in the LMM data than in the DR data. LMM applies BEX for all the farms that indicate that they use BEX and where the available data are sufficiently accurate. In the DR data, BEX is applied on only 1 percent of the farms.

Nitrogen from inorganic fertiliser and other organic fertilisers

The differences in the use of nitrogen from inorganic fertilisers and other organic fertilisers are small when compared to those for nitrogen from livestock manure. They can largely be explained by the fact that:

1. The farms which are excluded (sample limitations and confidence intervals) have a higher use of inorganic fertilisers (possibly compensating for the lower use of livestock manure).
2. The DR data regard the excretion of hobby animals as other organic fertilisers.

Phosphate

The relationship between nitrogen and phosphate in livestock manure is reasonably stable, as is the case for other organic fertilisers, so the reasons for the differences in Table A6.1 for phosphate from livestock manure and other organic fertilisers are the same as for nitrogen. The absolute difference for phosphate from inorganic fertilisers in Table A6.1 is small (about 1 kg per hectare) but at the same time relatively large (over 50 percent), because in 2010 not much phosphate from inorganic fertilisers was used on the derogation farms.

The differences for nitrogen and phosphate give no rise to adjusts the LMM calculation method.

A6.3 Material

The following data sources were used for the comparison of DR and LMM figures for the year 2010:

- The LEI FADN: this concerns the 298 farms that qualified for derogation monitoring (DM) in 2010. In principle fertilisation data are looked at, but if necessary other data of these farms from the FADN are used as well. These farms are all participants in the LMM, so will be referred to below as ‘LMM farms’, and the data provided as ‘LMM data’.
- Data from the National Service for the Implementation of Regulations (DR): these concern 22,947 farm relation (BRS) numbers of farms which applied for derogation in 2010. Besides, 17 BRS numbers have been added which are included in the 298 LMM farms but not in the 22,947 BRS numbers.
- Data from the Agricultural Census 2010 concerning the 22,964 BRS numbers. For 626 BRS numbers no number could be found in the Agricultural Census 2010, so that 22,338 BRS numbers remain with data from the Agricultural Census.

On LMM farms fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers separately, as well as total fertilisation (inorganic fertilisers, + livestock manure + other organic fertilisers) must fall within the confidence intervals for the LMM, both for nitrogen and for phosphate. The table in question is to be found in Appendix 3.3.

Furthermore, LMM farms with anaerobic digestion installations are also excluded, as well as farms that did not actually use the derogation in the year concerned (N = 4 in 2010). Consequently, the number of LMM farms used for the derogation monitoring in 2010 dropped from 298 to 280.

A6.4 Comprehensive results

A6.4.1 Nitrogen from livestock manure

Differences in population

Table A6.3 Excretion (= production), import/export, stocks and use of livestock manure in kg nitrogen per farm and per ha according to DR for BRS numbers in 2010 with application for derogation in 2010.

	No arable land	*Arable land*			
		Total	*Outside confidence intervals*	*< 10 ha or < 16 NGE or > 800 NGE*	*>= 10 ha and 16-800 NGE*
Number of farms	703	22,244	1810	2610	17,824
Acreage arable land (in ha)	0	38	30	7.6	43
Kg N use of livestock manure		218	109	189	233
Kg N initial stock		93	164	69	89
Kg N final stock		94	174	62	90
Kg N initial stock – final stock		-0.6	-9.6	7.2	-0.6
Kg N import – export		-24	-158	16	-15
Kg N excretion (= kg N production)		243	276	166	248

Source: processed data DR

Table A6.3 shows production, import/export and initial and closing stock of livestock manure in kg nitrogen per hectare for the 22,947 DR observations, excluding observations without arable land. Of these 22,947 DR observations, 1810 fell outside the confidence intervals. Approximately 40 percent of these 1810 was also smaller than 10 hectare. Additionally, the DR data include 2610 farms which were smaller than 10 hectare, smaller than 16 NGE or larger than 800 NGE, but which did fall within the confidence intervals.

The use per hectare was determined by calculating the use per hectare for each farm and then averaging these uses per hectare. Observations without land could not be included (it is not possible to divide by zero). Table A6.3 shows that the BRS numbers with 10 or more hectare of arable land and between 16 and 800 NGE had a higher use of nitrogen from livestock manure per hectare than the BRS numbers with less arable land or smaller than 16 NGE or larger than 800 NGE. The main reason for this was that the N excretion per hectare was more than one and a half times as high. As noted before, the LMM data are limited to farms with a minimum of 10 hectare of cultivated land and between 16 and 800 NGE. Therefore, only the 17,824 DR observations below with a minimum of 10 hectare of cultivated land and between 16 and 800 NGE (the far right column in Table A6.3) were taken into account in the comparison with the LMM results. Of those 17,824 DR observations (DR >= 10 hectare, 16-800 NGE), 280 (DR in LMM) were linked to the same amount of LMM observations (see end of section A6.3).

Table A6.4 shows that in 2010 the whole group of derogation farms in the DR data with a minimum of 10 hectare of cultivated land, 16 to 800 NGE and falling within the confidence intervals applied by LMM, was on average smaller in acreage (43 hectare compared to 53 hectare) and less intensive (2.35 phosphate/LSU per hectare compared to 2.45 phosphate/LSU per hectare) than the LMM derogation farms according to the DR data. According to the LMM data the differences are somewhat higher still.

According to the LMM calculation shown in Table A6.4, the use of nitrogen via livestock manure on the 280 LMM derogation farms was almost 255 kg per hectare, whereas Table A6.1 shows 246 kg for the 280 LMM farms.

Table A6.4 Use, import minus export, stock difference and excretion (= production) of livestock manure in 2010, divided per group of animals, in kg nitrogen per ha according to the DR and according to the LMM for farms in the derogation monitoring by the LMM and for the derogation farms of the DR with a minimum of 10 ha cultivated land, 16 to 800 NGE and with fertiliser use falling within the confidence intervals of the LMM.

	DR >= 10 ha, 16-800 NGE	*LMM*	*LMM in DR*	*LMM - LMM in DR*
Number of farms	17,824	280	280	
Acreage arable land (ha)	43	53	53	0
Phosphate LSU/ha	2.4	2.6	2.5	0.1
Results per ha				
Kg N use of livestock manure	233	255	229	26
Kg N initial stock – final stock	-0.6	-7.6	-1.2	-6.4
Kg N import – export	-15	-24	-25	0.9
Kg N excretion (= kg N production)	248	286	255	31
- of which dairy cows	166	193	178	15
- of which other cattle, excl. white-fleshed calves	69	73	64	9.6
- ditto after correction for type of fertiliser	*78*	*73*	*72*	*1.2*
- of which sheep, goats and horses	4.5	4.3	2.6	1.7
- ditto after adding excretion of hobby animals	*5.8*	*4.3*	*3.6*	*0.7*
- of which housed animals incl. white-fleshed calves	8.7	16	10	5.4

Source: processed data DR and FADN LEI

<u>Differences between calculated excretions</u>

In Table A6.4 the excretions are fully based on forfeits, whereas for the LMM farms in Table A6.1 in 76 cases the calculation according to the farm-specific excretion (BEX, Guidance) was applied. In respect of the calculations in the DR data it is not known whether the farms used BEX.

The use of nitrogen via livestock manure on LMM derogation farms according to the LMM calculation was 22 kg (255 versus 233) higher than according to the calculation on basis of the DR data. The use on the DR derogation farms was slightly higher (233 versus 229) than that of the LMM derogation farms when calculated on basis of DR data.

The differences between the calculation according to the LMM and the calculation according to the DR mainly concern the excretion (31 kg). Because the stock imports were higher according to the LMM calculation and net exports were slightly lower than according to the DR calculation, the difference in the use of livestock manure was smaller: 26 kg.

The 31 kg difference in excretion concerns the following groups of animals:

- Dairy cows 15 kg: the LMM figures included all the milk produced, i.e. not only supplies, but also milk fed to young animals or pigs and waste milk. This resulted in a 100 kg higher milk production per cow, corresponding with a difference of 1.2 kg nitrogen excretion per hectare, than when calculated on basis of DR data. Also, the DR calculation was probably based on an excretion which was 2 kg N lower per cow, resulting in a difference in nitrogen excretion of about 3 kg per hectare. It appears that the DR cannot always calculate the excretion of dairy cows because it lacks data on milk supplies or urea levels. Also, in more than 300 DR observations milk supplies, urea levels and numbers of dairy cows were known, but the excretion for the dairy cows was nevertheless not calculated. Of the 280 LMM observations, there were 10 cases in which the excretion of dairy cows according to the DR data was zero, while according to the LMM data excretion of dairy cows was known, and in 4 of those 10 cases figures on milk supplies, urea levels and number of dairy cows were present in the DR data. This resulted in a 7.5 kg per hectare higher nitrogen excretion in the LMM data than via the DR data.
- Other cattle, excluding white-fleshed calves, 9.6 kg: for this group of animals the DR apparently used excretions for solid manure, which are lower than those for liquid manure. According to the Agricultural Census 2008 (the most recent Agricultural Census which requested information on the use of solid manure versus liquid manure for cattle) approximately 55 percent of the young animals up to 1 year old, 95 percent of the female young animals over 1 year old and intended for breeding, and 70 percent of beef cattle and grazing and suckler cows are housed in types of housing with liquid manure. By taking into account the difference in excretion between solid and liquid manure systems for these particular animal categories in respect of these percentages, the excretion in the calculation according to the DR will increase by 8.4 kg nitrogen per hectare, which means that there is hardly any difference left between the LMM calculation and the DR calculation.
- Sheep, goats and horses: more than half (1.0) of the difference of 1.7 between the LMM calculation and the DR calculation is caused by the fact that the DR regards groups of animals with less than 350 kg N excretion as hobby animals. It registers this excretion as other organic fertiliser. Hobby animals are mainly sheep and horses.
- Housed animals 5.4 kg: the LMM and the DR possibly does not use exactly the same calculation method for the excretions of housed animals.

A6.4.2 Nitrogen from inorganic fertilisers and other organic fertilisers
Table A6.5 shows the use of nitrogen from inorganic fertilisers and other organic fertilisers, calculated for all 22,947 BRS numbers in the DR data excluding the 703 BRS numbers without land (DR >0 hectare), as well as for the 17,824 BRS numbers with a minimum of 10 hectare of cultivated land, between 16 and 800 NGE and with fertiliser use falling within the confidence intervals (DR >=10 hectare, 16-800 NGE) of the LMM.

Table A6.5 Use in 2010 of nitrogen from inorganic fertilisers and from other organic fertilisers in kg N/ha according to DR and according to LMM for farms in the derogation monitoring of LMM, for the derogation farms of DR with cultivated land and for the derogation farms of DR with a minimum of 10 ha of cultivated land, between 16 and 800 NGE and with fertiliser use falling within the confidence intervals of the LMM.

	DR >0 ha	*DR >= 10 ha, 16-800 NGE*	*LMM*	*LMM in DR*	*LMM - LMM in DR*
Number of farms	22,244	17,824	280	280	
Acreage of arable land (ha)	38	43	53	53	0
Results per ha					
Inorganic fertilisers	131	117	120	117	3
Other organic fertilisers	3.7	1.6	0.0	1.3	-1.3
ditto after excluding excretion of hobby animals	*0.1*	*0.3*	*0.0*	*0.2*	*-0.2*

Source: processed data DR and FADN LEI

The DR results per farm for the 22,244 BRS numbers with cultivated land differed from the DR results for the 17,824 BRS numbers with a minimum of 10 hectare cultivated land, between 16 and 800 NGE and with fertiliser use falling within the confidence intervals of the LMM. For the group as a whole, the use of nitrogen from inorganic fertilisers as well as from other organic fertilisers was higher. The main reason for this is that BRS numbers were included with fertiliser use that fell outside the confidence intervals of the LMM.

In respect of the much smaller group of LMM derogation farms for which DR data were also available, there were hardly any differences in the use of nitrogen from inorganic fertilisers. The same applied to the use of nitrogen from other organic fertilisers after the DR data had been corrected for the nitrogen excretion of hobby animals.

A6.4.3 Phosphate from livestock manure, inorganic fertilisers and other organic fertilisers
The relationship between nitrogen and phosphate in livestock manure is reasonably stable, as is the case for other organic fertilisers, so the reasons for the differences in Table A6.1 for phosphate from livestock manure and other organic fertilisers are the same as for nitrogen. The absolute difference for phosphate from inorganic fertilisers in Table A6.1 is small (about 1 kg per hectare), but at the same time relatively large (over 50 percent), because in 2010 not much phosphate from inorganic fertilisers was used on the derogation farms. The derogation farms required virtually the full margin within the application standards for phosphate from livestock manure, so their scope for using phosphate from inorganic fertilisers was extremely limited.

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