DANISH MINISTRY
OF THE ENVIRONMENT

Environmental
Protection Agency

Danish Report
in accordance with the
Commission Decision
2005/294/EC and 2008/664/EC

February 2010
Danish Environmental Protection Agency
Danish Ministry of the Environment
Strandgade 29
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Contents

1. Introduction

With the Commission Decision 2005/294/EC and 2008/664/EC Danish cattle holdings are allowed to derogate from the general rules in the Nitrates Directive (91/676/EEC). If 70 per cent or more of the area available for manure application is cultivated with beets, grass or grass catch crops cattle holdings can apply manure comparable to 2.3 livestock units (LU[1]) per hectare per year. Furthermore cattle holdings shall comply with conditions laid in the decision. The implementation of Commission Decisions 2005/294/EC and 2008/664/EC into Danish legislation is shown in annex 1.

The aim of the report is to present maps showing the percentage of farms and percentage of agricultural land encompassed by the derogation in each municipality of Denmark for 2007/2008, the control of compliance with the Danish derogation for 2006/07 and monitoring results for 2008.

According to Article 7(1) of Commission Decision 2005/294/EC Denmark shall update two maps, showing the percentage of farms and percentage of agricultural land encompassed by the derogation in each municipality of Denmark, and transmit the maps to the Commission.

According to Article 8 (2 and 3) of Commission Decision 2005/294/EC the results of the monitoring shall be transmitted every year to the Commission, with a concise report on evaluation practice (control at farm level) and water quality evolution (based on root zone leaching monitoring, surface/ground water quality and model-based calculations).

This report will present:

- Maps showing the percentage of farms and percentage of agricultural land encompassed by the derogation in each municipality of Denmark,
- Controls on farm level, and
- Report on monitoring results (controls at farm level and water quality)

[1] One livestock unit is defined as 100 kg nitrogen in the livestock manure ex. storage.

2. Maps on cattle holdings, arable land and LU in 2008

Kirstine Damm, Danish Plant Directorate, 4.1.2010

In 2008 the Danish Plant Directorate had about 47,000 fertilizer status accounts containing key figures on the use of nitrogen (commercial fertilizer and livestock manure). The accounts are registered and subject to inspection. The number of accounts has fallen due to an increase in size of the farms. The following maps are based on data on the number of agricultural holdings, number of livestock units and arable land in use in the year 2007/2008. A fertilizer account year runs from 1 August to 31 July. Accounts must be submitted to the Danish Plant Directorate no later than 31 Marts 2009.

The data used in the following maps are from these fertilizer status accounts. In the fertilizer status account the farmer has to indicate whether the derogation is used. The maps are drawn on the basis of these indications, which means on the basis of farmers' own information.

2.1.Map on Cattle Holdings 2007/2008

The map shows at municipality level cattle holdings encompassed by the derogation in percentage of the total number of agricultural holdings registered in the specific municipality.

For the year 2007/2008 a total of 1,296 cattle holdings were encompassed by the derogation. This corresponded to 2.8 per cent of all registered accounts. The applied manure on these farms lies in the range 170 to 230 kg N per hectare per year. If the production of manure on a derogation farm corresponds to more than 230 kg N per hectare, the farmer must deliver the excess manure by contract to other farmers.

2.2. Map on Arable Land 2007/2008

The map shows at municipality level the arable land on cattle holdings encompassed by the derogation in percentage of the total agricultural area in the specific municipality.

For the year 2007/2008 the arable land on cattle holding encompassed by the derogation was 92,282 hectare. This corresponded to 3.9 per cent of all registered hectares.

2.3. Map on Livestock Units 2007/2008

The map shows at municipality level livestock units at cattle holdings encompassed by the derogation in percentage of the total number of livestock units in the specific municipality.

For the year 2007/2008 the number of livestock units on cattle holding encompassed by the derogation were 186,313 LU. This corresponded to 8.3 per cent of all registered livestock units.

2.4. Development in the use of the derogation over the last 6 years

During the first three years where the derogation could be used, i.e. 2002/03, 2003/04 and 2004/05, an increase in the use of the derogation was recorded both regarding the number of farms, the number of hectares and the number of livestock unit. This tendency was broken in the period 2005/06, where a decrease was registered at all three measured parameters: the number of farms, the number of hectares and the number of livestock units. In 2006/07 a further decrease in use of the derogation is seen for all parameters which resulted in that, on all measured parameters, the level is now well under the level in 2002/03. See table 2.1 below.

Year	Number of farms	Number of farms, Pct	Number of hectares	Number of hectares, pct	Number of livestock units	Number of livestock units, pct
2002/03	1,845	4	123,068	5	213,617	10.6
2003/04	1,927	4	128,523	5	225,586	10.6
2004/05	2,331	5	134,780	5	277,330	12.9
2005/06	1,779	3.4	115,336	4.2	220,839	10.3
2006/07	1,610	3.2	111,845	4.0	211,765	9.5
2007/08	1,296	2.8	92,282	3.9	186,313	8.3

Table 2.1 Development in the use of the derogation regarding number of farms, hectares and LU

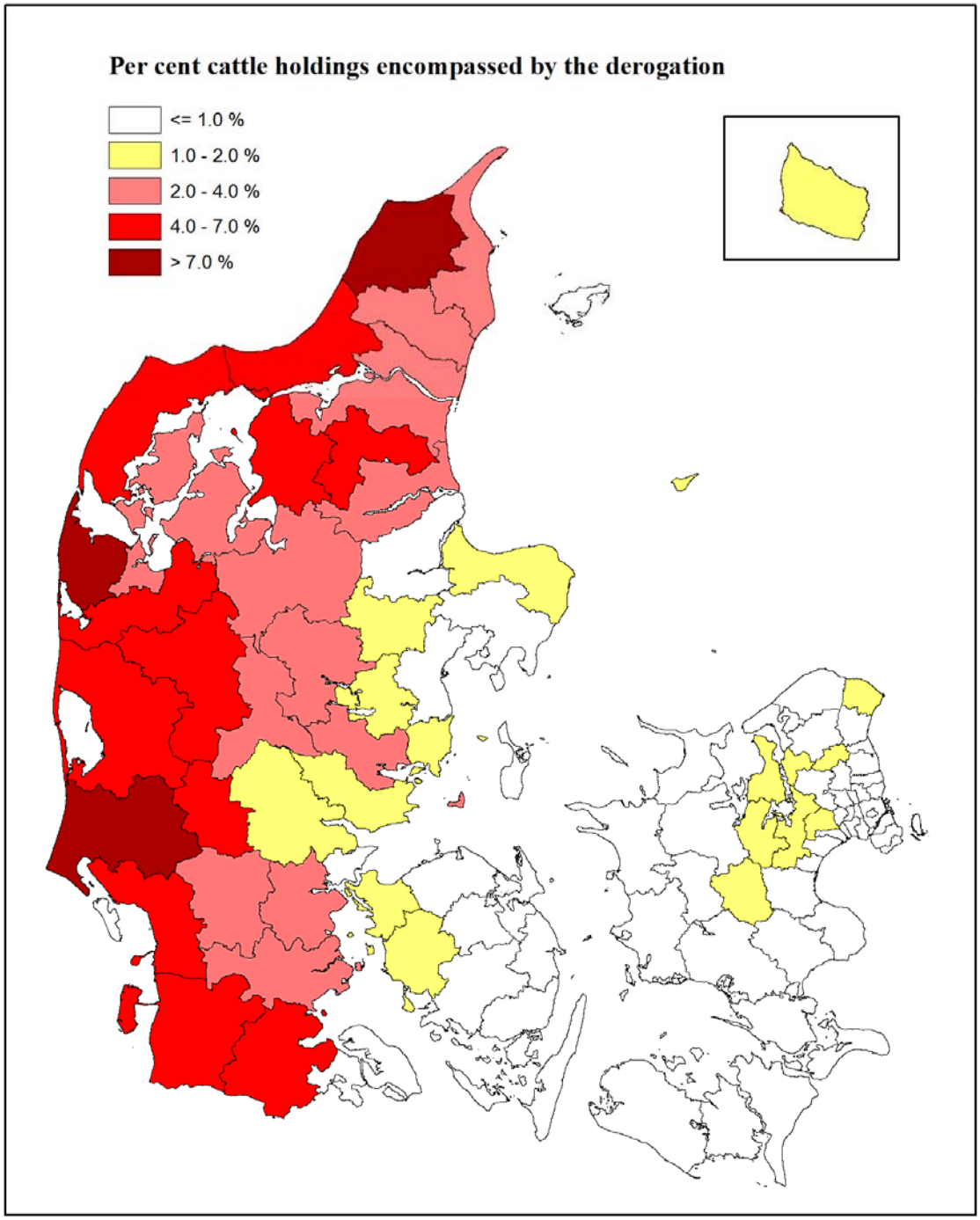
The average number of livestock units per farm has increased over the years and this also applies to the last year. The average number of livestock units per hectare has changed up and down over the years, and is now close to the highest level measured in 2004/05. See table 2.2.

Year	LU/holding	LU/hectare
2002/03	115.78	1.74
2003/04	117.07	1.76
2004/05	118.97	2.06
2005/06	124.14	1.91
2006/07	131.53	1.89
2007/08	143.76	2.02

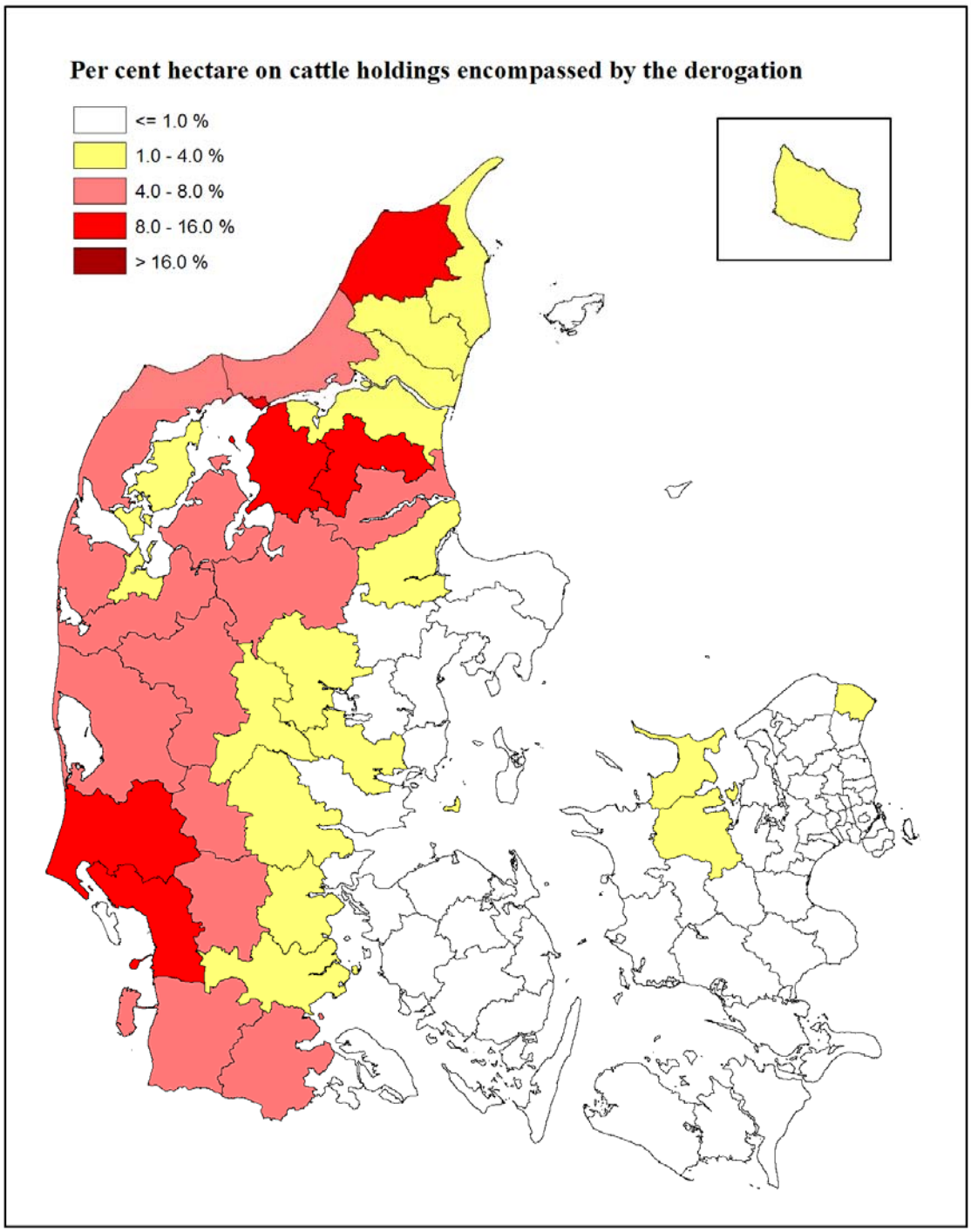
Table 2.2 Average number of livestock units per holding and per hectare under the derogation

The following maps illustrates that cattle holdings encompassed by the derogation are concentrated in the western parts of Jutland, some on Funen, and less on Zealand and on the island of Bornholm.

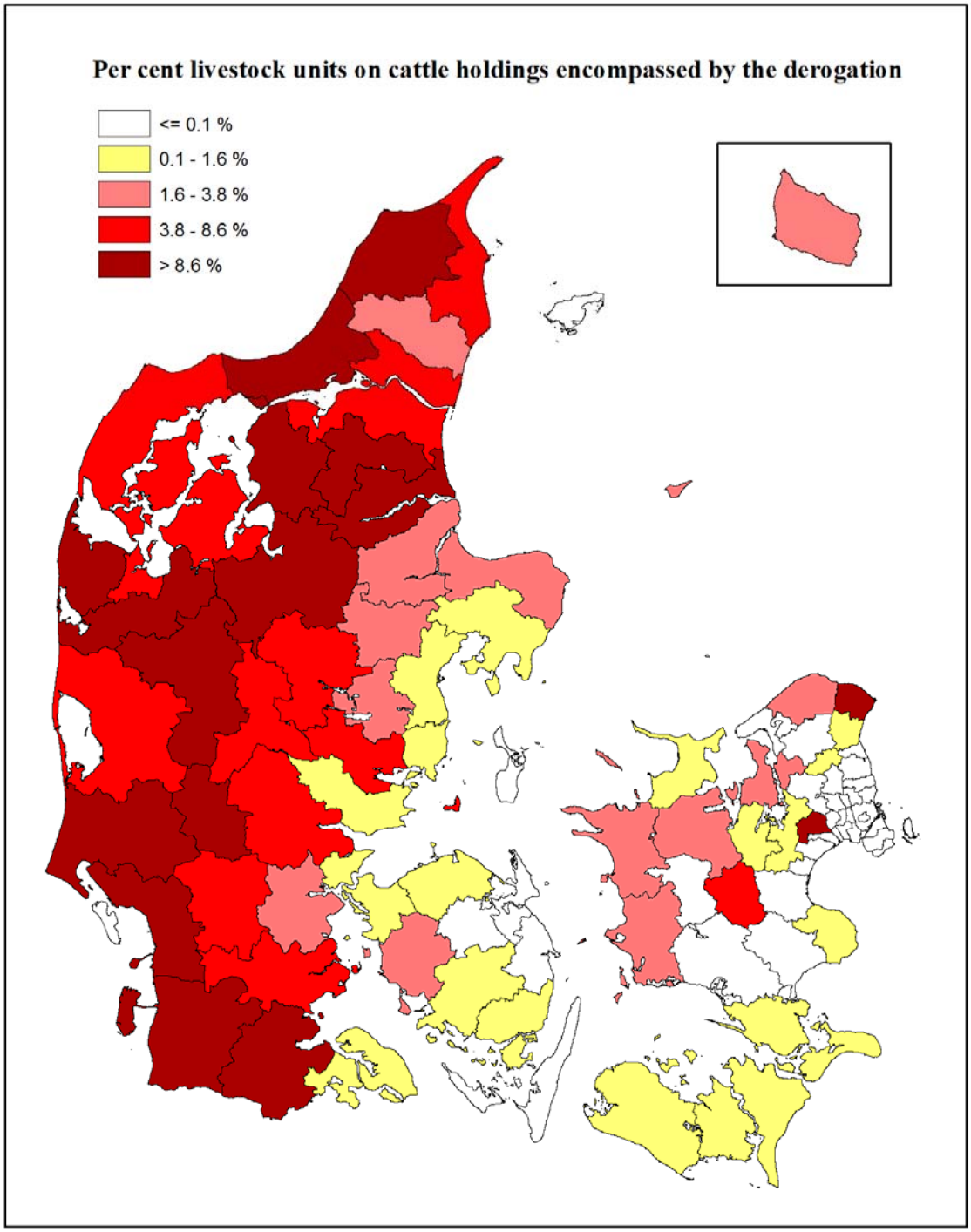
Year 2007/08 Cattle holdings encompassed by the derogation in percent of total number of agricultural holdings in Denmark



Year 2007/08 Arable land encompassed by the derogation in percent of total agricultural land in Denmark



Year 2007/08 Livestock units encompassed by the derogation in percent of total number of livestock units in Denmark



3. Controls on farm level

Kirstine Damm, Danish Plant Directorate, 4.1.2010

3.1. Control of compliance with the Danish derogation

According to Article 8 of Commission Decision 2005/294/EC results of the monitoring of the use of the derogation shall be transmitted every year to the Commission, with a concise report on evaluation practice (control at farm level).

Control of compliance with the Commission Decision 2005/294/EC and 2008/664/EF follows two strategies.

1. Inspection of compliance with management conditions, which is carried out within the year the farmer uses the derogation. This includes field inspections when necessary.
2. Control of the amount of livestock manure applied per hectare per year (control of compliance with the harmony rules), which is carried out after the derogation year has ended. This control is carried out in two ways: as a control at the farm of all parameters of the production and as an administrative inspection of submitted fertilizer status accounts.

3.2. Summery of results of inspections in 2009

Compliance with management conditions:

- Inspection at the farm: 51 inspections were carried out, 49 farms met the management conditions, 2 farms did not comply and cannot use the derogation, 32 planned not to use the derogation and declined inspection.
- Administrative control of harmony rules of the farms declining farm inspection in 2007: 9 farms were investigated, 7 complied with the rules, 2 did not comply of which 1 is still under investigation.

Compliance with the harmony rules for farms using the derogation:

- Inspection at the farm: 65 inspections were carried out, 59 farms complied with the rules, none received warnings, 5 farms received fines for not complying, 1 case is still under investigation.
- Administrative inspection: 41 inspections were carried out. All farms complied with the rules.

3.3. Inspection of compliance within the derogation year

The Danish Plant Directorate has carried out inspections of the Danish derogation on specific cattle holdings concerning the years from 2002/2003 until 2008/09. The use of the derogation is based on the farmer complying with certain conditions. Some conditions have to be checked at the farm like ploughing of fields. Therefore a physical inspection is carried out in January and February.

During the inspection at the farm the following questions are answered:

1. Do cattle make up 2/3 of the livestock units i.e. is the farm mainly a cattle holding?
2. Has a plan for crops grown in the actual planning period been drawn up?
3. Has the manager planned to comply with the 2.3 LU per hectare derogation?
4. Does the plan contain leguminous and other crops fixing nitrogen, e.g. red clover and white clover?
5. Has a statement about manure application been made?
6. Does the plan include ploughing fields with grass or grass catch crops in the planning period?
7. If the answer is Yes in question 6: Are the fields ploughed at the time of inspection?

The inspection is based on an interview with the farmer, on inspection of the farm's crop rotation plan for the coming growing season and on a visual inspection of fields viable for ploughing.
At the inspection the inspector draws up a report, which includes answers to the above mentioned questions. At the end of the inspection the farmer is informed whether the holding can apply manure comparable to 2.3 LU per hectare i.e. whether the derogation can be used or not. If the holding is not complying with the derogation conditions the holding is only allowed to apply livestock manure up to 170 kg N per hectare. In this case the farmer has to find other means of disposing the surplus manure produced on the farm.

If a farmer informs the inspector that the derogation will not be used, the field inspection is not carried out. Instead an administrative control of the farm is carried out when the fertilizer status account has been submitted. This control is carried out to secure that no more than 1.7 LU per hectare was used.

The inspection report is submitted by the inspector to the Plant Directorate for possible further administrative inspection where the data are verified. Additional remarks made by the inspector, if any, are examined. This includes a process where the parties of interest are allowed to make statements on the case, when necessary.

3.4. Results

From 1 January until 1 March 2009 the Plant Directorate carried out 51 inspections on cattle holdings to inspect whether the conditions were met. The control refers to the fertilizer accounts of the year 2008/09. Table 3.1 shows the results of the inspection over the last 7 years. Only very few remarks have been given and generally a good compliance with the rules can be seen.

Control year	Total number of inspections	Inspections without remarks	Inspections with remarks
2003	35	29	6
2004	46	46	0
2005	50	49	1
2006	50	49	1
2007	54	54	0
2008	47	46	1
2009	51	49	2

Table 3.1 Development in results of Inspection of Compliance within the derogation year

During the period from 1 January until 1 March 2007 nine cattle holdings notified the inspector that the derogation was not used and therefore a field inspection was not carried out. The succeeding administrative inspection of the fertilizer account of those nine farms found that two farms reported to have used the derogation anyway. One farm used an amount below the punishable limit; the other is still under investigation.

3.5. General inspection of the harmony rules

Harmony rules

Control of the amount of livestock manure applied per hectare per year on derogation farms is carried out after the derogation year has ended. This control is carried out within the general inspection of the Danish harmony rules, where the inspector visits the farm to inspect the production based on various documents. Violation of the harmony rules, i.e. the allowed amount of applied livestock manure per year, is sanctioned. For minor violations the farmer is imposed a warning. For more sever violations the farmer is imposed a fine. Both the farmers who receive warnings and the farmers who receive fines are reported for not complying with the cross compliance criteria.

Concerning the year 2006/2007 626 livestock holdings have been inspected for violation of the harmony rules, including the farms using the derogation. 65 holdings used the derogation. Of these derogation controls 90% (59 holdings) were closed without remarks, none were closed with a warning because of small violations, 8 % (5 holdings) were fined because of more severe violations, 2% (1 holding) is not finalized yet. All of those fined this year, were fined for not complying with the requirements of soil analysis, see below. The farmers receiving fines have been reported for not complying with the cross compliance criteria.

Control year	Total number of inspections	Inspections without remarks	Inspections with minor violations	Inspections with fines	Inspections still under investigation
2007	65	59	0	5	1

Table 3.2 Results of inspection of compliance with the harmony rules

Soil analysis

If the derogation is used for three consecutive years the farmer must provide a soil analysis where phosphorous and nitrogen levels are examined. One sample per five hectares must be provided. The year 2004/05 was the first year where the derogation could have been used for three years, and therefore the first year that compliance with this requirement was examined. The present year, 2006/07, is the third year with this information.

In Denmark the soil analysis for phosphor (the phosphorous value) describes the soil's phosphorous status from a plant nutrient point of view. Internationally this equals to the Olsen-P. Olsen-P is often expressed in mg per kg soil. In Denmark phosphorous value is expressed in mg per 100 g soil. On average Olsen-P in Danish agricultural soil is around 45 mg P per kg soil (Pv. 4.5). When determining the phosphorous value only part of the plant's available content of inorganic phosphorous is extracted, this equals around 5-10 percent of the total phosphorous content of the soil. A phosphorous value at 2-4 is generally accepted as a sufficient level for most crops and 2-2.5 is the lower critical soil P level. A phosphorous value level above 6 is considered very high.

The N-total is used to determine the crop demand, and describes the slow mineralization. In Denmark, depending on the C/N ratio in the soil, the standard is 0.13 %. If the level of N-total is 0.13 % the farmer cannot expect any N-supply from the mineralization. If the value is above 0.22 %, the level is high and expected mineralization is 40 kg N in maize and cereals per hectare. The N-total standard for grass fields is 0.18-0.22, and if the value is above 0.22 the expected mineralization is 10 kg N per hectare

Results of soil analyses on farms using the derogation.

For the year 2006/07 the inspection of farms using the derogation showed that 60 % of the farmers used the derogation for the third consecutive year. Those farmers, 39 holdings, were obliged to provide soil analysis. Two farmers did not provide soil analyses and three had not taken enough samples. They were all fined for not complying with the rules.

The results of the development of compliance with the requirement of soil analysis, when the derogation has been used for three consecutive years, are shown in table 3.2. Percentagewise the level of remarks is about the same in the years 2005/06 (11%) and 2006/07 (13%). It was a bit lower the first year of control in 2004/05 (4%).

Control year	Number of inspections with need for soil analysis	Inspections without remarks	Inspections with remarks
2004/05	74	71	3
2005/06	18	16	2
2006/07	39	34	5

Table 3.3 Development in results of Inspection of Compliance with the soil analysis requirement

The results of the soil analyses for phosphorous and nitrogen is shown in table 3.3.

Year		04/05	05/06	06/07
P	Average	4.55	4.66	4.22
	Minimum	1.21	2.90	2.90
	Maximum	7.56	7.00	5.90
N-total	Average	0.25	0.22	0.29
	Minimum	0.09	0.12	0.11
	Maximum	1.00	0.74	0.85
N in grass fields	Average	0.23	No results	0.19*
	Minimum	0.06	No results	0.19*
	Maximum	0.90	No results	0.19*

*Results from only one farm

Table 3.4 Phosphorous and nitrogen levels in soil analyses.

3.6. Control of fertilizer status accounts

Each year the farmers submit a fertilizer status account to the Danish Plant Directorate. The accounts include key data on:

- total arable land on the farm,
- arable land available for application of livestock manure,
- data on plant cover
- type and number of livestock (LU),
- production of livestock manure (kg N),
- consumption of livestock manure including manure contracts,

- consumption of fertilizers and organic matter other than livestock manure,
- the farm's nitrogen quota[2] and
- information on whether the farmer has used the derogation or not.

For the year 2006/07 about 3,300 of the submitted fertilizer status accounts were subject to administrative inspection. The data was verified and the parties of interest allowed commenting on the case, when necessary. The accounts were selected based on different risk criteria. From the year 2005/06 this inspection includes the harmony rules and cross compliance requirement 1.22. In 2006/07 250 accounts were selected based on harmony risk criteria of which 41 used the derogation.

The inspected farms were asked to send in their crop rotation plan and their statement regarding manure application. The crop rotation plan was inspected to see whether it included 70% of nitrogen consuming crops with long growing season and not included leguminous or other plants fixing atmospheric nitrogen.

Results
All of the 41 farms inspected met the criteria established to use the derogation.

Control year	Number of inspections	Inspections without remarks	Inspections with remarks
2006/07	41	41	0

Table 3.5 Results of administrative inspection of compliance with the harmony rules of farms using the derogation.

[2] The allowed nitrogen quota for the crops is set to a level at least 10 percent lower than the economical optimal level.

4. Water quality

Ruth Grant, Danish Environmental Research Institute, University of Aarhus, 14.12.2009

According to Article 7(2) of Commission Decision 2005/294/EC survey and continuous nutrient analysis shall be carried out in the national monitoring program on sandy and loamy soils providing data on local land use, crop rotations and practices on cattle holdings. These data can be used for model-based calculations of the magnitude of nitrate leaching from fields where up to 230 kg nitrogen in livestock manure is applied based on scientific principles.

According to Article 7(3) a network of sampling of soil water and streams and of shallow groundwater established as agricultural catchment monitoring sites under the national monitoring program shall be maintained to provide data on state of nitrate content in water leaving the root zone and entering the groundwater system, in order to prove that the derogation will not jeopardise the objective of the national action program and the Directive.

According to Article 8 the results of the monitoring shall be transmitted every year to the Commission with a concise report on water quality evolution (based on root zone leaching monitoring, surface/ground water quality and model-based calculations).

4.1 Introduction

Action Plan II

With the aim of fulfilling the obligations pursuant to the Nitrates Directive (91/676/EEC) the National Action Plan II 1999-2003 (Action Plan II for the Aquatic Environment) was adopted in 1998. In 2003 a final evaluation of Action Plan II showed that nitrate leaching from agriculture was reduced from 311 000 to 162 000 tonnes N during the period 1985-2003, corresponding to a reduction of 48 % (table 4.1) and thus fulfilling the reduction target set in 1989.

Table 4.1. Overview of reduction in nitrogen use in agriculture and modelled nitrogen leaching during the period 1985-2003. Statistical data were available for 1985-2002, and monitoring data for 1990-2002 whereas the effect for 2003 was based on a prognosis.

	Reduction in nitrogen
Evaluation of Action Plan II, 1985-2003	
• Modelled nitrate leaching, based on agricultural data, 1985-2002	42%
• Prognosis for further reduction in nitrate leaching 2003	6%
• Prognosis, 1985-2003	48%
Agricultural statistics (national level 1985-2002)	
• Use of inorganic fertilisers	49%
• Total nitrogen surplus in agriculture	37%

Action Plan III and Green Growth Agreement

In 2004 the Action Plan III for the aquatic environment was adopted, the aim being a further reduction in nitrate leaching of 13% compared to the N-leaching in 2003. The target was to be attained by 2015. The measures for nitrogen included further restoration of wetlands and tightened requirement to grow catch crops.

In 2008 a midterm evaluation of Action Plan III was performed. It included a recalculation of the nitrate leaching for 2003 using updated modelling systems. The revised estimate was a nitrate leaching at the national level of 161 000 tonnes N in 2003. Furthermore, the evaluation showed that there was not yet any significant decrease in modelled nitrate leaching during 2003-07, and that it was unlikely that the aim would be fully attained in 2015 (table 4.2).

Table 4.2 Midterm evaluation of Action Plan III in 2008, showing the aim and the prognosis for nitrate leaching in 2015.

	Aim of VMP III 2004-2015		Prognosis 2004-2015	
	Areal assignment (ha)	Reduced N-leaching (tons N)	Areal (ha)	Red. N-udvask. (tons N)
General development in agriculture		11.200		2.000
Afforestation	22.800	900	22.800	0
Restoration of wetlands (required N reduction 200-500 kg N/ha)	4.000	1.050	4.000	980
Environmentally friendly agriculture (wetlands required N reduction 100 kg N/ha)	4.000	400	-	150-250
Strengthened requirement to grow catchcrops	125.000	4.600	70.000	2.000
Strengthened requirement to utilize nitrogen in mink-slurry		100		130
Total		Ca. 18.000		Ca. 5.300
Technical possibility to increase the utilisation of nitrogen in manure and slurry by 4,5-5%		2.900		1.600
Cultivation of previous set-aside				-(300-500)

As a consequence, the Action Plan III was followed by the Green Growth Agreement in June 2009. This plan demonstrates a new concept for nutrient regulation. The previous action plans provided goals for the reduction of nitrogen leaching from the root zone whereas the aim of Green Growth Strategy is to reduce the export of nitrogen to marine waters by 19,000 tonnes N, and to reduce the emission of phosphorus from agriculture by 210 tonnes P. Green Growth Strategy includes the following measures:

- establishment of further 140,000 ha catch crops
- tightened regulation on existing catch crops

- restoration of further 10,000 ha wetlands
- establishment of 10 m buffer zones along rivers and lakes, equivalent to app. 50,000 hectares
- possible change in the nitrogen regulation system in the agriculture
- ban on certain forms of soil cultivation in the autumn
- ban on ploughing grass fields at certain periods of the year

This report

This report presents data from the National Monitoring Programme for the period 1990/91-2007/08, with particular reference to the Agricultural Catchment Monitoring. The modelling of nitrate leaching in this report is done by means of the latest version of the empirical model N-LES (version 4) from 2008, and the water percolation has been calculated using the Daisy model. Modelled nitrate leaching represents the leaching at a standardised climate whereas all measurements represent the actual climate.

4.2. Agricultural practises, fertilisation and modelled nitrate leaching

Information on agricultural practises is supplied from the Agricultural Catchment Monitoring Programme. This programme is carried out in 6 small agricultural catchments situated in various parts of the country in order to cover the variation in soil type and rainfall and hence in agricultural practises. The farmers are interviewed every year about livestock, crops and fertilisation practises. Nitrate leaching is modelled for every field in the catchments based on the information on agricultural practises and percolation values calculated on basis of the average climate for 1990-2005.

In 2008 128 farmers participated in the investigation. 27 farms were cattle holdings, and of these 6 were applying more than 170 kg organic N ha^{-1}.

General development in modelled leaching

The development in modelled nitrogen leaching from the agricultural area in the catchments from 1990 to 2008 (representing the hydrological years 1990/91 to 2008/09) is shown in figure 4.1 as an average for sandy and loamy catchments, respectively. It was found that nitrate leaching had been reduced by 39 % for the loamy soils and by 43 % for the sandy soils. If weighted in accordance with the distribution of the main soil types in Denmark this corresponds to a reduction of 41 %. The reduction was attained mainly during the period 1990/91- 2002/03 due to the general improvement in agriculture and fertilisation practise. Since then modelled nitrate leaching has been almost constant. For 2008/09 nitrate leaching was estimated to be 46 and 88 kg N ha^{-1} for loamy and sandy soils, respectively.

The average leaching was found to be higher for cattle holdings than for other farm types. For 2008/09 the average nitrate leaching was calculated at 46, 72 and 83 kg N ha^{-1} for arable, pigs and cattle farms, respectively. However, the cattle farms are mainly situated in the Western part of Denmark where rainfall is high. This leads to increased dilution of nitrate in the percolating root zone water relative to root zone water in the Eastern part of Denmark; the average flow weighted nitrate concentrations being 72, 76 and 81 mg l^{-1} for the three farm types.

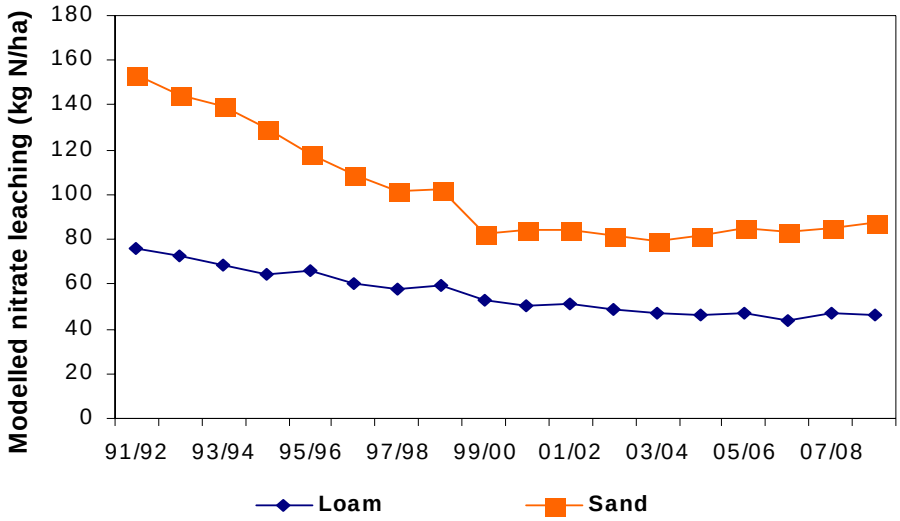


Figure 4.1. Modelled nitrate leaching at a standard climate for the fields of the Agricultural Catchment Monitoring Programme, 1990/91-2008/09

Modelled nitrate leaching for cattle farms

The results of modelled nitrate leaching for 26 cattle holdings are shown in table 4.3 for 2004, representing agriculture after full implementation of Action Plan II, and 2007 and 2008 representing the third and fourth year with Action Plan III (one cattle holding is excluded due a considerable decrease in livestock density in 2008).

In 2008 modelled nitrate leaching amounted to 70, 81, and 89 kg N ha^{-1} for holdings using less than 100 kg organic N ha^{-1} (6 farms), 100-170 kg organic N ha^{-1} (14 farms) and 170-230 kg organic N ha^{-1} (6 farms). The corresponding nitrate concentrations were 73, 79, and 96 mg NO_3 l^{-1}, respectively (Table 4.3). The nitrate concentrations were higher than in 2007, particularly for the group 170-230 kg organic N ha^{-1}. This is caused by an increase in the use of both inorganic and organic nitrogen due to the cease of the set-aside obligation. Thus, for the group 170-230 kg organic N ha^{-1} the area with set-aside decreased from 5.1 % in 2007 to 0.2 % in 2008 (table 4.4). At the national level about 80.000 hectares of set-aside were cultivated in 2008. The crop nitrogen standards will be reduced accordingly, so that the total nitrogen consumption at the national level will not be affected. However, this reduction must be based on the statistical data for the cultivated

area resulting in a delay of two years. This implies a temporary increase in use of fertilisers which will decrease again after two years.

Table 4.3. Modelled nitrate leaching and flow weighted nitrate concentrations in water leaving the root zone at cattle farms, the Agricultural Catchment Monitoring Programme, 2004, 2007 and 2008.

Manure group	Soil type		Percola-tion	Fertiliser N	Organic N	N-fixation	Nitrate leaching	Flow wgt. conc
kg orgnic N ha^{-1}	loam %	sand %	mm	kg N ha^{-1}	kg N ha^{-1}	kg N ha^{-1}	kg N ha^{-1}	mg NO_3 l^{-1}
2004								
0-100	30	70	391	104	61	22	55	62
100-170	13	87	452	44	139	6	78	77
170-230	13	87	466	69	202	26	81	77
2007								
0-100	68	32	362	44	73	37	51	62
100-170	10	90	445	54	137	41	76	76
170-230	17	83	425	18	198	47	73	76
2008								
0-100	12	88	422	71	76	8	70	73
100-170	16	84	457	61	136	30	81	79
170-230	13	87	410	58	226	34	89	96

The average crop rotation for the 3 manure groups of cattle holdings in 2007 and 2008 is shown in table 4.4. As stated above, the area with set-aside decreased considerably in 2008 causing an increase in the use of both inorganic and organic nitrogen for the group 170-230 kg organic N ha^{-1}. At the same time the acreage of winter rape increased from 0 to 9 % of the area. Maize was grown on 28% of the area which was similar to that in 2007, but the maize area with undersown grass was smaller than in 2007. Maize has a high leaching potential; hence this specific crop rotation for the manure group 170-230 kg organic N ha^{-1} will also add to increased nitrate leaching in 2008.

Coarse fodder includes grass, fodder beet and crops (cereal, silage, maize) with undersown grass. In 2008 the 6 farms using 170-230 kg organic N ha^{-1} grew coarse fodder on 65 % of the spreading area whereas the farms using less organic manure had coarse fodder on 51-57 % of their area. 2008 may be regarded a ‘transition’ year where crop rotation has not yet stabilised after the set-aside obligation has ceased.

Table 4.4. Average crop rotations for cattle holdings using 0-100, 100-170 and 170-230 kg organic N ha^{-1}, the Agricultural Catchment Monitoring Programme 2007 and 2008.

Manure group kg organic N	winter wheat	barley	cereal/ undersown grass	silage/ under-sown grass	rape/ peas	Maize/ no grass	Maize/ with grass	fodder -beet	grass	Set-aside	Coarse fodder
	% of area										% of spreading area
0-100	19	22	14	1	14	0	0	2	27	1.9	45
100-170	14	9	12	4	2	17	1	2	33	5.4	55
170-230	7	1	17	2	0	19	11	0	38	5.1	72
0-100	4	26	27	0	4	14	0	0	24	1.7	51
100-170	11	9	17	5	4	18	2	0	33	1.2	57
170-230	5	2	16	5	9	20	8	2	33	0.2	65

4.3. Measurements of nitrate in water leaving the root zone

In five of the six Agricultural Monitoring Catchments water samples are collected regularly at 30 sites. The samples represent the root zone water (1 m depth – 30 samples per year) and the upper groundwater (1.5–5 m depth – 6 samples per year). The measured concentrations are shown as annual average values for loamy and sandy soils, respectively, for the period 1990/91-2007/08 (figure 4.2).

Generally, measured data for nitrate leaching from the root zone cannot be used directly for estimating the effect of a single variable because of the variability between monitoring fields. However, the data are used for development and testing of the nitrate leaching model, N-LES4. This model is then used for calculating the leaching from all the fields in the catchment based on the agricultural practises (figure 4.1) and for scenario analyses. The measurements are also used for statistical trend analysis as shown below.

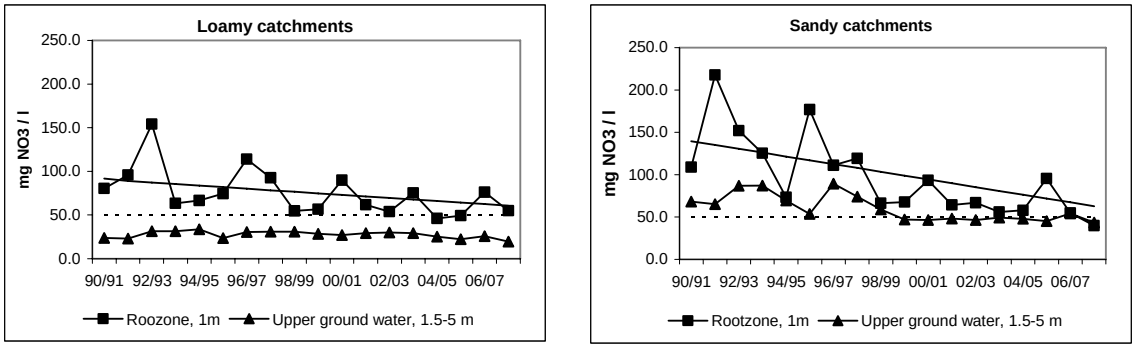


Figure 4.2. Annual flow weighted nitrate concentrations in root zone water and annual average nitrate concentrations in upper groundwater, the Agricultural Catchment Monitoring Programme 1990/91-2007/08.

General trend for nitrate concentrations in water leaving the root zone

There is a high annual variation in measured nitrate concentrations due to variations in rainfall and temperature. Therefore, a long time series and a large number of measuring points are needed to detect any statistically significant trend. Such data series are available from the Danish Monitoring Programme. A statistical trend analysis showed that the nitrate concentrations in water leaving the root zone with 95% probability have decreased with 1.8 and 4.5 mg NO_3 l^{-1} per year for loamy and sandy soils, respectively, during the period 1990/91-2007/08.

The trend analysis showed a decrease in nitrate concentrations of about 33% (17-46%) and 55% (43-66%) for loamy and sandy soils, respectively, during the period 1990/91-2007/08. The trend lines of figure 4.2 show that the nitrate concentrations, when corrected for annual variations in climate (rainfall), have decreased to about 61 and 63 mg NO_3 l^{-1} for loamy and sandy soils, respectively.

In the upper ground water (1.5-5.0 m), nitrate concentrations are lower than in the root zone water, indicating that nitrate reduction and denitrification take place in the uppermost layer of the soils. The variations in groundwater concentrations between the years follow the same pattern as for root zone water but with a time lag of about one year. During the five-year period 2003/04-2007/08 the upper groundwater concentrations were 24 and 48 mg NO_3 l^{-1} for the loamy and sandy sites, respectively.

The general conclusion to be drawn from the Agricultural Catchment Monitoring Programme is that:

- Nitrate concentrations in soil water (1.0 m below soil surface) have decreased steadily from 1990 to 2004, approaching the limit of 50 mg nitrate l^{-1}. Since 2004 this trend has levelled out.
- Nitrate concentrations in the upper groundwater (1.5-5.0 m below soil surface) are reduced to a level below the limit of 50 mg nitrate l^{-1}.

Nitrate concentrations in water leaving the root zone for cattle holdings

Three of the monitoring sites belong to cattle holdings using less than 170 kg organic N ha^{-1} and 4 belong to holdings using more than 170 kg organic N ha^{-1} on the measuring site. Measurements of nitrate in water leaving the root zone are shown in figure 4.3 for each of the sites. There is a high annual variation in measured concentrations, partly caused by the crop rotation and by the variations in climate. In the previous reports a fifth station belonged to the latter group. However, it is moving towards a lower application and therefore excluded in this analysis.

As an average for the last 5 years (2003/04-2007/08) the measured concentrations were 50 and 86 mg NO_3 l^{-1} for farms using less than 170 kg organic N ha^{-1} and more than 170 kg organic N ha^{-1},

respectively. For the group using more than 170 kg organic N ha^{-1}, one field in particular seemed to be responsible for the increased concentration.

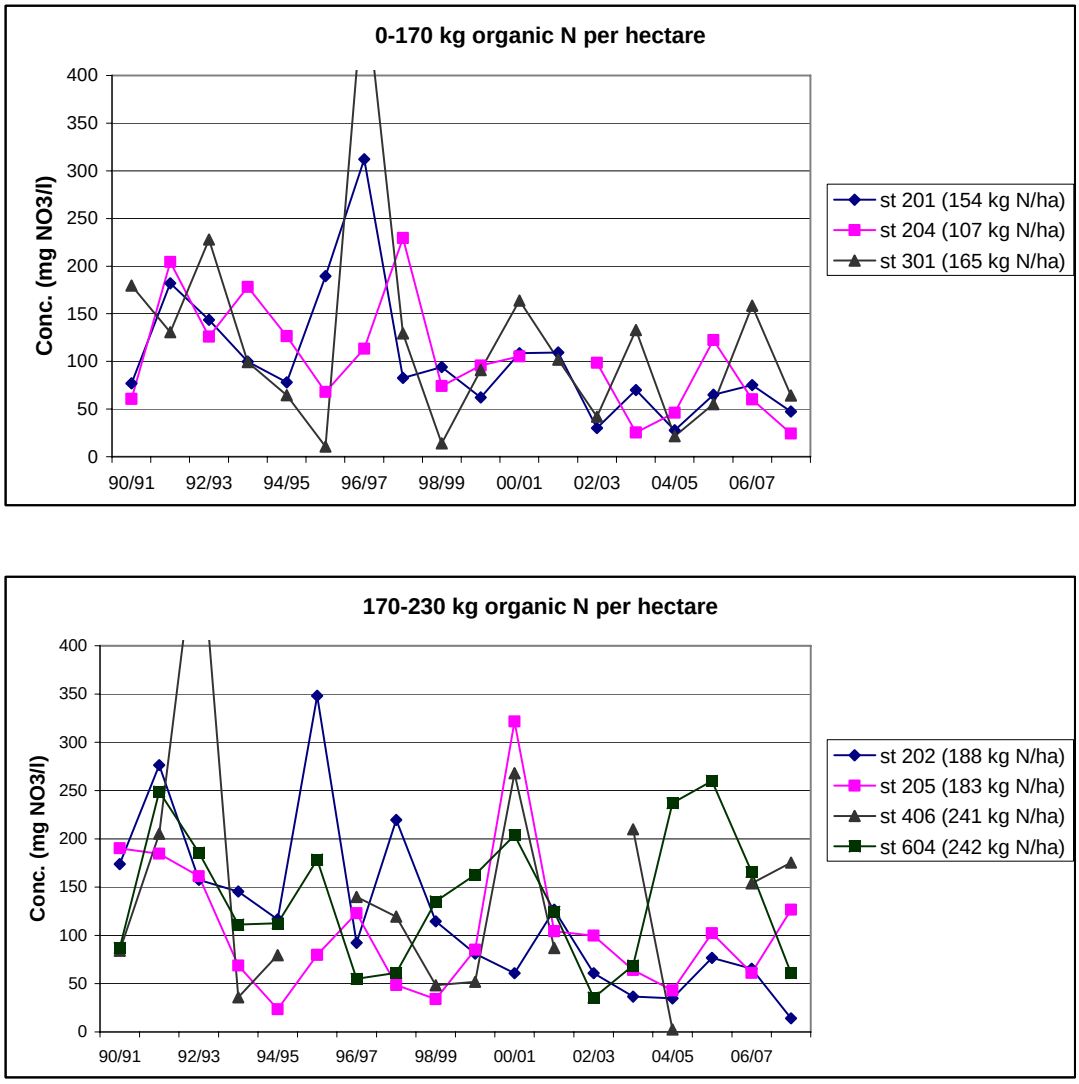


Figure 4.3. Measured nitrate concentrations at soil water stations (1 m) with average application of 0-170 and 170-230 kg organic N per hectare.

4.4. The nitrogen flow to surface water in agricultural catchments

When percolating water leaves the root zone it will divide into a component which discharges to the surface water, and a component which discharges to the ground water from where it will eventually - often many years later - drain into the streams. The pathways for water and nutrients in agricultural catchments are analysed in the Agricultural Catchment Monitoring Programme. Nitrate concentrations are measured in soil water, drainage water (on loamy soils), upper groundwater and stream water. The monitoring programme includes three loamy catchments and two sandy catchments.

It is not possible from the monitoring programme to evaluate the effect of derogation farms specifically, on the nitrate transport in the stream, as this measure is a combined effect of all activities in the catchment. However, the monitoring programme will provide an overview of the general trend for surface water, including the effect of any derogation farms in the catchment.

4.5. Nitrogen pathway in the hydrological cycle and trends for nitrate in water.
This chapter gives an overview of the nitrogen pathway in the hydrological cycle and describes the trends for nitrate in water for the period 1990-2008. Continued monitoring of the Agricultural Catchment Programme and the Stream Programme will provide indicators for the future development.

The hydrological pathway
An analysis of the water flow in the streams of the 5 agricultural catchments has shown that the flow-path can be divided into three arbitrary components with a rapid, intermediate and slow response to precipitation, respectively (table 4.5). These components may be regarded as flow from the upper soil layers (including drainage), from the upper groundwater and from deep groundwater.

In loamy catchments the flow-path is characterised by rapid responding water (from upper soil layers) whereas in sandy catchments there is a larger proportion of slowly responding water (from deeper groundwater).

Table 4.5. Partitioning of water discharge in streams into three flow components – rapid, intermediate and slow responding water. The analysis is for three loamy catchments and two sandy catchments (1989/90-2002/03).

	Flow response		
	Rapid	Intermediate	Slow
Loamy catchments	41 %	16 %	43 %
Sandy catchments	20 %	23 %	57 %

This flow pattern is outlined in figure 4.4. Measurements of nitrate concentrations in soil water (1 m), upper groundwater (1.5-5 m) and the streams are also shown. When water percolates from the root zone to the upper groundwater denitrification processes take place, thus nitrate concentrations in the upper groundwater are lower than in the root zone water. When the water passes through the deeper geological layers it will usually reach the redox cline where the remaining nitrate will be removed by biological and geo-chemical reduction processes.

As sandy catchments are characterised by groundwater flow, the water discharging to the streams has been exposed to reduction processes. Thus nitrate concentrations in the stream water are low. In

loamy catchments, the discharging water has mainly passed through the upper soil layers and through drainage systems where less nitrate reduction takes place. Hence nitrate concentrations in the streams are higher than in sandy catchments.

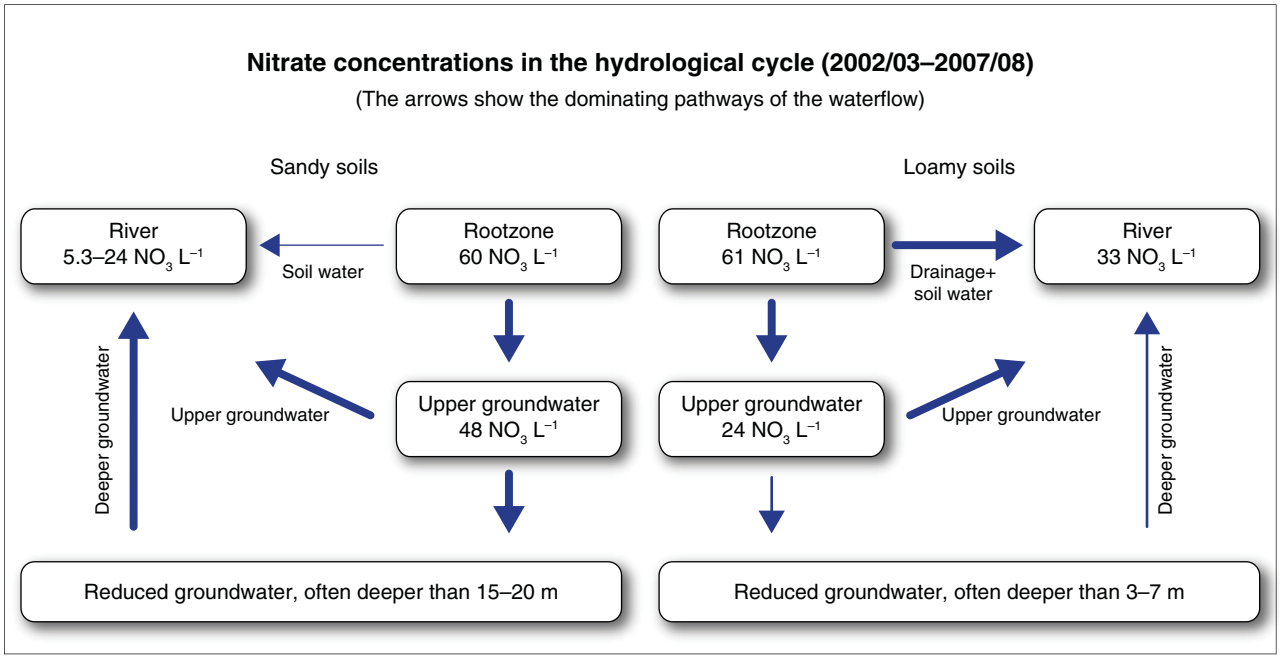


Figure 4.4. Nitrate concentration in the hydrological pathway in 3 loamy catchment and 2 sandy catchments, the Agricultural Catchment Monitoring Programme.

Trends in nitrate concentrations in the hydrological cycle

The development in concentration level for root zone water, upper groundwater and stream water is shown in figure 4.5.

Statistical analyses allowing for annual variations in climate showed that nitrate concentration in rootzone water had decreased by 33 % and 55% for the three loamy and two sandy catchments, respectively, during the period 1990/91 to 2007/08 (see section 4.3). In the Stream Monitoring Programme the development is analysed for a larger number of streams. This programme showed during the same period an average reduction of 39 % in nitrate concentration for 63 agricultural catchments representing both loamy and sandy soils. The Agricultural Catchment Monitoring Programme enables detailed studies of the hydrological pathways whereas the Stream Monitoring Programmes provide nationwide estimates for the trends in surface water.

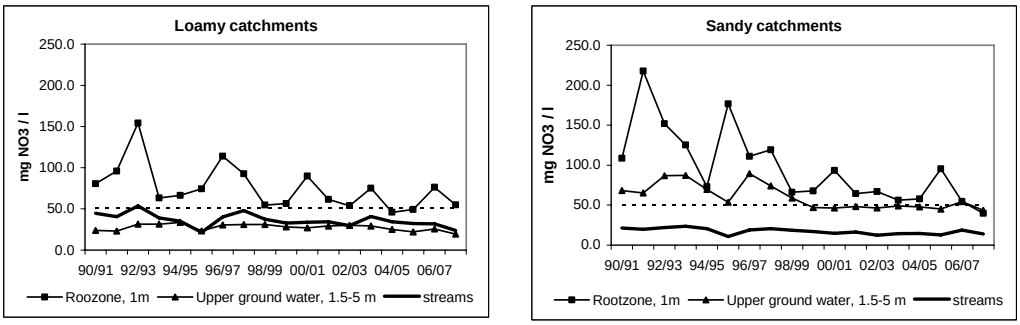


Figure 4.5. Trends in nitrate concentration in rootzone water, upper ground water and in streams for three loamy catchments and two sandy catchments, the Agricultural catchment Monitoring programme, 1990/91-2007/08

4.6. Conclusions

By adoption and implementation of the measures of the National Action Plan II for the aquatic environment 1999-2003. Denmark has fulfilled the obligations pursuant to the Nitrates Directive (91/676/EEC). In 2003 a final evaluation of Action Plan II was performed showing a reduction of 48 per cent of the nitrate leaching from the agricultural sector, fulfilling the reduction target set in 1985. In 2004 a new Action Plan III for the aquatic environment was adopted, the aim being a further reduction in nitrate leaching of 13% compared to the N-leaching in 2003. This target was to be attained by 2015. A midterm evaluation of Action Plan III in 2008 showed that there was not yet any significant decrease in nitrate leaching during 2003-07, and that it was unlikely that the aim would be fully attained in 2015. As a consequence, in June 2009 the Green Growth Agreement followed the Action Plan III. The aim of this plan is to reduce agricultural emissions of nitrogen to marine waters by 19,000 tonnes N, and to reduce the emission of phosphorus from agriculture to rivers and lakes by 210 tonnes P.

Modelling of the nitrate leaching from the root zone for cattle holdings using 170-230 kg organic N in the monitoring catchments showed an average concentration of 76 mg NO_3 l^{-1} in 2007 and 96 mg NO_3 l^{-1}. The reason for the increased concentration in 2008 is likely to be a temporary effect of the cease of the set-aside obligation. Measured average flow weighted nitrate concentrations in root zone water at cattle holdings (170-230 kg organic N per hectare) were 86 mg NO_3 l^{-1} for the five-year period 2003/04-2007/08.

In the upper ground water (1.5-5.0 m), nitrate concentrations are lower than in the root zone water, indicating that nitrate reduction and denitrification take place in the uppermost layer of the soils. The variations in groundwater concentrations between the years follow the same pattern as for root zone water but with a time lag of about one year. During the five-year period 2003/04-2007/08 the

upper groundwater concentrations were 24 and 48 mg NO_3 l^{-1} for the loamy and sandy sites, respectively.

The general conclusion to be drawn from the Agricultural Catchment Monitoring Programme is that:

- Nitrate concentrations in soil water (1.0 m below soil surface) have decreased steadily from 1990 to 2004, approaching the limit of 50 mg nitrate l^{-1}. Since 2004 this trend has levelled out.
- Nitrate concentrations in the upper groundwater (1.5-5.0 m below soil surface) is reduced to a level below the limit of 50 mg nitrate l^{-1}.

5. Conclusions

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In 2004 a new **Action Plan III** for the aquatic environment was adopted, the aim being a further reduction in nitrate leaching of 13% compared to the N-leaching in 2003. The target must be attained by 2015. An evaluation was carried out in 2008 and showed that there was not yet any significant decrease in modelled nitrate leaching during 2003-2007. In June 2009 the government launched The **Green Growth strategy**, which also deals with the problems formerly encountered in achieving expected goals in APAEIII. As the Green Growth strategy is much broader that the APAEs a Danish Nitrate Actions Programme will be composed specifying the elements that implement the Nitrate Directive.

Modelling of the nitrate leaching from the root zone of the monitoring catchments showed an average concentration of 89 mg NO_3 l^{-1} for holdings using 170-230 kg organic N in 2008. **Measured** average flow weighted nitrate concentrations in root zone water at cattle holdings (170-230 kg organic N per hectare) were 96 mg NO_3 l^{-1} for the five-year period 2002/03-2007/08.

In the upper ground water (1.5-5.0 m), nitrate concentrations are lower than in the root zone water, indicating that nitrate reduction and denitrification take place in the uppermost layer of the soils. The variations in groundwater concentrations between the years follow the same pattern as for root zone water but with a time lag of about one year. During the five-year period 2003/04-2007/08 the upper groundwater concentrations were 24 and 48 mg NO_3 l^{-1} for the loamy and sandy sites, respectively.

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In 2007/2008 a total of 1296 cattle holdings made use of the derogation corresponding to **2.8** percent of the total number of agricultural holdings in Denmark. The number of livestock units on these cattle holdings was 186,313 LU corresponding to **8.3** percent of the total number of livestock units. The arable land encompassed by the derogation in year 2007/2008 was 92,282 hectare corresponding to around **3.9** per cent of the total arable area. All numbers have decreased from previous year and number of farms using the derogation is under the level of 2002/03.

In January 2009 **51 inspections** of compliance with the derogation management conditions were carried out and 49 inspections were closed without remarks. Out of the 626 general harmony inspections of the amount of livestock manure applied per hectare per year concerning the year 2006/2007, **65 of inspected farms** use the derogation. 90% of these inspections were closed without remarks, none received a warning for minor violations but 8% of the farmers were fined for a more severe violation. Out of 250 accounts selected for administrative control based on harmony risk criteria, **41 used the derogation**; all of them were closed without remarks. About 12 % of the total derogations farms were controlled in 2009.

Annex 1. Implementation of Commission Decision (2005/294/EC and 2008/664/EC) into Danish legislation

Commission Decision 2005/294/EC and 2008/664/EC	**Implementation in national legislation** Ministry of Environment Ministry of Food, Agriculture and Fisheries	**Control and inspection** Danish Plant Directorate
Article 2 (a) 'Cattle farms' means holdings with more than three livestock units, where at least two-thirds of livestock are cattle.	*Article 27 (3)* of Statutory Order 2006/1695 [i]	*On the spot inspection:* The size and composition of the farms livestock.
Article 4 (1) Cattle farmers shall submit an application for derogation to the competent authorities annually.	*Annex 2 (8)* of Statutory Order 2006/1695	*Administrative inspection:* Information from signed fertiliser status accounts
Article 5 The amount of livestock manure applied to the land each year on cattle holdings, including by the animal themselves, shall not exceed the amount of manure containing 230 kg nitrogen.	*Article 27 (3)* of Statutory Order 2006/1695	*On the spot inspection:* On the basis of information on the size of livestock and on the crop rotation plan the amount of livestock manure applied per hectare is inspected.
Article 5 (a) The total nitrogen input will comply with the nutrient demand of the considered crop and the supply from the soil; the fertilisation rate being fixed 10 % under optimal economic level.	*Article 5 and 6* of Act 2006/757[ii] *Article 7* of Statutory Order 2006/975[iii]	*Administrative inspection:* On the basis of the submitted fertiliser status account the farm's nitrogen quota and the total use of nitrogen is inspected.
Article 5 (b) A fertiliser plan and account will be kept for each farm.	*Article 21 and 22* of Act 2006/757	*On the spot inspection:* The crop rotation and fertiliser plan is inspected. *Administrative inspection:* It is checked whether the

		fertiliser status account is submitted to the Plant Directorate.
Article 5 (c) Each farm must annually submit an application together with the fertilisation account to the competent national authority and accept that they can be subject to random control.	*Annex 2 (8)* of Statutory Order 2006/1695	*On the spot inspection:* The farmer's written commitment to comply with the derogation is inspected.
Article 5 (d) Periodic autumn and spring nitrogen and phosphorous analyses in soil will be done by each farmer who is granted derogation (at least every three years per 5 ha of land) for accurate fertilisation.	*Annex 2 (7)* of Statutory Order 2006/1695	Inspections have not yet been carried out. The first data on N- and P-analyses in soil are reported to the Danish Plant Directorate in spring 2006.
Article 5 (e) No manure will be spread on the autumn before grass cultivation, and the ploughing will be followed be a high nitrogen demanding crop.	*Annex 2 (3) and (4)* of Statutory Order 2006/1695	*On the spot inspection:* Fields for possible ploughing are inspected. The crop rotation and fertiliser plan is inspected concerning the planning of ploughing of fields with grass. The farmers written commitment about manure application is inspected.
Article 6 (1) 70 % or more of the acreage available for manure application on the cattle holding in question shall be cultivated with grass, grass catch crops or beet and other crops being undersown by grass with low nitrate leaching potential.	*Annex 2 (1) and (2)* of Statutory Order 2006/1695	*On the spot inspection:* On the basis of the crop rotation and fertiliser plan the share of grass, grass catch crops and beet are inspected.
Article 6 (2) Grass catch crops shall not be ploughed before 1 March in order to ensure permanent	*Annex 2 (5)* of Statutory Order 2006/1695	*On the spot inspection:* Fields for possible ploughing are inspected.

vegetal cover of arable area for recovering subsoil autumn losses of nitrates and limit winter losses.		The crop rotation and fertiliser plan is inspected concerning the planning of ploughing of fields with grass catch crops.
Article 6 (3) Temporary grasslands shall be ploughed in spring	*Annex 2 (4)* of Statutory Order 2006/1695	*On the spot inspection:* Fields for possible ploughing are inspected. The crop rotation and fertiliser plan is inspected concerning the planning of ploughing of fields with grass.
Article 6 (4) Crop rotation shall not include leguminous or other plants fixing atmospheric nitrogen. This will however not apply to clover in grassland with less than 50% clover and to barley/pea undersown with grass.	*Annex 2(6)* of Statutory Order 2006/1695	The crop rotation and fertiliser plan is inspected concerning the planning of cropping leguminous or other plants fixing atmospheric nitrogen.

[i] Statutory Order from the Ministry of Environment no. 1695 of 19 December 2006 on Livestock and Animal husbandry of more than 3 livestock units, Livestock Manure, Silage etc. (Changes in: no.1209, 2007 and no.766, 2008)

[ii] Consolidated Act from the Ministry of Food, Agriculture and Fisheries no. 757 of 29 June 2006 on Farms' use of Manure and on Plant cover. Changes in no.1272 of 16/12/2009 and no. 1528 of 27/12/2009.

[iii] Statutory Order from the Ministry of Food, Agriculture and Fisheries no. 975 of 25 September 2006 on Farms' use of Manure and on Plant cover. Changes in: no.17, 2007, no 188 of 14/03/2008 and no 1183 of 09/12/2008.