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Agricultural practice and water quality in the Netherlands in the 1992-2002 period

Background information for the third EU Nitrates Directive Member States report

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PREFACE

This report has been realised in close co-operation with different institutes and organisations committed to making the necessary data available and performing the data analysis order for creating the tables, figures and maps included. Major contributions were made by:

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ABSTRACT

This overview provides the background information for the Netherlands Member State report 'Nitrate Directive, status and trends of aquatic environment and agricultural practice' to be submitted to the European Commission in mid-2004. It documents current agricultural practice, and groundwater and surface-water quality, in the Netherlands, outlines the trends in these waters (especially the 1992-2002 period) and assesses the time scale for change in water quality as a consequence of changes in farm practice. The report deals with the evaluation of the implementation and impact of the measures in the Action Programmes, and forecasts the future evolution of water body quality. The Netherlands has, since 1987, turned the increase of nitrogen and phosphorus surpluses in Dutch agriculture into a decrease. After the implementation of a mineral accounting system (MINAS) in 1998, the nitrogen surplus, which had been stable for about seven years, decreased again. In the reporting period (1992-2002) water quality, both with respect to nitrate concentration and eutrophication, improved due to measures taken since 1987. Nitrate concentrations in deep groundwater (> 30 m depth) still increase as a consequence of increasing nitrogen loads in the period before 1987. Water quality is expected to continue to improve in the next reporting period (2003-2006) as a result of measures taken during the second Action Programme (1999-2003). With respect to nitrate concentration in deep groundwater, reversal of the increasing trend has been estimated to take several decades.

SUMMARY, SYNTHESIS AND CONCLUSIONS

Introduction

This report contains background information for the third EU Nitrates Directive Member States report to be submitted to the European Commission in mid-2004. It presents the status and trends in agricultural practice and water quality in the Netherlands for the 1992-2002 period. The data presented in this background document refer to the period preceding the first Action Programme (before December 1995), and the period of the first (1995-1999) and part of the second Action Programme (1999-2003). In general, water quality is slow to react to changes in agricultural practice. Therefore changes in water quality in the 1992-2002 period have also been a result of policy measures and changes in agricultural practice before 1992. In addition, expected improvements in water quality as a consequence of the second Dutch Action Programme are only partly noticeable in this period.

Agricultural policy measures and practice

Agricultural policy

The Netherlands has not designated Nitrate Vulnerable Zones, but informed the European Commission in 1994 that they would apply an Action Programme to their whole national territory. Since 1987, use of manure in Dutch agriculture has been regulated by manure application standards based on phosphate (P_2O_5). The application standards were lowered from 125 kg phosphate (P_2O_5) for arable land, and 250 kg/ha for grassland and silage maize in 1991-1992 to 85 kg/ha for all crops in 2000.

In 1998 a mineral accounting system (MINAS) was introduced to regulate the use of both fertiliser and manure nitrogen through loss standards for farms with more than 2.5 livestock units per ha. Loss standards in the 1998-2002 period are a compromise between the desired environmental quality and what is attainable for agriculture. In 2001 MINAS became compulsory for all Dutch farmers. In the 1998-2002 period, loss standards were tightened and stricter standards were introduced for soils prone to nitrate leaching (about 7% of the agricultural area), see Table S1. Loss standards for nitrogen were 14-43% lower in 2002 compared to 1998. Since 2002, livestock farms that produce more manure nitrogen than 170 kg/ha for arable land and 250 kg/ha for grassland are obliged to enter into manure transfer contracts with other farmers or to reduce their livestock numbers. Livestock farmers may enter into manure transfer contracts with arable farmers, other (less intensive) livestock farmers or manure processors.

Table S1: Nitrogen loss standard in the 1998-2002 period in kg/ha as N for arable land and grassland on clay, peat, sand and loess soils[*1].

	Grassland	Arable land	
Year	All	Clay/Peat	Sand/Loess
1998-1999	300	175	175
2000	275	150	150
2001	250	150	125
2002	220/190[*2]	150	110/100[*2]

1) Since 2002 loss standards have been tightened for those sand and loess soils that are prone to nitrate leaching; these are soils with groundwater levels at a greater depth than average.
2) The second figure here represents the loss standard for soils prone to nitrate leaching (see note 1), while the first figure represents the loss standard for other soils.

Manure and artificial fertiliser application methods and timing were subjected to more stringent regulation between 1993 and 1999. Since 1995, it has been compulsory to always incorporate manure directly (for grassland) or within a few hours (for arable land) so to minimise ammonia volatilisation, except for the application of solid manure to grassland. Manure storage facilities should be covered to minimise ammonia volatilisation.
The low-emission techniques also prevent direct emissions to ditch water. In addition, special artificial fertiliser-spreading equipment has been used on a large scale since 1997, and since 2000, zones adjacent to waterways have been designated where fertilisation is prohibited.

To minimise nitrogen leaching, application between the beginning of September and 1 February has been prohibited since 1996. Application of manure has been prohibited to snow-covered ground since 1994. In 1998 this was extended to frozen or partly frozen ground. The application of manure and artificial fertiliser to water-saturated, flooded, frozen or snow-covered ground has been prohibited since 1999.

The Dutch government has developed initiatives for revision of nutrient application recommendations. It has also provided much information on the use of nutrients as well as demonstration projects with respect to improved nutrient management. In the 1999-2003 period, 120 million Euro was spent on the development and transfer of knowledge to farmers.

Characteristics of agriculture in the 2000-2002 period
In 2000-2002 the cultivated area in the Netherlands was 1.92 million ha, amounting to 57% of the total land surface. Of the cultivated area, 52% comprised grassland (90% permanent), 11% silage maize and 31% other arable crops. The remaining area (6%) is used for horticulture. There were about 93,000 farms, of which 49% consisted of grazing animals, 13% arable farms, 20% horticultural, and 18% pig and poultry, and mixed farms.

Livestock included 4 million head of cattle, 13 million pigs, 102 million heads of poultry and 1.5 million sheep and goats. The livestock produced manure containing about 509 million kg of nitrogen (N) and 79 million kg of phosphorus (P). Cattle manure was responsible for 62% of the nitrogen and 53% of the phosphorus production. Nitrogen (N) input to soil was on average 403 kg/ha, of which 195 kg/ha was via manure, 155 kg/ha via artificial fertiliser and 53 kg/ha via atmospheric deposition and other sources. The nitrogen surplus in the soil surface balance was on average about 190 kg/ha. Phosphorus (P) input to soil was on average 53 kg/ha, of which 37 kg/ha was via manure, 13 kg/ha via artificial fertiliser, and 3 kg/ha via atmospheric deposition and other sources. The phosphorus surplus in the soil surface balance was on average about 23 kg/ha.

Trends in agricultural practice in the 1992-2002 period
The area of land used for agriculture in the 1992-2002 period decreased by 2% and the number of farms by 20%. The number of cattle and pigs decreased by 17% and 14%, respectively, but poultry increased by 6%.

Manure nitrogen and phosphorus production by livestock decreased by 24% and 19%, respectively, due to a combination of the decrease in number of livestock and excretion per head as a consequence of lower nitrogen and phosphorous contents in fodder and an improved fodder conversion. In this period, the use of artificial fertiliser nitrogen and phosphorus also decreased by 21% and 23%, respectively. As a result, the nitrogen and phosphorus surplus in Dutch agriculture decreased, respectively, by 27% and 37%.

The transport of manure between regions decreased from 155 million kg nitrogen in 1994 to 100 million kg in the 2000-2002 period. The ammonia emission from agricultural sources into the atmosphere decreased by about 45% between 1990 and 2002.

Nitrogen and phosphorus load to surface waters

In the 2000-2002 period, the domestic contribution to the total nitrogen load of fresh surface waters in the Netherlands was 23% and to the total phosphorus load, 27%. The foreign contribution was 67% and 63% for N and P, respectively. Agriculture is the main contributor to the domestic loads for nitrogen and phosphorus (both about 60%).

The nitrogen load to fresh surface waters decreased by about one-quarter in the 1992-2002 period, while the phosphorus load decreased by one-third in this period. The nitrogen load from agriculture decreased by about 15%, while the phosphorus load did not.

Quality of groundwater and surface waters

Nitrate concentrations in the 2000-2002 period
Average nitrate concentrations in groundwater and surface waters for the 2000-2002 period are shown in Table S2. In the Netherlands, groundwater occurs on average at depths of 1 to

1.5 m. For this reason it has been decided to monitor the effect of the Action Programme in the upper metre of groundwater or tile drain water.

Table S2: Average measured nitrate concentration (in mg/l) in groundwater and surface waters for the 2000-2002 period[*1]*.*

Water type	Sand	Clay	Peat	All
Groundwater				
at a depth of < 5 m (agriculture)	75 (66%)	40 (30%)	< 5 (0%)	-
at a depth of 5-15 m (agriculture)	40 (21%)	< 5 (0%)	< 5 (0%)	-
at a depth of 15-30 m (agriculture)	10 (6%)	< 5 (0%)	< 5 (0%)	-
at a depth of > 30 m (phreatic groundwater abstraction wells)	7 (2%)	-	-	-
Fresh surface waters[*2]				
Agriculturally-influenced				15 (3%)
Other regional water				14 (1%)
National waters				12 (0%)
Marine waters[*2]				
Coastal waters				5 (0%)
Open sea				< 1 (0%)

1) Percentages showing exceedance of the EU target value of 50 mg/l in the 2000-2002 period are given in parentheses. For groundwater at about < 5 m percentage of farms showing exceedance is given. For groundwater at depth > 5 m it refers to percentage of wells and for surface waters to percentage of monitoring locations.

2) Winter-average nitrate concentrations, the period in which leaching plays a significant role insurface water quality.

Nitrate concentrations in groundwater and surface waters decrease with the increasing distance to the agricultural nitrogen source, both in depth and spatially. Nitrate concentrations in groundwater decrease with depth as is shown in Table S2. Nitrate concentrations in surface waters decrease spatially in the following order of importance: agriculturally-influenced regional waters > other regional waters > national fresh surface waters > coastal water > open sea.

Two factors contribute to this decrease in concentrations. The first is the conversion of nitrate into elementary nitrogen (denitrification) during transport, and the second is the mixing that occurs with water from non-agricultural areas (dilution). For groundwater, two other factors also play a role, namely time and hydrological conditions. Groundwater at a depth of less than 5 m is young water (1-5 years). In the sandy areas, groundwater at a depth of 5-15 m has a travel time of about 10 years, and groundwater at 15-30 m a travel time of about 40 years. On average, groundwater at a depth of 15-30 m therefore reflects the agriculture of 40 years ago. In clay and peat regions groundwater at depths of 5-15 and 15-30 m is usually even older. In this case hydrological factors (groundwater pathways) are important, as groundwater in clay and peat regions at a depth of 5-15 m, as well as 15-30 m, is usually confined or semi-confined. In these regions the precipitation surplus drains superficially to surface waters. Confined and semi-confined aquifers also occur locally in sand regions.

Nitrate concentrations in groundwater in peat regions are lower than in clay regions; and, in turn, are lower than in sandy regions. This is caused by an increase in denitrification in ascending order, from sand to clay to peat.

Eutrophication of surface waters in the 2000-2002 period
The chlorophyll-*a* concentration is an effect indicator for eutrophication. Total nitrogen and total phosphorus concentrations are state indicators for eutrophication. Summer average concentrations for the 2000-2002 period are shown in Table S3. Just like nitrate, concentrations of the eutrophication indicators decrease spatially in the following order of importance: agriculturally-influenced regional waters > other regional waters > national fresh surface waters > coastal water > open sea. Chlorophyll-*a* concentrations are higher than 75 µg/l in 18% of the agriculturally-influenced regional water stations and 11% of the other regional water stations.

*Table S3: Eutrophication parameters (chlorophyll-a in µg/l and total nitrogen and phosphorus in mg/l, summer average values[*1)]) for several types of surface waters in the 2000-2002 period.*

Water type	Chlorophyll-*a*	Total nitrogen	Total phosphorus
Agriculturally-influenced regional waters	51 (18%)[a]	4.1	0.46
Other regional waters	38 (11%)[a]	3.8	0.28
Main fresh waters	20 (0%)[a]	3.6	0.18
Coastal waters	11 (0%)[a]	0.5[b]	0.09
Open sea	2 (0%)[a]	< 0.1[b]	0.02

1) Summer-average values are reported, since summer is the most critical period with respect to eutrofication
a Percentage of locations with concentration > 75 µg/l in parentheses.
b Total dissolved inorganic nitrogen.

Trends in nitrate concentrations in the 1992-2002 period
Nitrate concentrations in on-farm water decreased in the 1992-2002 period, along with the number of farms exceeding the EU target value of 50 mg/l; even when accounting for confounding factors, such as variation in net precipitation (see Figures S1 and S2). Nitrate concentrations decreased, especially in the sand regions where the average concentration decreased from 135 mg/l (both measured and standardised) to about 75 mg/l (measured) and about 95 mg/l (standardised).

Nitrate concentrations in groundwater at depths of 5-30 m did not show a clear trend, with the exception of groundwater at a depth of 5-15 m in agricultural areas of the sand regions. Both nitrate concentration and target value exceedances were lower in the 1998-2002 period than in the 1992-1997 period. Nitrate concentrations in phreatic groundwater at drinking-water production sites (at a depth > 30 m in sand regions) showed a slightly increasing trend in the 1992-2002 period. Trends in nitrate concentration in groundwater in clay and peat regions are not expected, because the concentrations are low and the aquifers usually confined, with little or no impact of agricultural practice.

Winter-average and maximum nitrate concentrations in fresh surface waters decreased after 1998. In marine and coastal water there was no trend in winter-average nitrate concentration. The winter-average dissolved inorganic nitrogen concentrations, corrected for riverine discharge (precipitation) showed a decrease begin nineties, than stabilised and since the end of the nineties the concentration seems to decrease again.

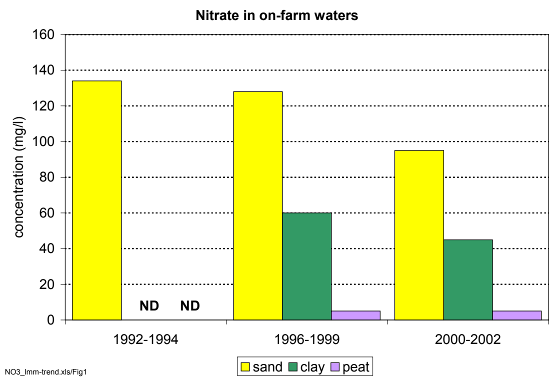


Figure S1: Nitrate concentration in upper metre of groundwater (sand, peat) and tile drain water (clay) on farms in the Netherlands for the 1992-1994, 1996-1999 and 2000-2002 period.

Nitrate concentrations have been corrected for confounding factors.
ND = no data

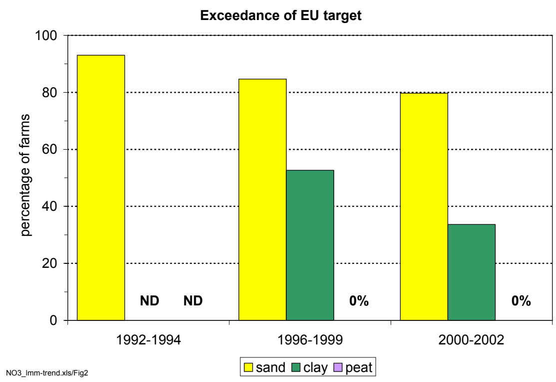


Figure S2: Exceedance of the EU target value of 50 mg/l in on-farm waters (see text Figure S1) in the Netherlands for the 1992-1994, 1996-1999 and 2000-2002 period.

Nitrate concentrations have been corrected for confounding factors.
ND = no data

Trends in eutrophication in the 1992-2002 period
Since 1998, the chlorophyll-*a* concentration in fresh waters in the summer decreased continuously in agriculturally-influenced regional waters. In other regional and national waters, the decrease in chlorophyll concentration had already started at the end of the 1980s and the beginning of the 1990s. Similar trends are shown for total nitrogen and total phosphorus concentrations in fresh waters in summer. In other regional, and in national,

waters the total phosphorus concentration in the summer was more than halved during the 1985-2002 period.

All Dutch marine waters are characterised as eutrophication problem areas (OSPAR Convention). The average summer chlorophyll concentrations did not show any clear trend in marine and coastal waters in the 1992-2002 period.

Effect of the Action Programmes and estimation of future evolution of water quality

In general, several years pass before policy measures are fully implemented by farmers. Measures taken by farms are not immediately revealed in a change in water quality due to factors such as processes in the soil and water environments, and confounding factors such as year-to-year variation in the precipitation surplus.

On-farm water quality – upper metre of goundwater, tile drain water, etceteras - will show the clearest and quickest response to the Action Programme measures. The effect of measures from the third Action Programme (2004-2007) is estimated to be shown in the on-farm water quality between 2008 and 2013.

Groundwater quality of phreatic aquifers at a depth of more than 5 m will only show the effects of the measures after one or more decades. Moreover, these effects will be hard to detect due to the mixing of groundwater of different ages and origins as well as soil physico-chemical processes. The effect of measures of the third Action Programme on surface water quality will also be evident between 2008 and 2013. Yet these effects will be masked, particularly in the case of national waters and coastal and marine waters, due to mixing effects (influence of foreing contribution via main rivers) and chemical processes in groundwater and surface water bodies.

Estimating future evolution in relation to agricultural practice is for eutrophication even more difficult than for nitrate concentrations. Main reasons are:

(i) the differences in surface waters with regard to their sensitivity to eutrophication.
(ii) phosphorus levels and other factors such as hydromorphology, which play an important part in the eutrophication process as well.
(iii) the contribution by other sources of nutrient input, notably urban waste water and transboundary rivers.
(iv) the very poor predictability of the lag of response of aquatic ecosystems to a substantial reduction of nutrient inputs and nutrient concentrations.

In addition to source-oriented measures, regional effect-oriented measures such as fish stock management have been taken in several cases where prospects were good. Expectations are that it will be pursued further. In some cases the ecological restoration process was accelerated substantially as a result of these measures (for example, for the Veluwe border lakes). However, as Figure 32 (page 127) and Figure 39 (page 144) show, the ecological restoration proces in Dutch surface waters is seen to take place at a relatively slow pace, and a general, clearly observable acceleration of this restoration proces is not expected in the short term.

CONCLUSIONS

Since 1987, the Netherlands turned the increase in nitrogen and phosphorus surpluses in Dutch agriculture into a decrease. After the implementation of MINAS in 1998, the nitrogen surplus, which had been stable for about seven years, decreased again.

In the reporting period (1992-2002) water quality, both with respect to nitrate concentration and eutrophication, improved due to measures taken since 1987. That nitrate concentrations in on-farm water were significantly lower in the 2000-2002 period than in the previous periods is connected with the lowering of nitrogen use since 1998. Nitrate concentrations in deep groundwater (> 30 m depth) are still increasing as a consequence of the increasing nitrogen loads in the period before 1987.

Water quality is expected to continue to improve in the next reporting period (2003-2006) as a result of measures taken during the second Action Programme (1999-2003). With respect to nitrate concentration in deep groundwater, a reversal of the increasing trend is estimated to take several decades. With respect to eutrophication, clearly observable acceleration of the restoration proces is not expected.

The nitrate concentration in groundwater and the frequency, with which the EU target value of 50 mg/l is exceeded, not only depends on human activities but also on weather conditions, soil type and sampling depths. The last factor is the result of local hydrological and geochemical conditions in the sediments.

SAMENVATTING, SYNTHESE EN CONCLUSIES

Inleiding

Dit rapport bevat achtergrondinformatie voor de derde landenrapportage die de Nederlandse overheid medio 2004 aan de Europese Commissie dient toe te sturen in het kader van de EU-Nitraatrichtlijn verplichtingen. Het geeft een overzicht van de toestand en verandering in de landbouwpraktijk en waterkwaliteit in Nederland in de periode 1992-2002. De in het voorliggende rapport gepresenteerde gegevens hebben betrekking op de periode voorafgaande aan het eerste Actieprogramma (vóór december 1995), de periode van het eerste Actieprogramma (1995-1999) en een deel van de periode van het tweede Actieprogramma (1999-2003). In het algemeen reageert de waterkwaliteit slechts langzaam op veranderingen in de landbouwpraktijk. Daarom zijn de veranderingen in de waterkwaliteit in de periode 1992-2002 ook het gevolg van beleidsmaatregelen en veranderingen in de landbouw van voor 1992, en zijn verwachte verbeteringen in de waterkwaliteit als gevolg van het tweede Actieprogramma slechts deels zichtbaar in deze periode.

Landbouwbeleid en landbouwpraktijk

Landbouwbeleid

Nederland past de Actieprogramma's, opgesteld ten behoeve van de implementatie van de Nitraatrichtlijn, toe op het gehele grondgebied. Nederland heeft daarom formeel geen kwetsbare zones aangewezen (Nitrate Vulnerable Zones).

Vanaf 1987 is het gebruik van dierlijke mest in de landbouw gereguleerd middels gebruiksnormen gebaseerd op fosfaat (P_2O_5). Deze gebruiksnormen zijn sindsdien aangescherpt van 125 kg fosfaat voor bouwland en 250 kg/ha voor grasland en voedermaïs in 1991-1992 tot 85 kg/ha voor alle gewassen in 2000.

In 1998 is een mineralenaangiftesysteem (MINAS) geïntroduceerd voor bedrijven met meer dan 2,5 grootvee-eenheden, waardoor de stikstoftoepassing van zowel dierlijke mest als van kunstmest middels verliesnormen werd gereguleerd. De verliesnormen in de periode 1998-2002 zijn een compromis tussen wat milieukundig gewenst is en wat landbouwkundig haalbaar is. Vanaf 2001 zijn alle landbouwbedrijven MINAS-plichtig. In de periode 1998–2002 zijn de verliesnormen verlaagd en tevens zijn lagere verliesnormen geïntroduceerd voor de uitspoelingsgevoelige zand- en lössgronden (circa 7% van het landbouwareaal), zie Tabel S4. De stikstofverliesnormen waren in 2002 zo'n 14-43% lager dan in 1998. Vanaf 2002 zijn landbouwbedrijven met vee verplicht mestafzetovereenkomsten te sluiten voor de dierlijke mestproductie die hoger is dan een stikstofproductie van 170 kg/ha voor bouwland en 250 kg/ha voor grasland. Als zij herin niet slagen, moeten zij de mestproductie verminderen door het verkleinen van de veestapel op het bedrijf. Men kan mestafzetcontracten sluiten met akkerbouwbedrijven, andere (extensieve) veehouderijbedrijven of mestverwerkingbedrijven.

*Tabel S4: Stikstofverliesnormen in de periode 1998-2002 in kg/ha als N, voor bouwland en grasland op klei-, veen-, zand- en lössgronden *1.*

	Grasland	Bouwland	
Jaar	Alle	Klei/Veen	Zand/Löss
1998-1999	300	175	175
2000	275	150	150
2001	250	150	125
2002	220/190[*2]	150	110/100[*2]

[1] Sinds 2002 zijn de verliesnormen aangescherpt voor de uitspoelinggevoelige zand- en lössgronden.
[2] Tweede getal is de verliesnorm voor de uitspoelinggevoelige gronden, het eerste getal de verliesnorm voor de andere gronden.

De aanwendingmethode voor dierlijke mest en kunstmest, als ook de aanwendingsperiode zijn in de jaren 1993 tot en met 1999 wettelijk gereguleerd en de regels zijn aangescherpt. Sinds 1995 moet dierlijke mest altijd direct ondergewerkt worden (grasland), dan wel binnen enkele uren na aanwending (bouwland), dit om de ammoniakemissie te minimaliseren; uitgezonderd hiervan is de aanwending van vaste mest op grasland. Om de emissie van ammoniak uit mestopslagen tegen te gaan, dienen mestopslagen afgedekt te zijn.
De emissiearme aanwending van mest draagt ook bij aan het voorkomen van directe emissie naar oppervlaktewateren. In aanvulling hierop is er sinds 1997 ook op grote schaal gebruik gemaakt van een kantstrooivoorziening op de kunstmeststrooiers om te voorkomen dat kunstmest direct in de sloot komt of op de mestvrije zone die bedrijven sinds 2000 verplicht zijn te hanteren nabij waterlopen.
Om de nitraatuitspoeling te beperken is sinds 1996 de aanwending van mest tussen begin september en 1 februari verboden. Sinds 1994 was het al verboden om mest toe te passen op besneeuwde grond. In 1998 is dit verbod uitgebreid tot gronden die geheel of gedeeltelijk bevroren zijn. Sinds 1999 is de aanwending van alle mest (dierlijke mest en kunstmest) verboden op waterverzadigde, overstroomde, bevroren en besneeuwde grond.
De Nederlandse overheid heeft initiatieven ontwikkeld voor het verbeteren en verspreiden van de bemestingsadviezen. Eveneens zijn initiatieven genomen voor het verstrekken van informatie over het efficiënt gebruik van nutriënten, via onder andere demonstratieprojecten, gericht op verbeterd nutriëntenmanagement. In de periode 1999-2003 is 120 miljoen Euro uitgegeven aan kennisontwikkeling en kennisoverdracht aan boeren.

Karakteristieken van de landbouw in de periode 2000-2002
Het areaal landbouwgrond in Nederland in 2000-2002 was 1,92 miljoen ha, dit is 57% van het totale landoppervlak. Van het areaal landbouwgrond is 52% grasland (waarvan 90% permanent), 11% voedermaïs en 31% overige akkerbouwgewassen. Het resterende areaal (6%) wordt gebruikt voor tuinbouw. Er waren ongeveer 93.000 landbouwbedrijven, waarvan 49% graasdierbedrijven, 13% akkerbouwbedrijven, 20% tuinbouwbedrijven en 18% hokdier- en gemengde bedrijven.

De veestapel bestond uit 4 miljoen runderen, 13 miljoen varken, 102 miljoen stuk pluimvee en 1,5 miljoen schapen en geiten. De mestproductie van deze dieren was 509 miljoen kg stikstof (N) en 79 miljoen kg fosfor (P). Het rundvee was verantwoordelijk voor 62% van de stikstof- en 53% van de fosforproductie met mest.
De stikstofaanvoer (als N) naar landbouwgrond was gemiddeld 403 kg/ha, waarvan 195 kg/ha via dierlijke mest, 155 kg/ha via kunstmest en 53 kg/ha via atmosferische depositie en andere bronnen. Het stikstofoverschot op de bodembalans was gemiddeld ongeveer 190 kg/ha.
De fosforaanvoer (als P) naar landbouwgrond was gemiddeld 53 kg/ha, waarvan 37 kg/ha via dierlijke mest, 13 kg/ha via kunstmest en 3 kg/ha via atmosferische depositie en andere bronnen. Het fosforoverschot op de bodembalans was gemiddeld ongeveer 23 kg/ha (als P).

Ontwikkelingen in de landbouwpraktijk in de periode 1992-2002
In de periode 1992-2002 is het areaal landbouwgrond afgenomen met 2% en het aantal agrarische bedrijven met 20%. Ook de veestapel werd kleiner. Het aantal runderen en varkens nam af met respectievelijk 17% en 14%, de pluimveestapel nam daarentegen toe met 6%.
De stikstof- en fosforproductie van de veestapel met dierlijke mest nam in deze periode af met respectievelijk 24 en 19% als gevolg van een afname van de veestapel gecombineerd met een afname van de nutriëntexcretie per dier. Deze daling in de excretie per dier werd veroorzaakt door een lager nutriëntgehalte in het voer en een verbetering van de voederconversie. Ook het gebruik van kunstmeststikstof en -fosfor nam af, respectievelijk met 21% and 23%. Deze afnamen in de aanwending hadden tot gevolg dat zowel het stikstof- als het fosforoverschot in de Nederlandse landbouw verminderde, en wel met 27% and 37% voor respectievelijk stikstof en fosfor.
Het transport van dierlijke mest tussen de landbouwgebieden in Nederland nam af van 155 miljoen kg stikstof in 1994 tot gemiddeld 100 miljoen kg in de periode 2000-2002. De emissie van ammoniak uit agrarische bronnen naar lucht nam af met ongeveer 45% tussen 1990 en 2002.

Stikstof- en fosforemissie naar oppervlaktewateren

De binnenlandse bijdrage aan de totale stikstofemissie naar het zoete oppervlaktewater in Nederland in de periode 2000-2002 is 23%, de bijdrage aan de totale fosforemissie is 27%. Het overige deel is afkomstig uit het buitenland. De landbouw is de belangrijkste binnenlandse bron voor zowel stikstof als voor fosfor (beide circa 60%).

De stikstofemissie naar het zoete oppervlaktewater nam in de periode 1992-2002 met ongeveer een kwart af. De fosforemissie verminderde met ongeveer eenderde in deze periode. De stikstofemissie door de landbouw nam met 15% af, terwijl de fosforemissie niet afnam.

De kwaliteit van grondwater en oppervlaktewater

Nitraatconcentraties in de periode 2000-2002

De gemiddelde nitraatconcentraties in grond- en oppervlaktewater in de periode 2000-2002 zijn weergegeven in Tabel S5. In Nederland is de grondwaterstand in het algemeen hoog en komt gemiddeld voor op een diepte van 1 tot 1½ m. Mede om deze reden is besloten de effecten van het Nederlandse Actieprogramma te meten in de bovenste meter van het grondwater.

Tabel S5: Gemiddelde gemeten nitraatconcentratie (in mg/l) in grondwater en oppervlaktewateren in de periode 2000-2002[*1].*

Watertype	Zand	Klei	Veen	Alle
Grondwater				
Bovenste (< 5 m; landbouw)	75 (66%)	40 (30%)	< 5 (0%)	-
Ondiep (5-15 m; landbouw)	40 (21%)	< 5 (0%)	< 5 (0%)	-
Middeldiep (15-30 m; landbouw)	10 (6%)	< 5 (0%)	< 5 (0%)	-
Diep (> 30 m; freatische winningen)	7 (2%)	-	-	-
Zoete oppervlaktewateren				
Landbouwbeïnvloede wateren				15 (3%)
Andere regionale wateren				14 (1%)
Rijkswateren				12 (0%)
Zoute oppervlaktewateren				
Kustwater				5 (0%)
Open zee				< 1 (0%)

1) De mate van overschrijding van de EU-waarde van 50 mg/l voor de periode 2000-2002 is vermeld tussen haakjes. Voor het bovenste grondwater betreft dit het percentage van bedrijven met een concentratie hoger dan 50 mg/l. Voor het overige grondwater betreft het percentage putten en voor het oppervlaktewater het percentage meetlocaties.

2) Wintergemiddelde nitraatconcentration, de periode waarin uit- en afspoeling een belangrijke bijdrage levert aan e oppervlakterkwaliteit.

De nitraatconcentraties nemen af naarmate ze verder van de bron (de landbouw) gemeten worden, dit geldt voor zowel voor het grondwater met betrekking tot de (meet)diepte als voor oppervlaktewater met betrekking tot afstand. De afname van de nitraatconcentratie in het grondwater met de diepte is te zien in Tabel S5. De afname van de nitraatconcentratie in het oppervlaktewater met de afstand tot landbouwbedrijven volgt uit de afnemende concentraties in de volgorde landbouwbeïnvloede regionale wateren > andere regionale wateren > rijkswateren > kustwater > open zee.

Twee factoren dragen bij aan deze afname in de concentraties. Ten eerste de omzetting van nitraat naar elementair stikstof (denitrificatie) tijdens het transport en, ten tweede, het mengen van water afkomstig van landbouwpercelen met water afkomstig van gronden met een ander bodemgebruik. Voor het grondwater zijn aanvullend nog twee factoren van invloed op de afname, dit zijn de tijd en de hydrologische karakteristieken van de ondergrond. Het grondwater op een diepte minder dan 5 m is jong water (1-5 jaar), terwijl het grondwater in de zandgebieden op een diepte van 5-15 m een gemiddelde leeftijd heeft circa 10 jaar en het grondwater op een diepte van 15-30 m gemiddeld zo'n 40 jaar oud is. Het grondwater op een diepte van 15-30 m geeft daarom op zijn best een beeld van de landbouw van zo'n 40 jaar geleden. In de klei- en veengebieden is het grondwater op diepten van 5-15 en 15-30 meestal nog veel ouder. In dit geval zijn de hydrologische karakteristieken van de ondergrond (stroombanen) belangrijk, omdat het grondwater in deze gebieden op deze diepten meestal spanningswater is; d.w.z. dat de grondwaterstroming vooral horizontaal is en er geen of nauwelijks aanvoer van boven is door de aanwezigheid van afsluitende (klei)pakketten. Het neerslagoverschot in de klei- en veengebieden wordt voornamelijk oppervlakkig afgevoerd naar het oppervlaktewater. Dergelijke situaties komen lokaal ook voor in de zandgebieden.

De nitraatconcentraties in het grondwater in de veengebieden zijn lager dan die in de kleigebieden, en die zijn weer lager dan de nitraatconcentraties in de zandgebieden. Dit wordt vooral veroorzaakt door een toename van de denitrificatie gaande van zand naar klei naar veen.

Eutrofiëring van oppervlaktewateren in de periode 2000-2002
Een effectindicator voor eutrofiëring is de concentratie van chlorofyl-*a*. De totaal-stikstof- en totaal-fosforconcentraties zijn toestandsindicatoren. De zomergemiddelde concentraties van deze indicatoren voor de periode 2000-2002 zijn weergegeven in Tabel S6. Net als voor nitraat nemen de concentraties van de eutrofiëringindicatoren af in de volgorde: landbouwbeïnvloede regionale wateren > andere regionale wateren > rijkswateren > kustwater > open zee. De chlorofyl-*a* concentraties zijn bij 18% van de landbouwbeïnvloede regionale wateren hoger dan 75 µg/l, voor de andere regionale wateren is dit 11%.

Tabel S6: Eutrofiëringparameters voor verschillende typen oppervlaktewateren in de periode 2000-2002, chlorofyl-a in µg/l en totaal-stikstof en totaal-fosfor in mg/l (zomergemiddelden).

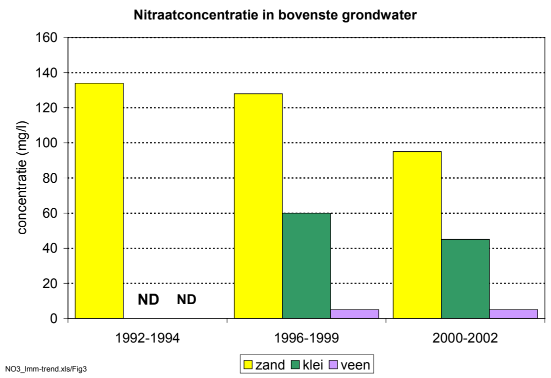
Watertype	Chlorofyl-*a*	Totaal stikstof	Totaal fosfor
Landbouwbeïnvloede wateren	51 (18%)[a]	4,1	0,46
Andere regionale wateren	38 (11%)[a]	3,8	0,28
Rijkswateren	20 (0%)[a]	3,6	0,18
Kustwateren	11 (0%)[a]	0,5[b]	0,09
Open zee	2 (0%)[a]	< 0,1[b]	0,02

1) Zomergemiddelde waarden zijn weergegeven, omdat de zomer de meest kritische periode is voor water betreft eutrofiëring.
a Tussen haakjes het percentage locatie met een concentratie > 75 µg/l.
b Totaal opgelost anorganisch stikstof.

Trends in de nitraatconcentraties in de periode 1992-2002

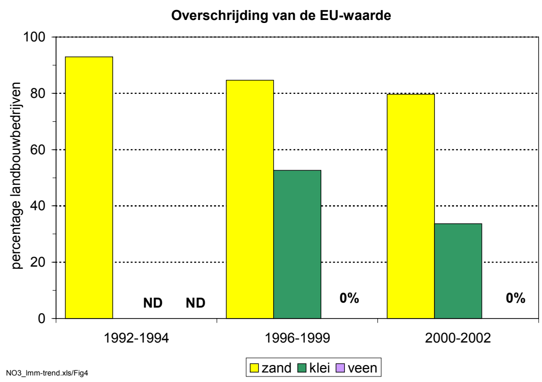
De nitraatconcentratie in het bovenste grondwater nam in de periode 1992-2002 af, evenals het percentage van de bedrijven waar de EU-waarde van 50 mg/l werd overschreden, zelfs als rekening wordt gehouden met storende factoren zoals de variatie in het netto neerslagoverschot (zie Figuren S3 en S4). Met name in de zandgebieden was sprake van een duidelijke daling van de gemiddelde nitraatconcentratie van circa 135 mg/l (zowel gemeten als gecorrigeerd) tot circa 75 mg/l (gemeten) en circa 95 mg/l (gecorrigeerd).

De nitraatconcentraties in het grondwater op een diepte van 5-30 m lieten geen ontwikkeling zien, uitgezonderd het grondwater onder landbouw in de zandgebieden op een diepte van 5-15 m en het freatische grondwater in deze gebieden op meer dan 30 m diepte. Voor het ondiepe grondwater (5-15 m) waren zowel de nitraatconcentraties als de mate van overschrijding van de EU-waarde lager in de 1998-2002 periode vergeleken met de periode 1992-1997. De nitraatconcentraties in het freatische grondwater gebruikt voor de drinkwaterproductie (op een diepte van meer dan 30 m in de zandgebieden) liet een lichte toename zien in de periode 1992-2002. Trends in de nitraatconcentratie in het grondwater in de klei- en veengebieden worden niet verwacht, omdat de nitraatconcentraties laag zijn en de watervoerende lagen meestal afgesloten zijn.



Figuur S3: Nitraatconcentratie in het bovenste grondwater (zand, veen) en drainwater (klei) in de perioden 1992-1994, 1995-1998 en 2000-2002.

Nitraatconcentraties zijn gecorrigeerd voor storende factoren.
ND = geen gegevens beschikbaar.



Figuur S$: Overschrijding van de EU-waarde van 50 mg/l in het bovenste grondwater (zand, veen) en drainwater (klei) in de perioden 1992-1994, 1995-1998 en 2000-2002.

Nitraatconcentraties zijn gecorrigeerd voor storende factoren.
ND = geen gegevens beschikbaar.

De wintergemiddelde en -maximum nitraatconcentraties in zoete oppervlaktewateren namen na 1998 af. In de zoute wateren was er geen ontwikkeling te zien in de gemeten nitraatconcentratie in de winter. De voor de rivierafvoer (neerslag) gecorrigeerde opgelost anorganisch stikstofconcentratie (voornamelijk nitraat) vertoont een afname begin jaren negentig, en lijken sinds eind jaren negentig verder af te nemen.

Trends in eutrofiëring in de periode 1992-2002
De zomergemiddelde chlorofylconcentratie in zoete oppervlaktewateren laat een continue afname zien. In de landbouwbeïnvloede regionale wateren treedt deze afname op sinds 1998. In de overige regionale wateren en de rijkswateren is de afname al zichtbaar sinds eind tachtiger en begin negentiger jaren. Vergelijkbare trends zijn zichtbaar voor de zomergemiddelde totaal-stikstof- en totaal-fosforconcentratie in de zoete oppervlaktewateren. De zomergemiddelde totaal-fosforconcentratie in de overige regionale wateren en in de rijkswateren is meer dan gehalveerd in de periode 1985-2002.
De Nederlandse zoute wateren zijn gekarakteriseerd als eutrofiëringprobleem gebieden (OSPAR-conventie). De zomergemiddelde chlorofylconcentraties in de zee en kustwater laten geen ontwikkeling zien in de periode 1992-2002.

Effecten van de Actieprogramma's en een prognose van de toekomstige ontwikkeling van de waterkwaliteit.

De volledige implementatie van beleidsmaatregelen door de landbouw neemt over het algemeen enige tijd in beslag. Verder zullen maatregelen die door de landbouw genomen worden in het algemeen niet een onmiddellijk effect hebben op de waterkwaliteit. Dit wordt veroorzaakt door processen in de bodem en het water en als gevolg van storende factoren zoals de variatie in het neerslagoverschot tussen jaren.

De waterkwaliteit op de landbouwbedrijven (bovenste grondwater, slootwater) zal het snelst en sterkst reageren op de maatregelen uit de Actieprogramma's. De verwachting is dat de effecten van de maatregelen uit het derde Actieprogramma (2004-2007) op de waterkwaliteit op landbouwbedrijven zichtbaar zullen worden tussen 2008 en 2013.
De effecten op de kwaliteit van het freatische grondwater op een diepte van meer dan 5 m zullen pas zichtbaar worden na één of meerdere decennia. Bovendien zullen de effecten moeilijk aan te tonen zijn als gevolg van menging van grondwater met een verschillende ouderdom en oorsprong en als gevolg van de fysisch-chemische processen in de ondergrond.

De effecten van het derde Actieprogramma op de kwaliteit van het oppervlaktewater zullen waarschijnlijk ook zichtbaar worden tussen 2008 en 2013. Maar ook hiervoor geldt dat de effecten versluierd zullen worden, met name in de rijkswateren en de zoute wateren, als gevolg van menging met water van andere oorsprong (o.a. de aanvoer vanuit het buitenland met de grote riveiren) en ouderdom en door de biochemische processen in het grondwater en oppervlaktewater.

Een prognose van de ontwikkeling van de eutrofiëringtoestand van het oppervlaktewater als gevolg van de veranderingen in de landbouwpraktijk is nog moeilijker te geven dan voor nitraat. De belangrijkste redenen hiervoor zijn:
(i) het verschil tussen oppervlaktewateren in hun gevoeligheid voor eutrofiëring.

(ii) de rol die andere factoren spelen bij eutrofiëring zoals de fosforconcentratie en de hydromorfologie.
(iii) de bijdrage van andere bronnen voor nutriëntenaanvoer, zoals stedelijk afvalwater en grensoverschrijdende rivieren.
(iv) de zeer moeilijk te voorspellen reactie van het aquatische ecosysteem op een substantiële vermindering van de nutriëntenaanvoer en nutriëntenconcentraties.

Aanvullend op de brongerichte maatregelen zijn er regionaal, in perspectiefvolle situaties, effectgerichte maatregelen genomen, zoals actief biologisch beheer. Dit beleid zal naar verwachting worden voortgezet. In enkele gevallen werd het ecologische herstel aanmerkelijk versneld, bijvoorbeeld van de Veluwerandmeren. Het ecologische herstel van de Nederlandse oppervlaktewateren blijkt echter slechts langzaam te vorderen, zoals te zien is in Figuur 32 (pagina 127) en Figuur 39 (pagina 144). Een duidelijk zichtbare algemene toename van het herstel wordt niet op korte termijn verwacht.

CONCLUSIES

Nederland heeft de tendens van stijgende stikstof- en fosfaatoverschotten in de landbouw in 1987 weten om te buigen in een dalende tendens. Na de invoering van MINAS in 1998 is het stikstofoverschot, dat tussen 1990 en 1998 stabiel was, opnieuw gaan dalen.

In de rapportageperiode (1992-2002) is de waterkwaliteit verbeterd, zowel voor wat betreft de nitraatconcentraties als met betrekking tot eutrofiëring, als gevolg van de beleidsmaatregelen genomen sinds 1987. De nitraatconcentratie in het bovenste grondwater op landbouwbedrijven was in de periode 2000-2002 duidelijk lager dan in de voorafgaande perioden. Dit hangt samen met de afname van het stikstofgebruik sinds 1998. De nitraatconcentraties in het diepe freatische grondwater (> 30 m) laten nog een toename zien, dit hangt waarschijnlijk samen met de toename van de stikstofoverschotten in de periode voor 1987.

De verwachting is dat de waterkwaliteit zal blijven verbeteren in de volgende rapportage periode (2003-2006), dankzij de maatregelen die zijn genomen in de periode van het tweede Actieprogramma (1999-2003). Voor wat betreft de nitraatconcentratie in het diepe grondwater is de termijn waarop een verbetering wordt verwacht veel langer (enige decennia). Een duidelijk zichtbare toename van het ecologisch herstel van oppervlaktewateren, dat wil zeggen een vermindering van de eutrofiëringverschijnselen, wordt niet verwacht.

De nitraatconcentratie in het grondwater alsook de mate van overschrijding van de EU-waarde van 50 mg/l zijn niet alleen afhankelijk van menselijke activiteiten, maar worden ook beïnvloed door weersomstandigheden, bodemtype en bemonsteringsdiepte. Deze laatste factor hangt samen met de hydrologische en geochemische karakteristieken van de ondergrond.

CONTENTS

1. INTRODUCTION

1.1 General

This report provides the background information for the Netherlands Member State report, 'Nitrates Directive, status and trends of aquatic environment and agricultural practice' to be submitted to the European Commission in mid-2004. It overviews current agricultural practice, and groundwater and surface-water quality, in the Netherlands, outlines the trends in these waters (especially the 1992-2002 period) and assesses the time scale for change in water quality as a consequence of changes in farm practice. The report deals with the evaluation of the implementation and impact of the measures in the Action Programmes and forecasts the future evolution of water body quality.

This introductory chapter summarises the goal of the Nitrates Directive and the main obligations arising from it (§1.2). The two obligations relevant for this report, i.e. reporting (§1.3) and monitoring (§1.4), are discussed in more detail. The 2004 Member State report represents the third reporting phase. A review of the first two reports is given in §1.5, with a more detailed, substantial description of the third report given in §1.6. References (§1.7) are found at the end of each chapter.

1.2 The Nitrates Directive

The European Nitrates Directive (EU, 1991) is aimed at reducing water pollution caused or induced by nitrate from agricultural sources and, further, at preventing such pollution. The Directive obliges Member States to take several actions to realise this objective.

First, Member States are obliged to designate areas in their territory (Nitrate Vulnerable Zones or NVZ) that drain into fresh surface waters and/or groundwater (Article 3, Annex 1) that contain, or could contain, more than 50 mg/l nitrate if actions prescribed in the Directive are not taken. This is valid for freshwater bodies, estuaries, coastal waters and marine waters that are now eutrophic or that in the near future may become eutrophic if actions prescribed in the Directive are not taken. Second, the Directive compels Member States to establish Action Programmes with respect to designated NVZ so that the objective of the Directive can be realised (Article 5). Third, Member States are obliged to implement suitable monitoring programmes to establish the extent of nitrate pollution in waters from agricultural sources and to assess the effectiveness of Action Programmes (Article 5, sub 6; see §1.4 for more details). Member States are to submit a report on the preventive actions taken, and the results and expected results of the Action Programme measures, to the European Commission (Article 10, see for more detail §1.3).

The Netherlands has not designated Nitrate Vulnerable Zones, but informed the European Commission in 1994 that they would establish an Action Programme, as laid down in the Nitrates Directive, which they would apply throughout their national territory. According to a study in 1994 (Working Group Designating NVZ, 1994), agriculture is a relevant source of nitrate emission to groundwater and/or fresh surface waters and/or coastal waters. The working group concluded therefore that an Action Programme should be applied to the whole country.

1.3 Reporting liability

The obligation of reporting to the Commission on preventive actions taken and the results and expected results of the Action Programme measures are elaborated in Annex 1 of the Directive. This Annex stipulates the information for inclusion in a report brought out every four years, which in the Netherlands is the responsibility of the Ministries of Housing, Spatial Planning and the Environment (VROM); Agriculture, Nature and Food Quality (LNV), and Transport, Public Works and Water Management (V&W).

Reporting obligations:

1) A statement of the preventive action taken pursuant to Article 4. This article states that within two years following the notification of the Directive, a code of Good Agricultural Practice (GAP) has to be established and a programme promoting the code has to be set up.
2) A map showing the following:
    a) waters identified as being affected or capable of being affected by pollution.
    b) the location of the Nitrate Vulnerable Zones, distinguishing between the existing zones and zones designated since the previous report.
3) A summary of the monitoring results obtained for the purpose of designating NVZs, including a statement of the considerations which led to the designation and to any revision.
4) A summary of the Action Programmes drawn up, in particular:
    a) the measures required with respect to the application of fertiliser, storage capacity for manure and other restrictions on the use of fertilisers, and measures prescribed in the GAP code.
    b) the implementation of a maximum amount of nitrogen per ha for application, along with manure, in the amount of 170 kg/ha.
    c) any additional measures or reinforced actions taken to overcome inadequate measures for achieving the Directive objective.
    d) a summary of the results of the monitoring programmes to assess the effectiveness of the Action Programmes.

e) the assumption made by the Member States about the likely time scale within which the waters identified are expected to respond to the measures in the Action Programmes, along with an indication of the level of uncertainty inherent in these assumptions.

This report focuses on points 4d and 4e of the reporting obligations.

1.4 Monitoring liability

Member States who have designated NVZ have different obligations to Member States who apply their Action Programmes to their entire territory.

Member States who have designated NVZ shall, for the purpose of designation and revising the designation of NVZ, monitor nitrate concentrations in fresh waters and groundwater for at least one year, within two years of notification of the Directive – i.e. the end of 1993 – and repeat the monitoring programme at least every four years,

Member States applying their Action Programme to their entire territory, e.g. the Netherlands, will monitor the nitrate concentrations in fresh waters and groundwater to establish the extent of nitrate pollution in waters from agricultural sources. The Directive does not provide a time limit in this case. Given that the first Action Programme took effect on 20 December 1995, monitoring has to be performed before that date to be able to record the starting point. The monitor for designation does not have to coincide with the monitor assessing the effectiveness.

The Nitrates Directive provides a limited outline on how monitoring is to be implemented. As a matter of fact, only a few outlines on monitoring are given for the purpose of designation (Article 6, Annex IV).

The European Commission published draft-monitoring guidelines according to Article 7 of the Directive in 1998 (EC/DG XI, 1998). In 1999 (EC/DG XI, 1999) and in 2003 (EC/DG XI, 2003) revisions were published, but these are still draft versions. Guidelines do not refer to any statutory obligation. The objective of the guidelines is to define the aim of each type of monitoring and suggest ways in which Member States might achieve this. In addition, the Commission aims at ensuring that it will be possible to cross-compare monitoring regimes between Member States.

1.5 The first and second Member States report on the Netherlands

The first Member States report on the Netherlands was submitted to the Commission in 1996 (LNV, 1996). This report referred to the period between 20 December 1991 and 20 December 1995. With respect to the obligation to report on the results of the monitoring programmes to assess the effectiveness of the Action Programme, it was thought too early to be able to show any effect, since the first Action Programme had only started on 20 December 1995. The report provided an overview of the operational monitoring programmes and the following remarks were made with respect to the results:

> 'The effectiveness of the Action Programme can't be properly assessed when the results of monitoring groundwater and surface waters only are considered. Measures aimed at a decrease of emissions of nutrients will have a delayed effect on nitrate concentration, especially in surface waters. Therefore the estimation of the surplus on the national agricultural nitrogen balance is an appropriate tool when assessing the effectiveness of the measures. This tool provides an opportunity to follow the achieved progress due to reduction measures in agriculture in a more direct manner.'

This report also states that the effectiveness of the Action Programme will be reported on in four years' time.

The second Member States report of the Netherlands was submitted to the Commission in 2001 (LNV, 2001). This report referred to the period from 20 December 1995 to 20 December 1999. It contains the results of the monitoring programmes to assess the effectiveness of the Action Programme and is based on the report of the Working Group - 'Monitoring Nitrates Directive' (Fraters et al., 2000). The following remarks were made in the Member States report with respect to the results of these programmes:

> 'The report (*of the Working Group - Monitoring Nitrates Directive*) indicates that there is a stabilisation, but not yet a substantial amelioration, of the environmental quality. This lack of amelioration was foreseen because:
>
> 1. During the reporting period (1995-1999) only the use of manure was regulated, the use of artificial fertiliser was not. The decrease in the amount of nitrogen used by manure application was often compensated by fertiliser application. Since 1998 the Netherlands have rules that include the regulation of use artificial fertiliser nitrogen, the Mineral Accounting System (MINAS). As a consequence, the effects of MINAS fall beyond the reporting period. In addition, expectations are that tightening of the mineral policy (September 1999) will show results in 2002 and 2003. That means that an amelioration of the environmental quality as a consequence of the mineral policy will show in the third reporting period.
> 2. Due to transport processes, and decomposition and conversion processes, in soil and groundwater effects of measures are lagging, and it will take some time before they show in a decrease in nitrate concentration. Yet, the extent of the lag time can not be specified. The results of monitoring particularly reflect the stabilisation in agricultural practice in the eighties and beginning of the nineties, when the development of an increase in environmental pressure was brought to a halt.'

1.6 The Member States third report and this report

1.6.1 Delineation and account

In mid-2004 the Member States will have to submit their Nitrates Directive Member States report to the European Commission. The third Member States report deals with the period from 20 December 1999 to 20 December 2003; it should also contain the results of the monitoring programmes to assess the effectiveness of the Action Programme (point 4d in section 1.3) and the assumption made by the Member States about the likely time scale within which the waters identified are expected to respond to the measures in the Action Programme (point 4e in section 1.3).

The ministries responsible for the reportage by the Netherlands (see §1.3) requested the Working Group - Monitoring Nitrates Directive to report on the two above-mentioned topics. This report represents the result of this working group's efforts.

The point of departure for drawing up this report was formed by the reporting guidelines published by the Commission in 2000 (EC/DGXI, 2000). These guidelines contained a request that the results for the monitoring periods be published using average values of three years of monitoring for each period. Because the guidelines are not updated, it is not clear whether results for only 2 monitoring periods should be given or for all the periods, in this case 3. Also not clear is which periods should be used for comparison of results, as prescribed in the guidelines.

The working group has advised that in order to show a comprehensive overview of the status and trend of agricultural practice and aquatic environment, results will be presented in tables in the prescribed format for each of the monitoring periods. In addition, figures will be presented with yearly averages for at least the 1992-2002 period. However, if earlier data are available, often going as far back as the mid-eighties of the last century, these will be presented as well. Nevertheless, to limit the number of maps presented, only the maps showing the water quality status for 2000-2002 and the change in water quality between 1996 and 2002 (second and third period), could be included. The ministries have agreed to this recommendation.

1.6.2 Structure of report

This report consists of an introduction and written account (Chapters 1 and 2, and the Annexes); the results of the monitoring programmes to assess the effectiveness of the Action Programme (Chapters 3 - 7); a forecast of how the quality of water bodies in the future will evolve (Chapter 8), and a chapter on synthesis of the results from the foregoing chapters and conclusions. For convenience of the reader this chapter is at the beginning of the report. To allow the chapters containing the results of the monitoring programmes to be read independently, references are provided at the end of each chapter.

After the general introduction to the report in Chapter 1, Chapter 2 goes on to describe the nationwide monitoring programme, and the aim and design of the respective sub-programmes contributing the results for this report. The mathematical processing of the data is described in the Annexes where references were not available.

Status and trends in agricultural practice are described in Chapter 3. The effect of both agricultural practice and changes in practice on the on-farm water quality is illustrated in Chapter 4. In the remaining three chapters, status of and trends in the aquatic environment are depicted for groundwater (Chapter 5), fresh surface waters (Chapter 6), and coastal and marine waters (Chapter 7), respectively.

Groundwater nitrate concentrations are shown for three depths, 5-15 m, 15-30 m and > 30 m below surface level; variation in depths is used since nitrate concentrations vary considerably with depth. Other important environmental factors considered when reviewing nitrate in groundwater are land use, soil type and aquifer type.

Nitrogen and phosphorus loads are given for surface waters, along with a description of water quality. Water quality is described by nitrate concentrations for the winter period and by eutrophication parameters for the summer period. Four water types are distinguished for fresh surface waters: agriculturally-influenced regional waters, other regional waters, national waters and drinking-water stations. These show a decreasing influence of agriculture on water quality. Other sources influencing water quality are, for example, effluent from wastewater and sewage treatment plants, sewerage overflow during storms (excessive rainfall) and atmospheric deposition. For marine waters, we distinguish coastal water from the open sea, showing a difference in the influence of nutrient loads, mainly by rivers and not by direct discharge.

The forecast of the future evolution of the quality of water bodies is taken up in Chapter 8. The estimations are mainly based on extrapolation of the evolution of water quality derived from current monitoring.

The synthesis of the results from the preceding chapters and any conclusions that could be drawn are incorporated in the 'Summary, synthesis and conclusions' at the beginning of the report.

1.7 References

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2. NATIONWIDE MONITORING PROGRAMMES

2.1 Introduction

Monitoring agricultural practice and the aquatic environment in the Netherlands comprises several monitoring programmes: agricultural practice (§2.2), the effectiveness of the minerals policy (§2.3), groundwater (§2.4), fresh surface waters and marine waters (§2.5), and water used for drinking-water production (§2.6). These programmes are carried out under the responsibility of various institutes and organisations.

This chapter provides a brief description of each of these programmes. In addition to a general account on the data collection, information is provided on data processing – used for the overviews to illustrate the status of and trend in agricultural practice and the aquatic environment. Details of data collection and processing are given in the Annex or in referenced literature sources.

2.2 Monitoring agricultural practice

2.2.1 General

Agricultural practice is monitored intensively in the Netherlands. In the next sub-section the monitoring programmes are discussed, followed in §2.2.3 by details on the calculation of mineral balances and manure and nutrient excretion and production and manure storage capacity.

2.2.2 Data collection

There are two agricultural monitoring programmes in the Netherlands, the Agricultural Census and the Farm Accountancy Data Network (FADN).

Agricultural Census

Statistics Netherlands collects general information on such topics as acreage and number of farm animals for all farms larger than three 'Dutch Magnitude Units' (NGEs) (CBS Statline, 2003). These NGEs represent units of gross balance corrected for price fluctuations; NGEs are also used as the basis of levies and issuing rules. The annual data collection is called the 'Agricultural Census'.

Farm Accountancy Data Network

The Dutch Agricultural Economics Research Institute (LEI) collects more specific information on farm economics and technical management through the Farm Accountancy Data Network (FADN) (Vrolijk, 2002; Poppe, 1993; Lodder and De Veer, 1985). This farm management information includes environmental relevant data such as mineral balances (inputs and outputs of minerals), the use of pesticides, water and energy consumption, fertiliser, import and export of minerals, and grazing frequency. FADN represents 1500 farms from the Agricultural Census, selected through stratified random sampling, and so forming a representative sample of Dutch agriculture. The FADN network is a participant in the EU networks (EU Council Regulation 79/65/EEG). Farms participate for a 5 to 6 year period and are visited annually. Since about 15-20% of the farms are replaced every year, the FADN network can remain representative of Dutch agriculture. FADN represents about 60% of the total number of farms and about 86% (in NGEs) of registered agricultural production in the Netherlands. For reasons of representiveness farms less than 16 NGEs, on which farming generally is not the main occupation of the farmer, are excluded in FADN. Farms (mostly nurseries under glass) greater than 800 NGEs are less appropriate for data-collection and therefore also excluded from the field of survey.

Surveillance of compliance to the code of Good Agricultural Practice and observance of regulations occur mainly by way of a check on the minerals return that each farmer has to complete and return to the Levies Office[1], and generally not on an individual measures level. Information collected by the General Inspection Service (AID)[2] provides insight into the level of observance of regulations on related administrative obligations like manure application (amount, timing and application method) and manure disposal contracts.

The National Reference Centre of the Ministry of Agriculture, Nature and Food Quality has overviewed the activities around fertilisation recommendations, promotion of the code and demonstration projects.

2.2.3 Data processing

Nitrogen and phosphorus balances

Nitrogen and phosphorus balances of the agricultural system are calculated annually by Statistics Netherlands. All balance items are based on statistical data, except for atmospheric deposition, which is based on model calculations by the RIVM (Erisman et al., 1998; Van Jaarsveld, 1995) using statistical data on emissions to air (Van Amstel et al., 2000). The surplus is the difference between supply and removal items of the balance. The destiny of the surplus on the balance is not specified because leaching, run-off, denitrification and accumulation can only be estimated through model calculations. The method used for the calculation of the balance items was described by Statistics Netherlands in 1992 (CBS, 1992). Since 1992, minor changes in calculation methods have occurred; these are published in every fourth issue of the quarterly bulletin of Statistics Netherlands, together with the

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[1] An agency under the Ministry of Agriculture, Nature and Food Quality which carries out the administrative audits required by Dutch legislation on manure and fertilisers, including MINAS.

[2] An authorised inspection agency under the responsibility of the Ministry of Agriculture, Nature and Food Quality.

definitive version of the balances of two years back and the draft version of the balance for the preceding last year (see, for example, Fong, 2000 and earlier issues).

Nutrient excretion and production

In these above-mentioned balance calculations the mineral excretion of national livestock is calculated as the difference between fodder consumption and animal products. Statistics Netherlands also calculates the manure and mineral production by livestock on the basis of a nutrient balance per animal in combination with the number of head of livestock from the Agricultural Census. The starting points for this method is:

1. nutrient excretion factors, calculated for each element on the basis of the balance sheet: excretion = intake via feed minus retention in animal products. For nitrogen this factor is corrected for ammonia volatilisation from stables and pastures.
2. statistics and technical administration of a certain year used in the place of expert knowledge and feeding standards as a source material for basic figures on quality and content. This makes it possible to follow not only changes in feed composition, but also zoo-technical developments such as more efficient milk and meat production from year to year in the calculations. Statistics are preferably used as source material since they show continuity in method, outcome and time of publication.
   Basic information is used from animal feed statistics (compound feed and their nutrient content, concentrates and their nutrient content, use and production of roughage, kg of feed per animal, etceteras), and from animal production statistics (milk production per cow, protein content of milk, egg production per hen, meat growth per animal, delivery weight of piglets, etceteras).
3. actual emission factors are calculated per year per animal category as defined in the Agricultural Census. This means that the outcome of technical administration and statistics has to be harmonised in this respect. Care should be taken to check whether basic information refers to a counted animal, a housing animal or a delivered animal.

The two calculations of nitrogen in manure are not completely independent.
Differences between nitrogen excretion (550 million kg N in Figure 1, p. 58) and the sum of manure nitrogen production and ammonia volatilisation (445 + 76 million kg N in Figure 1, p. 58) are mainly due to the use of species-specific data on animal cycles, animal production, etceteras for the calculation of the manure production.

Manure storage capacity

Manure storage capacity on livestock farms has been a subject of the Agricultural Census of 2003. Part B9 of the form deals with the manure storage capacity of animal manure on the farm site. The question is classified into storage capacity in volume (m^3) and in time (months) for three different types of manure, as there is solid manure, liquid manure and slurry. The analysis has only partly been performed and Statistics Netherlands has not yet published the data.

Data on the production and storage capacity for manure on farm level can also be obtained from the Farm Accountancy Data Network (FADN), see §2.2.2, which is a representative sample of Dutch farms. In FADN the storage capacity concerns only liquid manure and not the solid ones. These data are used in this report.

2.3 Monitoring effectiveness of the mineral policy

2.3.1 General

The monitoring of the effects of the Action Programme consists of the regular agricultural, groundwater, and surface-water monitoring programmes and a specialised monitoring programme, the National Monitoring Programme for the effectiveness of the Minerals Policy (LMM). The LMM was developed to assess the contribution of nitrate from agriculture to receiving waters and the effects of changing agricultural practice on these losses. It would thus monitor the effect of policy measures on water quality.

The LMM monitors both water quality and farm management, i.e. agricultural practice. Policy measures aim at changing farm management in such a way that water quality will improve. Water quality of groundwater and surface waters is generally not only influenced by farm practice, but also by other sources of pollution and environmental factors such as weather. To exclude other sources of pollution water quality as far as possible, on-farm waters, such as the upper metre of groundwater or soil moisture within 5 metres of the soil surface, tile drain water, or ditch water are monitored. This type of water also reflects the effect of recent management (less than 4 years ago). To be able to distinguish between the effects of measures on water quality and the effects of confounding factor, such as weather, these confounding factors are monitored as well, see Annex 1-3. The next sub-section (§2.3.2) provides more details on the LMM data collection, followed by §2.3.3 with details of data processing.

2.3.2 Data collection

LMM and FADN

When the LMM monitoring programme started up in the sandy regions in 1992, it was decided that linking LMM and FADN (see §2.2.2) would have many advantages. Linking these two would make both farm management and water quality data available to all farms. In 1996, after the evaluation of the first four-year period, it was decided to continue this co-operation. Because of the characteristics of Dutch agriculture, a high level of dynamics, the advantages of linking the FADN and the LMM were obvious. The choice for use of a changing group for the FADN was made in the second half of the 1960s. Monitoring a fixed group independent from FADN would implicate duplication of activities of the FADN, while regular replacement of farms would still occur due to the high level of dynamics (Fraters et al., in prep.). It should be marked that both FADN and LMM exclude farms from participation. For reasons of representiveness farms less than 16 ‘Dutch Magnitude Units’ (NGEs) and greater than 800 NGEs are excluded in FADN (see §2.2.2). Above these thresholds of FADN, in LMM also a minimum of 10 hectares of land farms belongs to the criteria for participation.

Main soil type areas
The Netherlands applies the Nitrates Directive Action Programme to the entire territory; nevertheless, legislation distinguishes between soil types, and measures are based on soil vulnerability to nitrate leaching. The effect-monitoring programmes therefore focus on the level of the main soil-type regions in the Netherlands, i.e. sand, loess, clay and peat. The different vulnerability situations, such as dry or wet soils (Groundwater Regime Class[3]) are taken into account in the sand and loess areas. Each of these areas can be considered as a group of similar groundwater bodies. The state of affairs with respect to the aquatic environment on farms is described for each main soil-type area. Each main soil-type area consists of one or more regions.

Main farm types
Within each main soil-type area, the LMM focuses on the main farm types with respect to acreage (i.e. arable farms and dairy farms) and sometimes includes a group of other farm types. The reason for this restriction of the sample population is to decrease the variation in farm practice and water quality within the sample and, in this way, increase the ability to observe a change in farm practice and water quality.

Sampling and other data collection
The water quality on farms is monitored by sampling soil water in the unsaturated zone below the root zone, shallow phreatic groundwater (within 5 m of the soil surface), tile-drain water and/or ditch water. Environmental data, e.g. precipitation and evapotranspiration, fraction of soil types and GRCs, are collected, and the influence of the data on the monitoring results is accounted for using modelling approaches (see §2.3.3, and Annex 2).

Sampling unit
The unit used for the sample location in the LMM is the farm. This is because Dutch legislation regulates agricultural practices on farm scale and because farm management can be monitored easier at farm level than at any other scale level: e.g. parcel, and farm management was already monitored on farm level in FADN (§2.2.2).

[3] In total, 11 groundwater regime classes are distinguished on the basis of average highest groundwater level (AHG) and average lowest groundwater level (ALG) in a hydrological year (April – April). The three highest (lowest) values in a hydrological year are averaged. Subsequently, the average of a succession of years is calculated. Mapping the GRC was largely based on field estimations using soil characteristics in combination with measurements. The influence of GRC on nitrate concentration in the upper metre of groundwater was studied by Boumans et al. (1989), who expressed this influence in a ‘Relative Nitrate Concentration’ factor (RNC), where the nitrate concentration found in soil with GWR VII* (lowest AHG and ALG) has an RNC of 1.

Sampling frequency
The sampling frequency varies between programmes and main soil-type areas. The sampling frequency is the key to the expected change in quality in time, and the variation in quality in time and space. For groundwater and surface waters, changes in nitrate concentrations in time should be relatively large if target values are to be reached. The current design of the LMM, i.e. the sampling strategy, is based on statistical analysis of the results of the research performed in the 1992-2002 period. This comprises research in the sand regions in the 1992-1995 period (Fraters et al., 1998), and in the clay (Fraters et al., 2001) and peat regions (Fraters et al., 2002a) in the 1995-2002 period. Farms were sampled each year in these periods.

This research showed three major sources of variation in nitrate concentration (in decreasing order of magnitude):
1. differences in nitrate concentration between farms,
2. differences in nitrate concentrations between years on a single farm,
3. differences in nitrate concentrations between sampling points on a farm in a certain year.

Differences in nitrate concentration between farm types were to a lesser extent a source of variation as well. The statistical analysis of the data pointed to more effectiveness by sampling more farms (and each farm) only a limited number of times in the FADN participation period than by sampling a smaller number of farms each year. The difference in nitrate concentration between farms as the most important source of variation justifies this approach.

The sampling strategy during the participation period of the farms is determined by both the importance of the sources of variation, and the organisational and financial aspects of sampling, e.g. travel time between farms and number of samples that could be taken on a farm in a day. On the basis of the importance of the sources of variation for nitrate concentration, one should first strive to maximise the number of farms in the sample population. This should be followed by maximising the number of years of monitoring on a certain farm and, finally, the number of sampling points per farm.

The potential number of farms in FADN that are eligible for participation in the LMM evaluation-monitoring programme is large. For this reason, the most cost-effective method is to sample farms in the sand and peat regions, where the upper metre of groundwater is sampled, but only in years 1, 4 and 7. However, in the clay regions, where tile drains artificially drain most of the farms and tile drain water is sampled, it is more cost-effective to sample farms each year.

Relevant farming practice information, an essential part of the FADN, is recorded each year on all participating farms in the LMM evaluation-monitoring programme. In general, data are available for years 0 - 6.

Loess region

For the loess region in the very southernmost part of the Netherlands, only data from the Provincial Soil Moisture Network of Limburg are currently available. The design for the sampling unit, the parcel instead of the farm, differs from the LMM (IWACO, 1999; Voortman et al., 1994).

Sample size

The total number of representative farms for all main soil type regions varied according to year in the 1992-2002 period (see Table 1). In total, about 880 farm samplings were performed for evaluation purposes on representative farms. In addition, another 175 farm samplings were done on specially selected farms for survey purposes, for example, to study the relationship between farm practice and water quality in more detail.
The number of different farms sampled per sub-period and the number of times they are sampled in that sub-period is given in Table 2.

Table 1: Number of representative farms where on-farm water quality was measured per farm type per year in the 1992-2002 period[*1]*.*

	Sand regions			Clay regions			Peat regions
Year	Dairy farms	Arable farms	Other farms	Dairy farms	Arable farms	Other farms	Dairy farms
1992	68 (68)	18 (18)	7 (7)				
1993	65 (65)	19 (19)	5 (50)	4 (0)	12 (0)		
1994	32 (32)		3 (3)	5 (0)	13 (0)		
1995	64 (64)	18 (18)	4 (4)	5 (0)	12 (0)		
1996							18 (18)
1997	10 (10)	10 (10)	7 (7)	2 (2)	4 (4)		
1998	17 (16)	10 (10)	17 (17)	16 (16)	11 (11)		
1999	13 (13)	8 (8)	21 (21)	23 (23)	26 (26)	3 (3)	17 (17)
2000	24 (24)	8 (8)	11 (10)	27 (27)	27 (27)	3 (3)	
2001	33 (31)	10 (10)	8 (6)	26 (26)	25 (25)	3 (3)	9 (8)
2002	27 (17)	10 (8)	19 (17)	23 (23)	22 (22)	3 (3)	25 (22)

[1)] The number of farms for which data on farm practice of the foregoing year were available are shown in parentheses.

Table 2: Number of different representative farms where on-farm water quality was measured per farm type per sub-period in the 1992-2002 period[*1].

	Sand regions			Clay regions			Peat regions
Year	Dairy farms	Arable farms	Other farms	Dairy farms	Arable farms	Other farms	Dairy farms
1992-1995	68 (3.3)	19 (2.9)	8 (2.4)	-	-	-	-
1996-1999	40 (1.0)	27 (1.0)	45 (1.0)	24 (1.7)	28 (1.5)	3 (1.0)	18 (1.9)
2000-2002	79 (1.1)	24 (1.2)	38 (1.0)	28 (2.7)	27 (2.7)	3 (3.0)	26 (1.3)

1) The average number of times farms were sampled in the sub-period is shown in parentheses.

2.3.3 Data processing

Calculating annual averages

Annual average concentrations and other parameters are calculated by averaging farm annual means. Period-average values are calculated by averaging farm period averages. Only for data from the loess region are averages based on average values per parcel; this is due to the different design of this monitoring programme (§2.3.2).

Statistical analyses and discerning effects

The residual maximum likelihood method is used to statistically analyse the relationships between farm management and nitrate concentration in recently formed groundwater (Payne, 2000). A statistical method is used to discern the effect of the Minerals policy and filter out effects of differences in weather and sample population between years (Boumans et al., 2001; 1997). This method is currently available for the programmes in the sand and clay region. A detailed description of the method is given in Annex 2.

2.4 Monitoring status and trends in groundwater

2.4.1 General

The groundwater monitoring in the Netherlands is carried out similarly to many other countries (Koreimann et al., 1996) using permanent wells specially placed for the purpose of monitoring. Permanent wells are placed outside the fields, so that groundwater sampled in the LMG is at least at a depth of 5 m – usually between 8 and 10 m - to ensure: (a) that the well screen is not in the vadose zone and (b) that groundwater sampled originated from the field. As a consequence, the quality of the groundwater at this depth reflects the effect of management practices of about a decade ago. In the next sub-section more details are given about the data collection by the LMG. In the following sub-section details of data processing are given.

2.4.2 Data collection

LMG lay-out

The National Groundwater Quality Monitoring Network (LMG), established between 1979 and 1984, comprises about 360 locations divided over the whole of the Netherlands (Van Duijvenbooden, 1987). Main criteria for site selection were type of soil, land use and hydrogeological state. At each location groundwater is sampled at depths of 5-15 m and 15-30 m below surface level. The number of well screens used for this study is given for each combination of soil type, land use and depth of sampling in Table 3.

*Table 3: Number of well screens for which complete[*1] data series are available for the 1984-2002 period, for each combination of soil type, land use and depth of sampling.*

Land use	Depth	Sand	Clay	Peat	Other
Agriculture	5-15	121	61	32	5
	15-30	120	60	32	4
Nature	5-15	55	4	4	3
	15-30	52	4	4	4
Other	5-15	36	16	2	5
	15-30	37	16	2	4

[1)] Series were complete or sufficient data were available to make estimations for missing data (see Annex 4).

Sampling frequency

From 1984 to 1998 locations were sampled annually (see results of Reijnders et al., 1998 and Pebesma and De Kwaadsteniet, 1997). After an evaluation in 1998 (Wever and Bronswijk, 1998), the frequency of sampling was decreased for certain combinations of soil type and depths. Shallow well screens in sandy regions are still sampled every year; while shallow well screens in other regions (clay and peat) are sampled every two years. Deep well screens are sampled every four years; shallow well screens with high chloride concentrations (more than 1000 mg/l due to marine influence) are also measured every four years. Finally, well screens dominated by local conditions, for example, near rivers and local sources of pollution, are eliminated. In this way, the number of well screens to be sampled each year has been reduced from 756 to about 350. The National Institute for Public Health and the Environment is responsible for the network and data interpretation, and reporting.

2.4.3 Data processing

Because of the design of LMG there are locations (well-screens) that are not sampled each year. In order to avoid apparent trends, as a consequence of the design, an estimate is made for all missing data, calculated by interpolating the available data. For data lacking at the beginning and end of the series, the first (beginning) or the last (end) available value is used as an estimation of the missing data. Annual average concentrations are calculated by simply averaging measured concentrations. Period-average concentrations are calculated by averaging period averages per location. More details on the data processing are given in Annex 4.

The data presented in this report may slightly deviate from the data presented in national Environmental Balance. Consistent with the previous report, for this study a larger number of wells-screens was used for analysis due to a less strict criterium with respect to missing data inthe 1984-2002 period.

2.5 Monitoring status and trends in surface-water quality

2.5.1 General

The surface-water monitoring networks comprise the monitoring networks for regional and main fresh waters, and coastal and marine waters. Even a regional water station is representative of an area larger than a farm, thus distinguishing it from the LMM (see §2.3). As a consequence, the influence of other sources of pollution and the time between measurement and effect increase in the following order of importance: regional waters > main fresh surface waters > coastal waters > open sea. Details of the data collection are given in the next sub-section (§2.5.2), followed by details of data processing in §2.5.3.

2.5.2 Data collection

Both national and local authorities perform surface-water quality monitoring. The national authorities are responsible for the Monitoring Water Status of the Country (MWTL) and the local authorities for the Regional Water Status Networks.

Monitoring the Water Status of the Country (MWTL)

The Department of Public Works of the Ministry of Transport, Public Works and Water Management collects data at 39 stations in marine waters (including the estuary) and at around 30 stations in main (national) fresh surface waters. These are larger rivers, canals and lakes. The frequency of sampling in marine waters is once a month in winter and once every two weeks in summer. The sampling depth for marine waters is about 1.5 m below water level, and for North Sea locations, 3.5 m below the water level. For most locations (23), nutrients, common parameters (temperature, oxygen, etc) and phytoplankton (species composition and chlorophyll) are determined, while for the other marine stations only nutrients and common parameters are determined. The frequency of sampling at most main freshwater stations is once every four weeks, for stations bordering on Germany and Belgium it is once every two weeks. The sampling depth is about 0.5 – 1.0 m below the water level. Samples are analysed for nutrients, common parameters and chlorophyll.

The National Institute for Coastal and Marine Waters (RIKZ) is responsible for the interpretation of the marine water data. The Institute for Inland Water Management and Wastewater Treatment (RIZA) is responsible for the fresh surface-water data.

Regional Water Status Networks

The 27 regional Water Boards and some of the regional departments of public works all have their own Regional Water Status Networks (RWSNs). These RWSNs comprise several thousands of freshwater monitoring stations in regional waters. The frequency of sampling varies but is usually once every four weeks. Depth of sampling depends on local conditions but is normally about 0.5 – 1.0 m below the water level.

The Commission for Integral Water Management (CIW) conducts an annual survey of water quality data of the main RWSN stations. In 2002 this survey comprised about 350 freshwater stations (CIW main stations), representative for the larger regional water systems, while in 1992 the number was around 250 (see Table 4). The water quality of these CIW main stations is not only influenced by agriculture but also by other sources, and in summer also by water inlets from the main water system. Therefore an additional survey was performed by CIW to collect data for smaller regional waters. These water stations should meet the following requirements:

1. water quality to be mainly influenced by agriculture
2. station representative of a larger area than a field or farm
3. station representative of soil types in the region
4. data available for all years since 1992 with continuing data collection.

These water stations, about 200, are called CIW agricultural stations. Nevertheless, the number of monitored agricultural-influenced, regional water stations for which data are available increased to 280 in 2002, see Table 4. There are some indications that water quality of at least some of the stations is influenced by other sources than agriculture. The CIW main stations are called ‘other regional water stations’.

The fluctuation in numbers of regional water stations in time is due to:

1. changes in number of locations in the RWSNs of the Regional Water Boards.
2. additional information provided by the Regional Water Boards in the next survey on request of the CIW.

The data presented in this report might (slightly) deviate from the data presented in the 2000-report (Fraters et al., 2000). On request of CIW the Regional Water Boards provide each time complete series of data for all relevant stations for the entire period. Any errors in previous databases will have been eliminated.

2.5.3 Data processing

Nitrate concentration

For fresh water the data on nitrate actually concerned ‘nitrate + nitrite’. For most stations only data on ‘nitrate + nitrite’ were available. For a few stations only data on nitrate were available for one or more years. Because nitrite concentrations in fresh water are very low compared to nitrate concentrations, the sum of nitrate and nitrite is present here as nitrate.

Table 4: Number of unique sample locations for fresh surface waters in the Netherlands in the 1985 – 2002 period, distinguished into national surface-water stations, agriculture-influenced regional stations, and other regional surface-water stations.

Year	National	Agricultural	Others
1985	21	157	173
1986	27	170	201
1987	28	181	215
1988	30	184	213
1989	25	189	240
1990	25	195	238
1991	25	186	231
1992	26	201	256
1993	25	199	258
1994	23	203	268
1995	23	183	263
1996	23	186	282
1997	23	197	306
1998	23	213	300
1999	23	223	314
2000	24	245	346
2001	24	256	362
2002	24	280	354

Balanced database

Similar to what was done for the processing of groundwater data, a supplemented or balanced database was made to tackle the problem of a changing number of surface-water sampling stations in the 1985-2002 period. This database was constructed in two steps. First, minor gaps were bridged. If, for a specific station in a certain year, no data were available, the average of the available values in the period ‘year –2’ up to and including ‘year + 2’ was used as estimate. If no data were available in that period, the station was marked as a ‘no data’ station. Second, all stations where data were still missing were removed from the database after the first step. So only stations with data (measured or estimated) for all years remained, see Annex 5 for details.

The tables and maps showing the status for each period and trends between periods are based on the original database. For each surface-water station an average value is calculated per period; this value can be based on 1 to 3 annual averages or maximum. All the stations that have been monitored in these two periods are used to compare the two periods.

Annual average values
The figures with winter and summer-averages and maximum in the 1984–2002 period are based on the supplemented database. The winter and summer-averages and maximum are calculated as the average of the winter and summer averages, and the respective averages of winter and summer maximum for all surface-water stations.

Definition of summer and winter
The six summer months are the most critical period with respect to eutrophication. The EU standard for nitrate is primarily aimed at assessing the effects of agriculture on surface water quality. Here the winter months, the period in which leaching plays a significant role, are of particular importance.
The winter period for fresh surface waters runs from October up to and including March, and for marine waters from December up to and including February, for obvious reasons. To make inter-annual comparisons of N for marine waters as measure for water quality (eutrophication) meaningful the data are analysed for the months were biological activity is close to zero. For the marine environment the data indicate that biological growth and therefore interference already occurs in March and the March data is for this purpose not suitable for nutrient trend analyses. The summer period runs from April up to and including September.

Variation in salinity
During the winter period nutrients show a more or less conservative behaviour and a clear linear relationship with salinity; an increase in concentration with decreasing salinity (i.e. an increase with increasing distance from the river mouth). In order to compensate for differences in salinity at the various locations from one year to another (due to differences in yearly river discharges), nutrient concentrations are usually normalised for salinity (Bovelander and Langenberg, 2004).

For the present study on nutrient trends no salinity correction was carried out for the results presented in the format of the reporting guidelines. Consequently, the conclusions on the inter-annual in-depth studies on trends in nutrients presented in this way are affected by inter-annual differences in riverine water discharges (as a consequence of differences in rainfall etceteras) and should be considered with care. Therefore, additional figures are presented. These figures present inorganic nitrogen concentrations after salinity correction for a number of locations in Dutch coastal waters. Dissolved inorganic nitrogen (DIN) is the sum of nitrite nitrogen (NO_2-N), nitrate nitrogen (NO_3-N) and ammonium nitrogen (NH_4-N). DIN is standardised to a salinity of 30 psu. PSU stands for Practical Salinity Units. The Dutch zone of the North Sea contains on average about 3.5% sodium chloride (NaCl) or about 35 psu. This presentation of data is in accordance with the OSPAR Comprehensive Procedure, and shows the long-term trend in inorganic nitrogen concentrations corrected for the effects of rainfall.

2.6 Monitoring status and trends in water used for drinking-water production

2.6.1 General

Water production companies carry out monitoring programmes focusing on quality control of the water resource (both groundwater and surface waters), the production process and the end product. Companies report results annually to the national Inspectorate for the Environment, which is a statutory obligation. Data management and reporting are carried out by RIVM. This report uses data on quality of water resources and not the quality of the end product (tap water). The lag between measurement and effect on water quality of water resources used for drinking water production is usually large. Details of the data collection are given in the next sub-section (§2.6.2), followed by the sub-section on details of data processing (§2.6.3).

2.6.2 Data collection

In 2001 drinking-water production in the Netherlands was covered by 21 companies (VROM, 2003). About 65% of the drinking water originates from groundwater (Joosten et al., 1998). There are about 200 groundwater production sites, of which 120 deliver from phreatic (unconfined) groundwater and 80 from confined groundwater. There are about another 30 sites where drinking water is produced from riverbank groundwater, dune infiltration groundwater and surface water, see Table 5. The average depths of the groundwater used for drinking-water production for phreatic aquifers is 45 m, with an average depth for the upper part of the well screen of 30 m and for the lower part, 65 m.

2.6.3 Data processing

Just as for the processing of data for fresh surface water (§2.5.3), a supplemented database was made to tackle the problem of the changing number of drinking-water production stations in the 1992-2002 period. This database was constructed in two steps. First, minor gaps were bridged. If no data were available for a specific station in a certain year, the average of the available values in the period ‘year –2’ up to and including ‘year + 2’ was used as estimate. If no data were available in that period, the station was indicated as a ‘no data’ station. Secondly, all stations that were still missing data were removed from the database, so only ‘data’ (measured or estimated) stations for all years remained.

The drinking-water data are used in the chapter on groundwater (Chapter 5, §5.4) for production stations using phreatic and confined groundwater. The data are also used in Chapter 6 (included in the surface-water database) for production stations making direct or indirect use of surface waters.

Table 5: Number of sample locations for drinking-water production in the Netherlands in the 1992–2002 period, with production sites distinguished into type of water used, i.e. phreatic groundwater, confined groundwater, direct surface-water intake, surface water after dune infiltration and surface water after river bank infiltration

Year	Phreatic groundwater	Confined groundwater	Surface water	Dune infiltration	River-bank infiltration
1992	127	86	8	9	13
1993	126	85	9	9	14
1994	125	87	9	8	14
1995	123	86	10	8	15
1996	123	86	10	8	14
1997	121	87	9	7	14
1998	120	86	9	7	13
1999	117	86	9	8	13
2000	117	87	9	6	12
2001	113	82	7	6	12
2002	105	84	6	5	13

The figures with annual averages and maxima for the 1992-2002 period are based on the supplemented database. The annual averages and maximum are calculated as average averages and average maximum of all drinking-water stations, respectively

The tables and maps showing the status for each period and trends between periods are based on the original database. For each drinking-water station an average value, which may be based on 1 to 3 annual average or maximum values, is calculated per period. Only the stations that have been monitored in both these periods are used to compare them.

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3. AGRICULTURAL PRACTICE

3.1 Introduction

This chapter discusses the trend of agricultural practice in the Netherlands, in general, and nitrogen and phosphorus use in Dutch agriculture, in particular, for the 1992-2002 period. First presented are the changes in land use, number of farms, livestock etceteras resulting from policy measures as well as autonomous developments (§3.2). The nitrogen and phosphorus balance of the agricultural system are discussed in §3.3, followed in §3.4 by a description of the other implications of the measures stipulated in the Code of Good Agricultural Practice (LNV, 1993a). The Dutch policy measures in the first (1995-1999) and second Action Programme (1999-2003) will be summarised first. Here, two periods can be distinguished that do not coincide exactly with the Action Programme periods, i.e. 1996-1998 and 1999-2003. More details are given in the subsequent sections.

In the 1996-1998 period the desired changes in agricultural practice were effectuated by limiting the amount of manure production (‘production rights’) in combination with a system of manure bookkeeping on livestock farms. In this period the following regulations applied to all farms:

1. the maximum amount of minerals to be applied (application standards);
2. the period of the year in which application of manure is prohibited because of the risk that nitrogen leaching will take place;
3. the way in which manure may be applied so as to reduce ammonia emission;
4. the covering of manure storage facilities to avoid ammonia emission.

In 1998-2003 period a new system was introduced and developed. The system of manure bookkeeping was replaced in 1998 by the system of minerals accounting at farm level based on the mineral balance of nitrogen (N) and phosphorus (P) (farm gate balance). In this system limits are set at the level of the N and P surplus of farms (so-called MINAS loss standards). The loss standards were gradually tightened. For nitrogen, both N fertilisers and manure N were included in this system. At first (1998-2000) the minerals accounting system was only effective for the larger livestock farms (> 2.5 LU/ha). Since 2001 this system has been in effect for all farms. Lower loss standards for N also became effective for cultivated land on sand and loess soils vulnerable to nitrogen leaching.
On 1 January 2002 the system of Manure Transfer Contracts (MAO) became effective in order to comply with the Nitrates Directive application standards for manure. Livestock farmers who produce too much manure have to enter into manure transfer contracts with arable farmers, other (less intensive) livestock farmers or those processing manure (called ‘manure processors’), for example. For calculating the exceedance of the allowable manure production the application limit is 170 kg/ha N, with a higher level of 250 kg/ha for grassland, in agreement with Dutch notification of derogation at that time. Farmers who are

unable to enter into manure transfer contracts for their excess manure will have to reduce their livestock numbers. Extensive advisory efforts and demonstration projects have accompanied this policy change.

3.2 Developments in agriculture

3.2.1 Land use

In the Netherlands the Nitrates Directive Action Programme applies to the whole of the country. In this respect land use is reported at the national level, see Table 6. The total land surface area is 3.38 million ha, with a cultivated area of 1.92 million ha (CBS, 2004a). Land use in the different reporting periods is presented in the table below.

Table 6: Land use in the Netherlands (x1000 ha).

Land use	1992-1994	1996-1998	2000-2002
Grassland - permanent	1024	966	892
- temporary[1)]	35	72	110
Silage maize	225	225	208
Other arable crops	576	584	602
Horticulture	111	112	113
Total cultivated area (receiving fertilisers/manure)	1971	1959	1924
Fallow land	10	11	18
Nature and forest areas [2)]	452	478	484
Other land use (urban, roads, leisure, etc.)	955	932	952
Total land surface	3388	3380	3378

Source: CBS, 2004a

1) Temporary grassland: land that a farmer will use as grassland for less than 5 years.

2) Data only available for the years 1993, 1996 and 2000.

In the 1992-2002 period the total cultivated area steadily decreased as a result of land claims for nature development, expansion of urban areas and the construction of roads. In this period about 47,000 ha of cultivated land was consigned to other land use. This corresponds to a decrease of 2.4%.

Organic farming

The organic farming production area (no fertilisers used), increased 4 fold in the 1991-2002 period and currently amounts to about 2% of the total cultivated area. Dairy farms account for the greatest part of the organic farm area.

3.2.2 Number of farms

The trend of the number of farms is presented in Table 7. The total number of farms decreased by 20% in the 1992-2002 period. There are differences in the extent of the decrease between farm types. The number of dairy farms decreased by19%, horticultural farms by 23%, and pig and poultry farms by 31%. The percentage of farms where farming is the main occupation of the farmer increased on average from 82% to 87%. This increase occurred for all farm types, except for arable farms.

Table 7: Total number of farms and number for each of the main farm types in the Netherlands per period[*1]*.*

	1992-1994	1996-1998	2000-2002
Arable farms	14,736 (82)	14,540 (80)	13,139 (82)
Horticultural farms [*2]	22,664 (87)	20,444 (91)	17,404 (93)
Dairy farms [*3]	56,936 (81)	51,334 (84)	45,879 (87)
Pig and poultry farms [*4]	11,191 (80)	10,023 (84)	7,740 (87)
Combinations	13,151 (79)	11,480 (82)	9,119 (86)
Total	118,678 (82)	107,820 (85)	93,282 (87)

Source: CBS, 2004a

1) The percentage of farms where farming is the main occupation of the farmer is given in parentheses.
2) Including farms with permanent cultivation
3) Farms with cows and sheep (grazing animals)
4) Farms with pigs, poultry and/or intensive veal calves

3.2.3 Livestock numbers

The trend in the number of heads of livestock in the Netherlands in the 1992-2002 period is given in Table 8. The figures concern the number of heads and not livestock units. The number of cattle and pigs decreased by 17% and 14%, respectively, in this period, while the volume of the poultry livestock increased by 6%. The maximum number of dairy cows is fixed by the milk quota. Due to an increase in milk production per cow, the number of cows needed to produce the amount of milk permitted by the quota decreased.

Table 8: Livestock numbers (million) in the Netherlands in the reporting periods.

Category	1992-1994	1996-1998	2000-2002
Cattle	4.8	4.4	4.0
Pigs	14.6	14.4	12.6
Poultry	95.7	94.4	101.8
Sheep/goats	1.9	1.6	1.5

Source: CBS, 2004a

3.2.4 Manure nitrogen and phosphorus production

Manure nitrogen production per head decreases for all animal species in the 1992-2002 period, see Table 9. This is mainly due to a combination of a reduction of the nitrogen content of fodder and an increase in efficiency of the fodder conversion. The calculated amount of produced nitrogen per head is larger than the amount of manure nitrogen applied to the soil, because part of the nitrogen is lost via volatilisation during storage and application.

Table 9: Gross nitrogen excretion per animal category (kg per animal per year).

Animal type	1992-1994	1996-1998	2000-2002
Dairy cow	140.2	139.1	127.7
Young cow (1-2yr.)	92.7	94.2	81.7
Pigs for meat production	14.6	13.6	12.0
Sow (with piglets)	31.3	30.4	30.4
Chickens for meat production	0.60	0.59	0.53
Laying hens	0.87	0.73	0.67

Source: CBS, 2004a

Cattle are responsible for about 60% of the total nitrogen production by Dutch livestock, see Table 10. Pigs contribute about 23% and poultry about 12% to the total nitrogen production by livestock. The total annual nitrogen production by livestock amounts to 509 million kg in the 2000-2002 period, which is about 24% lower than the production in the 1992-1994 period. This decrease is caused mainly by a decrease in nitrogen production by cattle (-25%) and pigs (-28%) as a consequence of a decrease in nitrogen production per head and a decrease in the livestock volume.

Table 10: Manure nitrogen production (million kg N per year).

Category	1992-1994	1996-1998	2000-2002
Cattle (exc. calves)	410	376	305
Calves	7	10	12
Pigs	154	142	111
Poultry	72	65	62
Other (sheep, goat, fur-bearing animals, etceteras.)	24	23	19
Total livestock	668	615	509

Source: CBS, 2004a

The phosphorus production of the Dutch livestock decreased by about 20% between the first and third reporting periods, see Table 11, and is mainly due to a decrease in phosphorus production by pigs and cattle. In the 2000-2002 period half the production was accounted for by cattle, a quarter by pigs and less than one-fifth by poultry.

Table 11: Manure phosphorus production (million kg P per year).

Category	1992-1994	1996-1998	2000-2002
Cattle (exc. calves)	49	42	40
Calves	1	2	2
Pigs	30	24	20
Poultry	15	13	14
Other (sheep, goat, fur-bearing animals, etc.)	3	3	3
Total livestock	98	84	79

Source: CBS, 2004a

3.3 Nutrient balances

3.3.1 Nitrogen balance of the agricultural system

Figure 1 depicts the N flows in the Dutch agricultural system for the year 2001. This balance combines the balance of the livestock production system with the soil surface balance.

Inputs are imported fodder, purchased fertilisers and a number of smaller inputs, including atmospheric nitrogen deposition from other sources in the Netherlands and from abroad (mainly as NO_x). The output is represented by a combination of the sale on the market and export of agricultural products, the export of manure, and the emission and transport of ammonia via the air. The figure illustrates the importance of the different flows. There are two important return flows; first, the harvested crops, used as fodder for livestock and, second, the atmospheric deposition of ammonia from manure and fertilisers on cultivated soil.

The difference between input and output is the surplus on the national farm gate balance (blue colour), along with the surplus on the national surface balance (yellow colour). The difference between these two surpluses –due to a difference in calculation of excretion and of manure production– is about 6% (see §2.2.3).

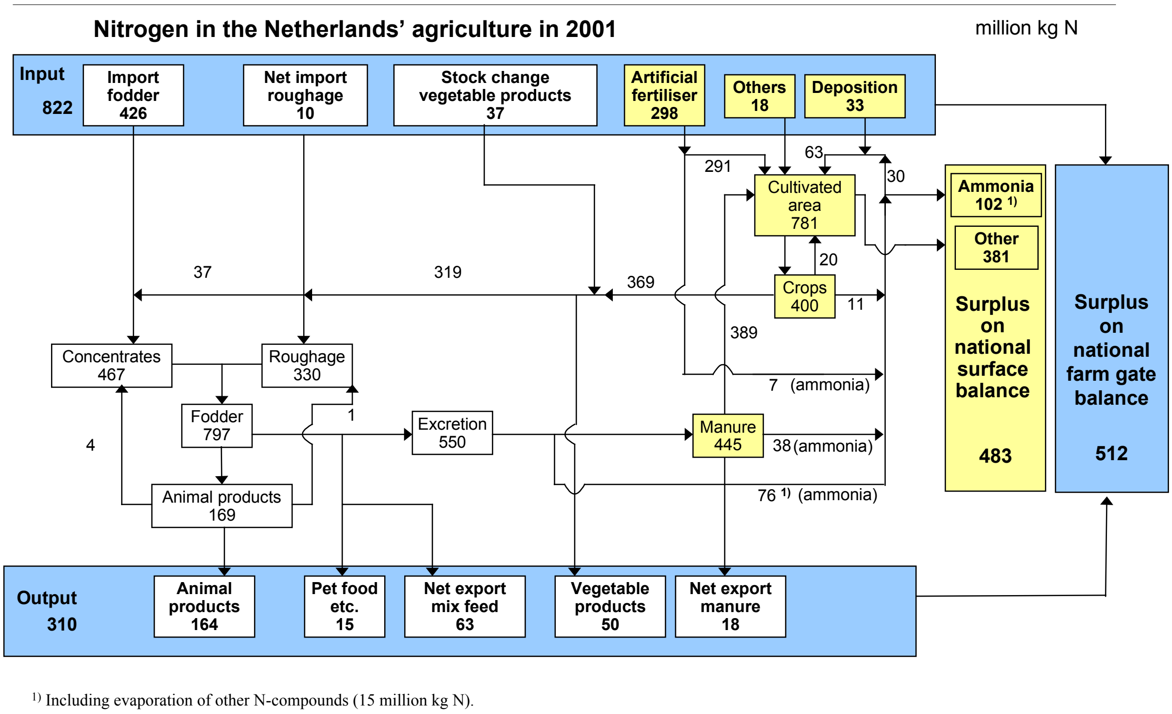


Figure 1: N flow diagram of the Dutch Agricultural system, 2001.
Source: CBS, 2004b.

3.3.2 Soil surface nitrogen and phosphorus balance

The 'soil surface balance' for nitrogen is given in Table 12 for the three reporting periods. The surplus of this balance is the net input to soil. The nitrogen surplus is on average 367 million kg for the 2000-2002 period, which is 26% lower than in the preceding period. The surplus given in Table 12 is similar to the item 'other' for the surplus on the national surface balance in Figure 1. The effect of this surplus on the environment, i.e. fate of the N surplus, cannot be explained on the basis of statistical data. The surplus may partly leach into groundwater and/or surface water, or may partly be denitrified (see §2.2.3).

The connecting link between the 'soil-surface balance' and the 'farm gate balance' approach, presented in other sections, is the production of manure. In the flow diagram in Figure 1 excretion is computed as the difference between consumed fodder and the agricultural production on the national scale. The manure production is also computed per animal in a similar way and multiplied with the total number of animals (see §2.2.3).

Table 12: Nitrogen soil surface balance in million kg N per year for total cultivated area for each reporting period

	1992-1994	1996-1998	2000-2002
Input*1 as:			
- manure	501	453	375
- fertilisers	377	387	299
- atmospheric deposition	75	79	63
- other*2	40	39	39
Total input	993	958	776
Output (harvested crops)	492	461	409
Surplus	501	497	367

Source: CBS, 2004a

1) NH_3 emission from manure and fertiliser is excluded.

2) Includes: Crop residues, seeds and plant materials, other organic fertilisers (e.g. compost).

The nitrogen input to the cultivated soil accounts for all input items including atmospheric deposition, biological nitrogen fixation and smaller items such as N-containing pesticides. The largest inputs are manure and fertilisers, which are corrected for ammonia emission during grazing and application.

The total nitrogen input in Table 12 shows a decrease of about 19% between the 1996-1998 period and the 2000-2002 period. This is larger than the 4% decrease between 1992-1994 and 1996-1998. The largest input term (manure) shows a decrease of nearly 25% between the first and last period, whereas the fertiliser input is nearly 21% lower.
The nitrogen output consists completely of the crops harvested from the fields. The harvest differs from year to year due to variable weather conditions. It is plausible that the nitrogen uptake has decreased but there is no indication that crop production has decreased due to lower nitrogen fertilisation. The nitrogen output in 2000-2002 period is about 17% lower compared to the 1992-1994 period.

The soil surface balance for phosphorus for the three reporting periods is depicted in Table 13. The main input items are manure and, to a lesser extent, artificial fertiliser. Both are reduced by almost 25% in the 1992-2002 period. The surplus was reduced by more than 35%, because the output via harvested crop was only reduced by 8%.

Table 13: Phosphorus soil surface balance in million kg P per year for total cultivated area for each reporting period.

	1992-1994	1996-1998	2000-2002
Input as:			
- manure	95	80	72
- fertilisers	31	29	24
- atmospheric deposition	2	2	2
- other*1	5	4	4
Total input	133	116	102
Output (harvested crops)	62	56	57
Surplus	71	60	45

Source: CBS, 2004a

1) Includes: crop residues, seeds and plant materials, biological N fixation, other organic fertilisers (e.g. compost) and pesticides.

In order to see the effects of weather and other influences in a broader perspective, see trends in nitrogen and phosphorus surplus from 1970 onwards plotted in Figure 2 using 1970 as a reference year (index 1970 = 100%; first year for which nutrient balances are calculated).

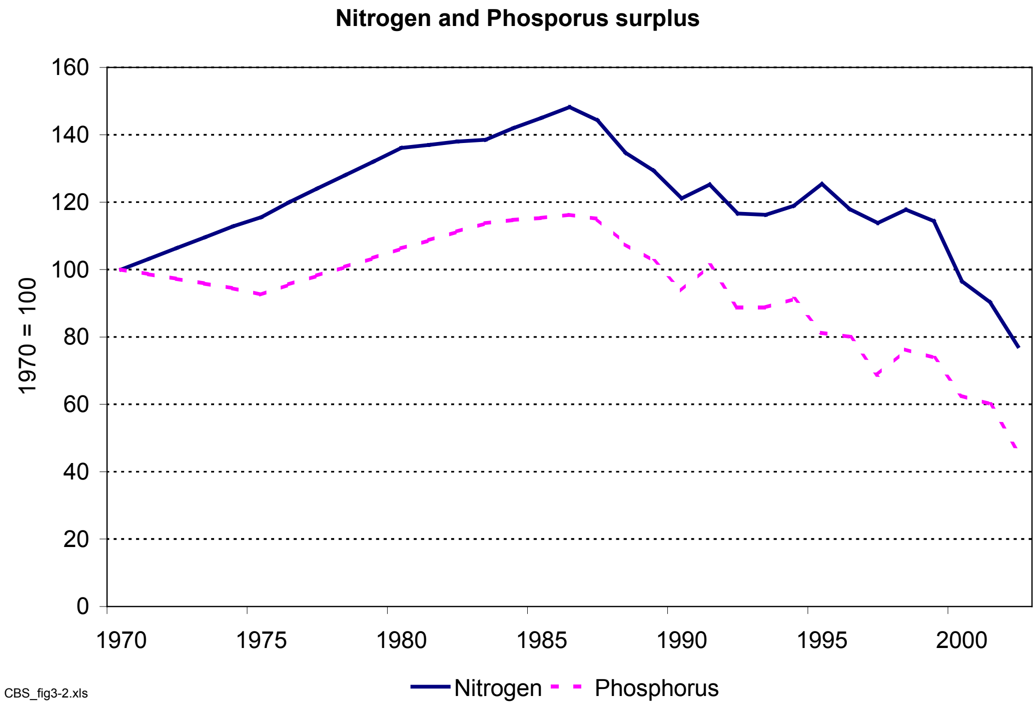


Figure 2: Trend of the nitrogen and phosphorus surplus in Dutch agriculture in the 1970-2002 period, with the 1970 value fixed at 100.

Source: CBS, 2004b.

The nitrogen surplus showed a nearly continuous decrease in the 1986-1990 period. This trend stagnated in subsequent years (1991-1998) and the year to year fluctuations in Figure 2 can be mainly attributed to weather-based fluctuations in crop production. The nitrogen surplus decreased substantially since 1998. The nitrogen surplus decreased substantially since 1998. This can be largely attributed to the new regulatory system based on the farm gate balance (MINAS) introduced in 1998, especially for dairy farms which reduced the use of nitrogen fertiliser by 40-50% (RIVM, 2004). The phosphorus surplus shows a nearly continuous decrease over the entire 1986-2002 period. This decrease is mainly a result of the decrease in the manure produced by livestock numbers and more efficient feeding practice (see Table 11).

3.4 Developments in agricultural practice

3.4.1 Introduction

The previous section dealt with the use of nitrogen and phosphorus. The present section deals with other aspects of the code of Good Agricultural Practice. First, attention is paid to the regulations with regard to total nitrogen use and manure application, including transport of manure and method and period of application, fertilisation close to waterways, winter-cover crops and irrigation (§3.4.2). Next, figures are provided on the manure storage capacity in the Netherlands (§3.4.3). After that, notice is taken of the efforts with respect to fertilisation advice, demonstration projects and counselling (§3.4.4), and of other developments (§3.4.5) such as winter cover crops, irrigation and limiting of the ammonia emission. In the last sub-sections attention is paid to compliance with the code of Good Agricultural Practice, the Mineral Accounting system and Manure Transfer contracts, and of other aspects in the agricultural regulations (§3.4.6).

3.4.2 Regulation of manure application and nitrogen surplus

Application and surplus standard

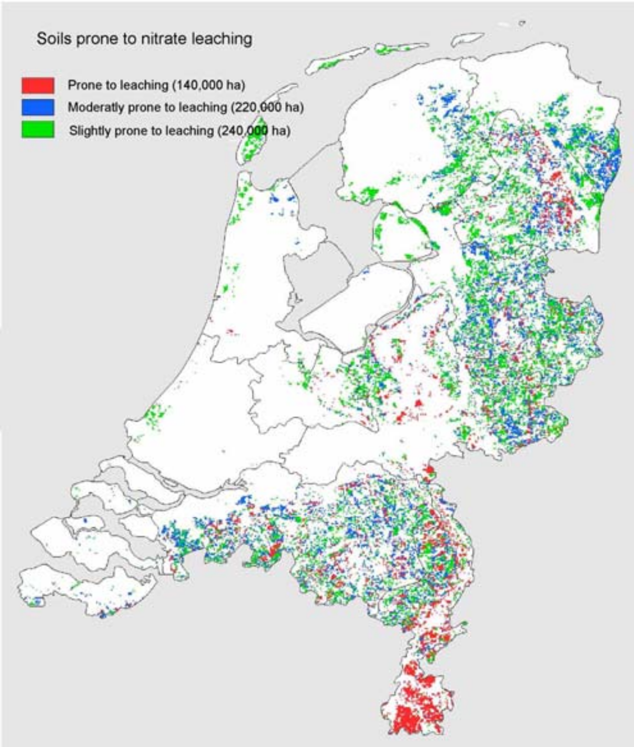
During the report period legislative measures were taken to limit the maximum quantity of livestock manure that could be applied to the land. Moreover, rules were drawn up with respect to the period and manner in which the livestock manure could be applied. The use of livestock manure was also further limited by means of the manure legislation. This was effected by a tightening of the application standards based on the phosphate content of the manure prescribing a maximum level for the use of livestock manure (see Table 14). In this way, the maximum nitrogen emission via livestock manure is also further limited.

Table 14: Manure application standards in the 1987-2000 period in kg/ha P_2O_5

Year	Grassland	Silage maize	Arable land
1987-1990	250	350	125
1991-1992	250	250	125
1993	200	200	125
1994	200	150	125
1995	150	110	110
1996-1997	135	110	110
1998-1999	120	100	100
2000	85	85	85

Source: LNV, 2001b, 1997, 1993b

In 1998 the Dutch government introduced the mineral accounting system (MINAS). This system regulates the N and P surplus of farms (farm gate balance). A certain amount of N and P surplus is considered to be acceptable and is free of levy. This amount is defined as the loss standard. When farmers have a surplus that exceeds these loss standards they have to pay a levy. These levies have been progressively raised from 1998 to 2003. The MINAS system was introduced in phases. Firstly (in 1998), it applied to livestock farms with high animal density (> 2.5 LU/ha). In 2001, it applied to all farms. The levy free loss standards for N in 1998-2002 are given in Table 15.



Map 1: Map showing the soils prone to nitrate leaching in the Netherlands (red areas)
Source: LNV, 2001a

The MINAS system has a greater significance than the old system that focused only on manure. The MINAS system includes regulation of fertiliser nitrogen and nitrogen fixation by legumes (arable land only). In 2002 special lower nitrogen loss standards were introduced for farms with soils prone to nitrate leaching. In total, 140,000 ha soils prone to nitrate leaching have been designated, see Map 1.

Table 15: Nitrogen loss standard in the 1998-2002 period in kg/ha as N, for arable land and grassland on clay, peat, sand and loess soils[*1]

	Grassland	Arable land	
Year	All	Clay/Peat	Sand/Loess
1998-1999	300	175	175
2000	275	150	150
2001	250	150	125
2002	220/190[*2]	150	110/100[*2]

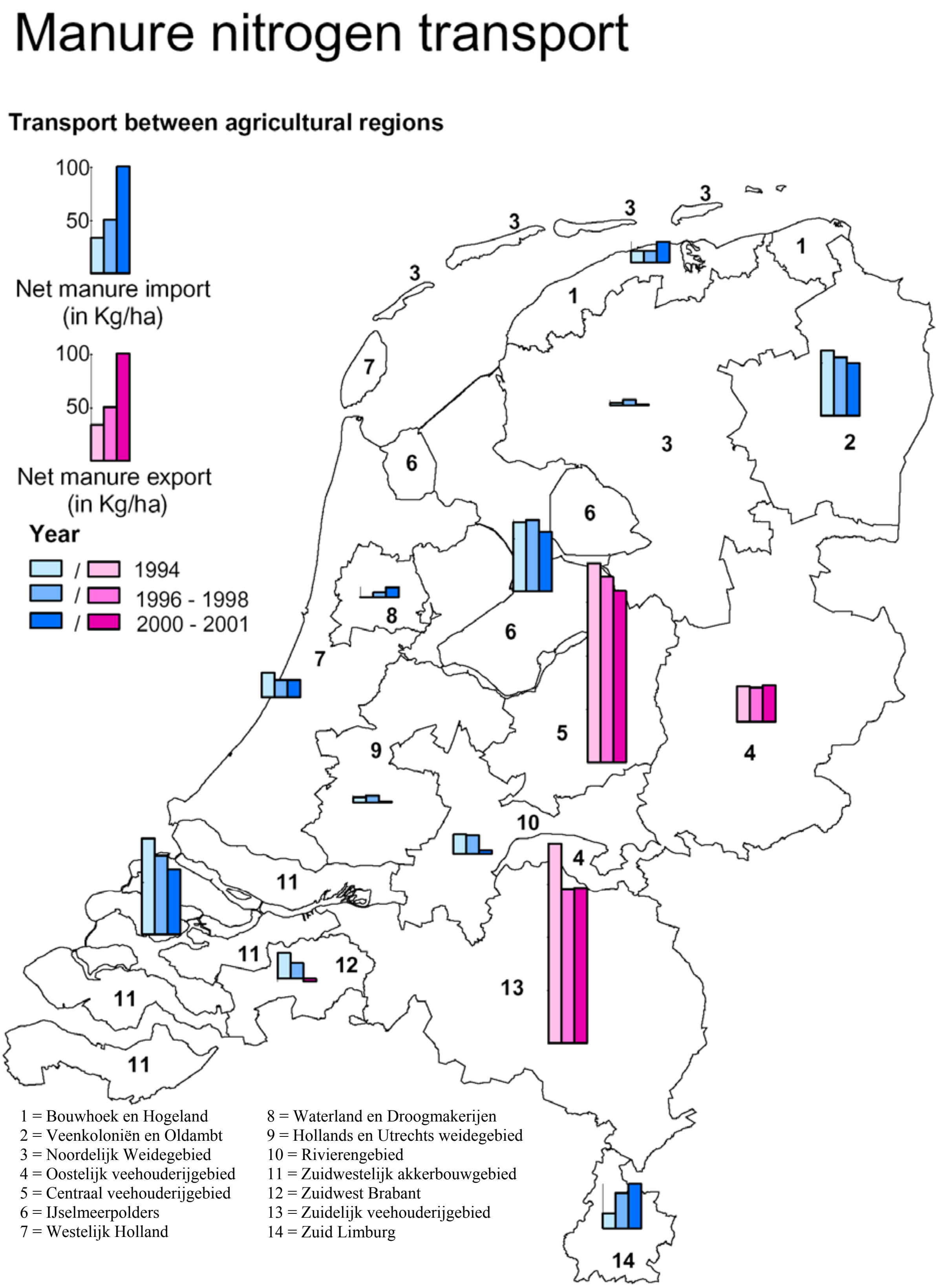
Source: LNV, 2001b, 1997

[1)] Vulnerable soils are those sand and loess soils that are prone to nitrate leaching, or soils with groundwater levels at greater depth than average.

Transport and disposal of manure

Due to the tightening of the application standards for livestock manure, increasing amounts of livestock manure had to be transported from farms with a nitrogen surplus to other farms, where there was space to accommodate this. Initially, as much of this excess manure as possible was transferred to nearby farms. However, in addition to this, manure increasingly needs to be transported over greater distances. This is mainly from areas where there are many farms with a surplus and where there is therefore a surplus at a regional level.
Map 2 gives the average size of this large distance transport for the years 1994, 1996-1998 and 2000-2001, expressed as the quantity of nitrogen per hectare (CBS, 2004a). A net import (blue colour) means that on balance, more nitrogen has been imported into an area in the form of manure, and a net export (red colour) means that on balance, nitrogen has been exported from the area concerned.

This map shows that manure transports mainly take place from the Central Livestock Area; no. 5 on map, and the Southern Livestock Area; no. 13, to the South-Western Arable Area; no. 11, the IJsselmeerpolders (Lake IJssel polders; no. 6) and to Veenkolonieën and Oldambt (Reclaimed Peat Areas; no. 2). In 1994, about 155 million kg of nitrogen was moved in the Netherlands by means of manure transports. In the 1996-1998 period this was about 128 million kg and in the 2000-2002 period about 100 million kg. This decrease is due to the smaller production of pig manure, particularly in the Southern Livestock Area (-30%) and in the Central Livestock Area (-18%).



Map 2: Net manure transport (as nitrogen N kg/ha) between agricultural regions in the Netherlands

Source: CBS, 2004b, 2004c

Manure application, method and period

In the 1993 to 1997 period, both the period and the method of manure application were subjected to an increasing number of limitations. The rules for the method of application were specifically targeted at limiting the emission of ammonia to the atmosphere (see §3.4.5). The manure application on sand and loess soils (see Map 3) took place according to the legislation as illustrated in Figure 3. Since 1995 manure can only be spread on these soils from 1 February to 1 September, if this is done in a low ammonia-emission manner. On grassland in clay and peat areas manure may be spread until 15 September. On arable land on clay, manure may be spread throughout the entire year as long as this is done in a low ammonia-emission manner.

Map 3: Map showing the sand and loess areas in the Netherlands (yellow areas)
Source: LNV, 1991, Appendix 1

	Febr	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**
	Sand and loess soils											
Grass & arable												
	Other soils (clay and peat soils)											
Grass cover												
Arable												

Key:

	Low NH_3-emission application allowed
	Application prohibited

Figure 3: Regulations on the period and method of manure application from 1996 onwards.

Since 1994 a ruling has been effective in the Netherlands which states that livestock manure must be incorporated into the soil within several hours of being applied in order to reduce the volatilisation of ammonia. This requirement does not apply to solid manure on grassland and in fruit stands.

In addition to the requirements for the period of manure application, such as those stated in Figure 3, the application of manure to ground partially or completely covered with snow has been prohibited in the Netherlands since 1994. In 1998 this ban was extended to include the spread of livestock manure on completely or partially frozen ground (this rarely occurred in practice due to the requirement to incorporate the manure into the soil).

Since 1999 it has also been prohibited to use livestock manure or nitrogen fertiliser if the top layer of the soil is waterlogged. In practice, this already rarely occurred because the equipment needed for low ammonia-emission application of livestock manure is heavy and therefore causes a lot of damage to the grass and soil structure under wet conditions.

Fertilisation close to waterways

The requirement to spread manure in a low ammonia-emission manner not only limits the ammonia emission and the associated nitrogen deposition, but it also has a favourable effect on the surface water quality. With the aid of low ammonia-emission application techniques the manure is better spread and incorporated in or under the sods. This prevents the surface run-off and direct entry of the manure into watercourses.

In addition to this, the ban on manure application on sand and loess soils during the winter months has prevented the application of manure during the wettest period. As a result of this, the chance of nitrogen entering watercourses due to surface run-off has been limited.

Since 2000, the watercourses have also been protected against pollution by means of the Discharge Open Cultivation and Livestock Farming Decree, which includes rules concerning the manner (distance) of manuring in the vicinity of watercourses. A strip of ground next to a watercourse, a so-called buffer strip, may not be manured. The width of this buffer strip varies from 0.25 m to 6 m (in special cases up to 14 metres) and is equivalent to the width of the strip, which may not be sprayed with pesticides. When spreading fertilisers along watercourses and/or their buffer strips it is obligatory to use a limiter for boarder spreading, to prevent the fertiliser from entering the watercourse and its buffer strip. These rules are usually complied with; at about 91% of farms the buffer strip has the required width (Vroomen and Van Veen, in prep.).

3.4.3 Storage capacity of manure

During the reporting period, the Netherlands had no legislative rules for the minimum storage capacity of livestock manure on livestock farms. However, the ban on spreading manure on grassland and arable land on sandy soil (from 1 September to 1 February; see Figure 3), which has been in effect in the Netherlands since 1995, means that farms need a storage space sufficient for a period of five months. For farms with grassland on clay and peat soils, a spreading ban applies from 15 September to 1 February (Figure 3), for this, a storage capacity of at least 4.5 months is needed.

Table 16 shows the development in storage capacity for liquid manure, calculated in months of manure production on farm level, for farm types on which mainly liquid manure is produced. From the 1992-1994 period onwards there was a tendency to an increasing storage capacity. For both farm categories the class of less than 4 months of storage capacity decreased. In the 1999-2002 period, 80% of the dairy farms and 91% of the pig and intensive veal calve farms had storage facilities sufficient for at least five months of manure production.

Table 16: Trend in available storage capacity (liquid manure) for several categories of livestock farms in the Netherlands (%)[*1].*

Storage capacity range	1992-1994	1996-1998	1999-2002[*2]
Dairy farms			
< 4 months	19	13	11
4-5 months	10	5	8
5-6 months	10	13	14
> 6 months	62	70	66
Pig and intensive veal calve farms			
< 4 months	15	8	7
4-5 months	5	3	2
5-6 months	2	5	2
> 6 months	77	85	89

Source: FADN

1) Percentage of farms with a period-average storage capacity for liquid manure production expressed in months within a given range of storage capacity.

2) No data available for 2000.

3.4.4 Fertilisation recommendations, advice and demonstrations

Fertilisation recommendations

In 2002 the 'Basic Recommendation for Fertilisation of Grassland and Forage crops' was republished (previous edition was from 1994). This basic recommendation is also available to the general public via Internet. For the recommendation on nitrogen fertilisation, a system was introduced for calculating the nitrogen supplying capacity of the soil. This calculation is based on either the organic nitrogen content of the soil or the total soil nitrogen content. The advisory report is, in principle, based on a sampling and analysis of the top 20 centimetres of the soil, but a sampling of the top 10 centimetres is also possible. In the recommendation consideration is given to the age of the grass sod. The basic recommendation also describes how an optimum use of the nitrogen from livestock manure is possible within the loss standards, and how the use of fertiliser can be optimised.

Soil research for the recommendation of the nitrogen emission on grassland is a measurement of the nitrogen supplying capacity of the soil. For this research the largest laboratory for soil research in the Netherlands, BLGG, analysed about 25,000 samples from grassland and provided the associated recommendation.

For arable crops and horticultural crops the basic recommendation for nitrogen in the report period has not changed. The number of soil samples for research into the N-min supply in the spring was about 16,000 (Source: BLGG, 2002). From 1 September 2004 onwards BLGG will also perform a measurement of the nitrogen supplying capacity during the standard soil investigation for arable land. For the time being no associated recommendation will be given with this.

The phosphate recommendations for outdoor vegetables and flower bulbs have been lowered and incorporated into the phosphate recommendations for arable crops. The other recommendations have not changed.

Advice and demonstrations geared towards a better minerals management

In the 1999-2003 period about 120 million Euro was spent on development and dissemination of knowledge with respect to improved minerals management. About 60 million Euro was spent on scientific research and about 60 million Euro on farm-based research (Action Plan Nitrate Projects). Within the framework of the Action Plan for Nitrate Projects, many projects were carried out with the aim of developing and spreading knowledge that could be used by farmers and horticulturists to improve the application of nitrogen, so as to reduce the amount of nitrogen lost. These projects were carried out in the form of an intensive co-operation between scientific research, farm-based research, agricultural advisers, farmers and horticulturists. All of the research and demonstration projects were targeted at reducing nitrogen surpluses on the nitrogen balance to the level of the permitted loss standards, such as would be applicable in 2003.

This knowledge development and dissemination was structured, by disseminating the knowledge according to a pyramid model. The projects were designed on the basis of this model, where a clear distinction is drawn between experimental stations (5), pioneering farms

(about 50), demonstration farms (about 500) and the 'broader practice' (about 50,000). In principle the flow of knowledge occurs top downwards, but in the development of knowledge it was also assumed that developments in broader practice could also be tested on demonstration farms or in research projects.
At any given time there is a wide range of courses and study groups in which the latest knowledge and insights in the area of nitrogen and phosphate management are being disseminated. Due to the large number of course/study group providers, accurate data on the number of courses/groups and the numbers of participants are no longer available.

3.4.5 Other developments

Winter cover crops

In the Netherlands winter grains on arable land play a favourable role in preventing nitrate leaching. They are sown in the autumn and not manured until the spring. The area of green manure crops sown each year is highly variable and is dependent on the weather conditions in the autumn concerned. Table 17 shows the areas involved.

Table 17: Cultivated area (x 1000 ha) in the Netherlands with crop cover in the winter period (not fertilised)[*1]

	1992-1994	1996-1998	2000-2002
Grassland[*2]	1059 (54)	1038 (53)	1002 (52)
Winter wheat	109 (6)	132 (7)	113 (6)
Green Manure Crops	15 (0.8)	3 (0.2)	10 (0.5)
Total	1183 (60)	1173 (60)	1125 (58)

Source: CBS, 2004a
[1)] The percentage of the total area manured and/or fertiliser application in parentheses.
[2)] Both permanent and temporary grassland, see Table 6.

After the cultivation of silage maize, grass or rye was increasingly being sown as a winter crop. This subsequent crop is not manured and its purpose is to assimilate the nitrogen that the silage maize did not assimilate. No systematically collected data were available on the area of winter crops sown after the cultivation of silage maize.

Irrigation

In the Dutch situation, irrigation in the form of temporarily submerging plots of land does not take place. If crops experience a lack of water, a sprinkling irrigation system will need to be used. For the 1992-1999 period, between 123,000 and 309,000 ha in the Netherlands were irrigated on one or more occasions a year, see Table 18. These areas are equivalent to 7% and 17%, respectively, of the manured cultivated land (Hoogeveen et al., 2003). The irrigate area is large in dry years an small in wet years. In 1997, almost 60% of the sprinkling was on grassland followed by 13% on potatoes and 7% on outdoor vegetables (Meeuwsen et al., 2000).

*Table 18: Cultivated area (*1000 ha) sprinkled on one or more occasions a year in the Netherlands in the 1992-1999 period.*

Year	1992	1996	1997	1998	1999
Type of weather		Dry		Wet	Average
Acreage (* 1000 ha)	265	309	198	123	161

Source: Hoogeveen et al., 2003; Meeuwsen et al., 2000

Water used for irrigation is mostly groundwater (65-80%). In normal and dry years the use of surface water is around 20%, while in wet years it is about 15% (Hoogeveen et al., 2003).

In 1997, 17% of farmers used an irrigation planner, with which the optimum quantity of water to be applied can be determined. This saves water and prevents unnecessarily high emissions of nutrients (as a result of which leaching could occur). The use of planners is stimulated by several provinces (where dry sandy soils are prevalent) and this is where they are used most (Meeuwsen et al., 2000).

Limiting the ammonia emission

Part of the nitrogen emission from agriculture occurs in the gaseous form, for example, ammonia. Most of these gaseous nitrogen compounds eventually end up in the soil and water via deposition from the atmosphere. A series of government measures has limited the emission via this route. As a consequence of this the non-emitted nitrogen now remains in the manure.

With the Ammonia and Livestock Farming (Interim Measures) Act (LNV, 1994) which has been in effect since 1994, municipalities now have various options with which they can require the building of low-emission sheds. There are also fiscal measures to encourage the building of low-emission sheds (Green label sheds). The municipalities know about the construction of these sheds due to the applications for environmental permits. These sheds are mainly found in the poultry sector (laying hens: 24% of total) and in the pig sector (6-10% of animal numbers).

An overview of the pattern of ammonia emission since 1985 is given in Table 19. In the 1990-2002 period the ammonia emission decreased with 45%. The decrease in the ammonia emission for sheds and the storage of livestock manure decreased by 31% and for manure application by almost 60%. The ammonia emission for grazing decreased by 37% during this period.

Table 19: NH_3 emission from agricultural sources (million kg NH_3)

	1985	1990	1995	1999	2000	2001	2002
Manure	226	210	166	141	128	120	114
Stable and storage	86	89	89	79	73	64	63
Manure application	125	105	62	51	45	46	43
Grazing	16	16	14	11	10	10	8
Fertilisers	12	13	13	12	11	9	9
Total	239	223	179	153	139	129	123

Source: CCDM, 2004

3.4.6 Compliance with the manure legislation in 2002

Check on compliance with the Code of Good Agricultural Practice

The monitoring of the compliance with the legal measures stated in the Code of Good Agricultural Practice (LNV 1993a) and the legal measures introduced after that took place mainly by means of the administrative inspection of farms. Further certain measures such as the spreading of livestock manure (non-permitted period) could easily be established in the field. This administrative inspection was carried out by the Levies Office of the Ministry of Agriculture, Nature Management and Food Safety. Random checks on the correct spreading of manure on farms were carried out by the General Inspection Service (AID) of the Ministry of Agriculture, Nature Management and Food Safety and by the police. However, within the framework of the action programme, farms did not receive separate visits for a quantitative inspection. Therefore quantitative data cannot be supplied in accordance with the reporting guideline.

Table 20 provides an overview of the planned and realised number of inspections carried out in 2002 and the number of infringements encountered.

Table 20: Inspection of compliance with the minerals regulations: planning and results. Data for 2002.

Inspection of	Planning	Result (numbers)	Result (hours)	Number of infringements
MINAS	2,800	3,500	40,320	1,355
Administrative regulations	2,500	2,140	12,940	270
Manure transfer contracts	1,500	600	6,940	125
Manure application regulations	200	200	2,000	100
Other inspections	500	2,110	20,550	410
Total	7,500	8,550	84,330	2,260

Source: AID, 2003

In 2002 an infringement was encountered in 26% of the inspections. In 2000 and 2001 these percentages were clearly lower, namely 14% and 16%.

Policy of enforcement in 2002

The activities of the General Inspection Service (AID, see §2.2.2) in the area of manure and fertiliser focused on the following activities in 2002: (a) the mineral accounting system, (b) the manure volume-limiting measures in the form of rights to keep a certain number of animal and manure transfer accounts, (c) the rules for applying manure. Many inspections of the administrative obligations were carried out (2140), often in combination with inspections on the mineral accounting system and manure transfer contracts, and during fraud investigations.

(a) Mineral accounting system

At the start of 2002, the AID helped with the evaluation of the Fertiliser Act. This revealed that the majority of infringements of mineral accounting system (almost 70%) were concerned with the import and export of animals and animal products, the import and export of animal feed and the number of animals present on farms.

About 3500 MINAS declarations for the years 1998 and 1999 were inspected in 2002. The files inspected were supplied by the Levies Office or by an AID workgroup based on an analysis and selection for possible fraud. In almost 40% of the cases investigated, the declarations were found to be incorrect. The AID reported all of the inspection results to the inspector of the Levies Office. These inspection results were used by the Levies Office to further deal with the declarations. Where applicable, the inspector required the declarant to make a retrospective collection payment based on the inspection report from the AID.

The work pressure at the courts was reduced with the implementation in 2002 of the so-called Registration, Transaction and Prosecution Guideline. This guideline from the Board of Procurators General gives instructions about when the inspector from the Levies Office can

deal with fraudulent MINAS declarations him- or herself (with fines) and when criminal prosecution is considered to be necessary.
The AID and the Levies Office meet regularly to discuss the selection of fraud cases to be investigated by the AID. This selection meeting is also used to discuss other cases of fraud with respect to the manure legislation. The integral inspection approach for the mineral accounting system is also worked out in consultation with the Levies Office.

(b) Manure transfer contracts (MAO)
The manure transfer contracts (MAOs) system came into effect on 1 January 2002. The inspection of the MAOs is a particularly demanding task for the AID. During the inspection, the AID closely co-operates with the Levies Office and the Basic Registration Service. In the spring of 2002, the AID started a pilot project to ensure that the process would run well and to gain experience. The results were evaluated together with the Levies Office and the Agriculture Directorate. In the end almost 600 inspections on the daily limit for the number of animals allowed on the farm were carried out, and 125 infringements were reported to the Levies Office.
A consistent enforcement policy, in which the Levies Office subjected offenders to a fine, ensured that the majority of the sector adhered to the legislation. Due to a number of uncertainties in the operational management related to the introduction of the system, the planned number of inspections was not achieved. These problems were discussed in continuous consultation with the Agriculture Directorate and the enforcement partners, the Levies Office and the Basic Registration Service. Furthermore, the annual plan had to be adjusted due to the demands made by the crisis due to the hormone Metoxyprogesteronacetate (MPA) and the support provided to other specialist groups. The number of inspections on the daily prohibition limit was therefore set at a maximum of 600. In 2003 inspections for enforcement of the annual prohibition limit have been started.

(c) Regulations concerning manure use, transport and export
In 2001, 177 inspections were carried out with respect to the spreading regulations and in 2002, 200 such inspections were carried out. An infringement was encountered in almost 50% of the cases. The AID mostly took action as a result of complaints, tips and requests for assistance from the police, and this accounts for the high percentage of infringements encountered. The fine for the illegal spreading of manure is about 600 Euro.
In 2002 targeted and general inspections were carried out on transport of livestock manure over short distances. The aim of the project was to increase the perceived risk of being caught. To this end, the results of the inspections were communicated to the sector via farming publications and in addition to this, a survey was held among the target group. The information placed in the farming press reached 70% of the target audience. The project revealed that the vast majority of the target group was well acquainted with the rules. This knowledge increased slightly from 82% in the spring to 90% in the autumn. There was also an increase in the perceived risk of being caught. In addition to inspection and detection,

enforcement communication was found to have a positive impact on the behaviour of farmers and their employees.
With respect to detection, a substantial effort has been put into uncovering manure constructions aimed at preventing the authorities from realising that the excess of produced manure on a farm had not been transferred to an arable farm. This gave some positive results. Moreover, in 2002, the AID established several cases of fraud with respect to the export of manure. A number of large investigations was started. The project 'direct export' was concluded in July. Inspections at 20 farms that directly exported manure led to six summonses and a warning for overproduction and nine summonses for infringements with respect to health certificates or proofs of delivery.

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4. EFFECT OF ACTION PROGRAMME ON FARM MANAGEMENT AND WATER QUALITY

4.1 Introduction

The effect of the Dutch Nitrates Directive Action Programmes on the contribution of nitrate from agricultural sources to receiving water and the effects of changing agricultural practice on this contribution, is assessed in the National Monitoring Programme for the effectiveness of the Minerals Policy (LMM) by monitoring both farm management and on-farm water quality, see Chapter 2.

This chapter presents the results for the three main soil-type areas in the Netherlands: sand, clay and peat. The results of the fourth main soil-type area, the loess area, will be presented together with those of the sand area, because the loess area is very small and the nitrate leaching is very similar. Each main soil-type area consists of one of more regions. Agriculture in the sand regions accounts for about 47% of the agricultural area in the Netherlands, the loess region about 1.5%, the clay regions about 39% and the peat regions about 12.5%.

Regional results for the most common farm types, i.e. dairy farming, arable farming and other farm types, are shown for all main soil-type areas in so far as this is relevant. Farm management characteristics for each period are given in the next section (§4.2) and nitrate concentrations in on-farm water in §4.3. The reported periods for farm characteristic and on-farm water quality differs by one year, e.g. farm characteristics for 1991-1994 are compared with on-farm water quality for 1992-1995. Is is assumed that on-farm water quality in year x is mainly related to farm practice in year x-1. Relationships between the change in farm characteristics and nitrate concentrations in on-farm water are discussed in §4.4.

4.2 Farm management

Some general characteristics of the farms monitored are given for arable farms in Table 21, for dairy farms in Table 22 and for other types of farms in Table 23. It should be marked that farms with less than 10 ha are not included in the sample (see §2.3). Therefore the average size of the LMM-farms is larger than the average of all Dutch farms.
Arable farms in the sand regions, which are on average about 75 ha, are larger than those in the clay regions, which are on average 58 ha. The crop rotation also differs somewhat; potatoes and sugar beets account for 60% of the rotation in the sandy regions and about 40% in the clay regions. Arable farms are larger than dairy farms, especially in the sand regions. Dairy farms in the sand and peat regions are smaller (at an average of 40 ha) than those in the clay regions (at an average of 52 ha). The percentage of grassland is highest for dairy farms in the peat regions (98%) and lowest for farms in the sand regions (68%); the remaining area is mainly maize. Livestock density is highest on dairy farms in sand regions (2.7 LU/ha) and

lowest on farms in the peat regions (2.2 LU/ha); farms in the clay regions have an intermediate livestock density (2.4 LU/ha).
The group of other farms in the sand and clay regions is very different with respect to size and crop rotation. Livestock density is on average lower than on dairy farms.
Over time the general tendency is an increase in farm size and a decrease in livestock density.

In the 1999-2001 period, the average use of manure nitrogen on arable farms was about 120 kg/ha. It decreased for farms in the sand regions but increased for farms in the clay regions. For the same period, the average use of manure nitrogen on dairy farms was about 260 kg/ha in the clay and peat regions and about 290 kg/ha in the sand regions. No clear decrease occurred between 1996 and 2001, whereas for farms in the sand regions the application of manure nitrogen was 70 kg/ha lower than in the 1991-1994 period. In the 1999-2001 period, other farms in the sand regions used about 280 kg/ha and other farms in the clay regions about 145 kg/ha. For both cases, this was clearly lower than in the previous period.

Fertiliser nitrogen use clearly decreased for all farms in all regions. Fertiliser use was higher on dairy farms (from 162 kg/ha in sand regions up to 295 kg/ha in clay regions) than on arable farms (from 85 kg/ha in sand regions up to 150 kg/ha in clay regions) and other farms (from 65 kg/ha in sand regions up to 194 kg/ha in clay regions).

*Table 21: Arable farms in the Netherlands participating in LMM; main characteristics of farming practice for farms in the sand and clay regions[*1] for each of the reporting periods.*

	Sand regions			Clay regions	
	1991-1994	1996-1998	1999-2001	1996-1998	1999-2001
Area (ha)	59	77	75	66[*2]	58
% potatoes	43	44	36	28	27
% sugar beets	21	20	24	16	14
% cereals	21	19	22	29	28
% other crops	15	17	19	27	31
Manure N (kg/ha)	135	142	120	89	119[*3]
Fertiliser N (kg/ha)	119	98	85	169	150

1) In peat regions arable farming is almost non-existent, LMM in the loess region started in 2002.
2) Average for the 1997-1998 period
3) Average for the 1999-2000 period

The average storage capacity for manure is sufficient to store manure for six months; this is the longest period during which land application is prohibited (September - February) plus one extra month. The storage capacity has increased over time on dairy farms, but has shown a large variation over time for other types of farm.

*Table 22: Dairy farms in the Netherlands participating in LMM; main characteristics of farming practice for farms in the sand, clay and peat regions[*1] for each of the reporting periods.*

	Sand regions			Clay regions		Peat region	
	1991 1994	1996 1998	1999 2001	1996 1998	1999 2001	1996 1998	1999 2001
Area (ha)	31	40	40	49[*3]	52	36	40
% grassland	79	66	68	87[*3]	83	98	98
% maize	19	25	25	6	8	2	2
% other crops	2	9	7	7	9	0	0
Livestock (LU/ha)	3.0	2.8	2.7	2.4	2.4	2.2	2.2
Manure N (kg/ha)	358	284	288	263[*3]	263	271	263
Fertiliser N (kg/ha)	253	211	162	345[*3]	295	245	206
% manure storage[*2]	90	103	107	128	-	89	101

1) LMM in the loess region started in 2002.
2) Percentage of total manure production over six months that can be stored on the farm.
3) Average for the 1997-1998 period.

*Table 23: Other farms in the Netherlands participating in LMM; main characteristics of farming practice for farms in the sand and clay regions[*1] for each of the reporting periods.*

	Sand regions			Clay regions	
	1991-1994	1996-1998	1999-2001	1996-1998	1999-2001
Area (ha)	23	29	30	61	61
% grassland	56	33	30	63	38
% maize	32	19	13	3	4
% potatoes, sugar beets, cereals	4	23	19	30	45
% other crops	8	25	28	4	15
Livestock (LU/ha)	2.3	1.6	1.2	2.1	1.5
Manure N (kg/ha)	394	308	277	169	145
Fertiliser N (kg/ha)	148	120	65	237	194
% manure storage[*2]	124	209	93	75	33

1) In peat regions other farm types are rare, LMM in the loess region started in 2002. In clay regions the number of other farm in very limited in both periods, therefore the dta should be considered with care.
2) Percentage of total manure production over six months that can be stored on the farm.

The average nitrogen surpluses of farms monitored in LMM differed between farm types and to a lesser extent between main soil-type areas, see Figure 4. The decrease in nitrogen surplus was similar to the decrease shown in Figure 2, and was due to the decrease in the use of artificial fertiliser and to a lesser extent the use of manure (on a farm scale a decrease in manure use is due to a reduction in the import of fodder and artificial fertiliser).

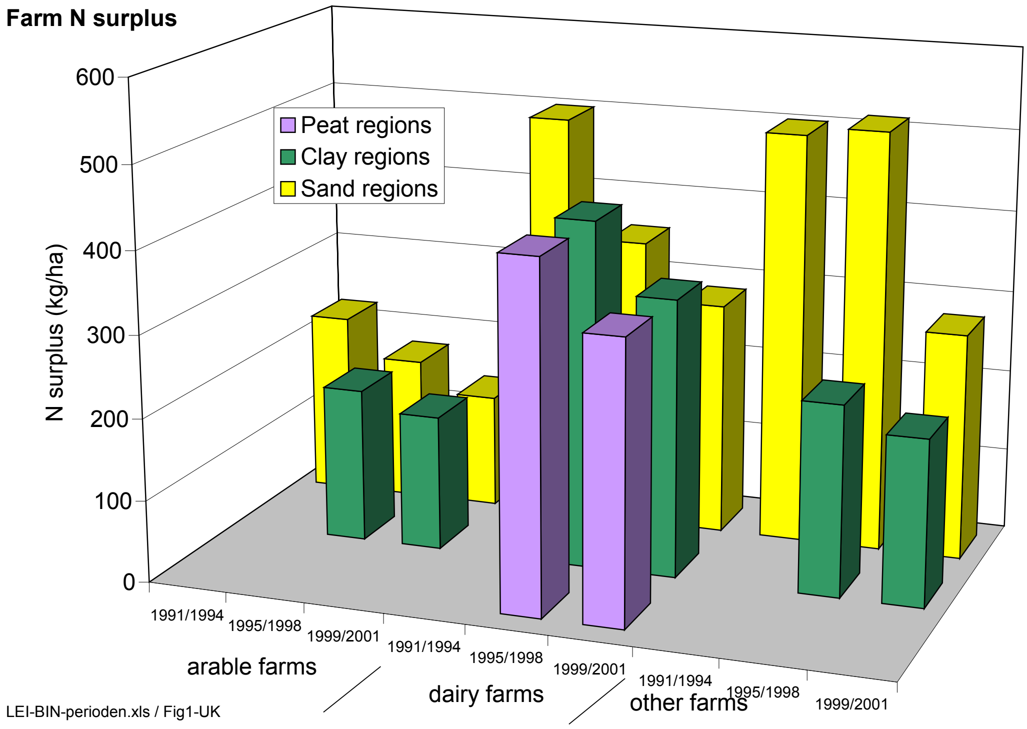

Figure 4: Average nitrogen farm gate balance surplus (LEI definition) of arable, dairy and other types of farms in the sand, clay and peat regions in the 1992-2002 period.

4.3 Nitrate in on-farm waters

4.3.1 Overview at national level

The average nitrate concentration in the upper metre of groundwater on farms differed between the main soil-type areas and increased from peat to clay to sand (see Figure 5). Nitrate forms the main N component in on-farm groundwater in the sand regions (84-88%) and tile drain water in the clay regions (81-85%), see Figure 6. Nitrate forms a minor N component in on-farm groundwater and ditch water in the peat regions (< 20%). Ammonium forms the main N component in groundwater in the peat regions (> 50%). Ammonium concentrations increase with depth in peat regions (Van der Grift, 2003) and are attributed to mineralisation of organic material (Meinardi, in prep.).

Within each area there were differences in status and trend in nitrate concentration between farms types and reporting periods (1992-1995, 1996-1999 and 2000-2002). In the sand regions a decrease in nitrate concentration was measured in the groundwater of all farm types. The highest nitrate concentration was measured in the groundwater of farms belonging to ‘other farms’, i.e. pig and poultry farming and mixed farming (animal husbandry and crop farming). In the first reporting period the nitrate concentration was higher on dairy farms than on arable farms, whereas in the last reporting period it was the other way around.

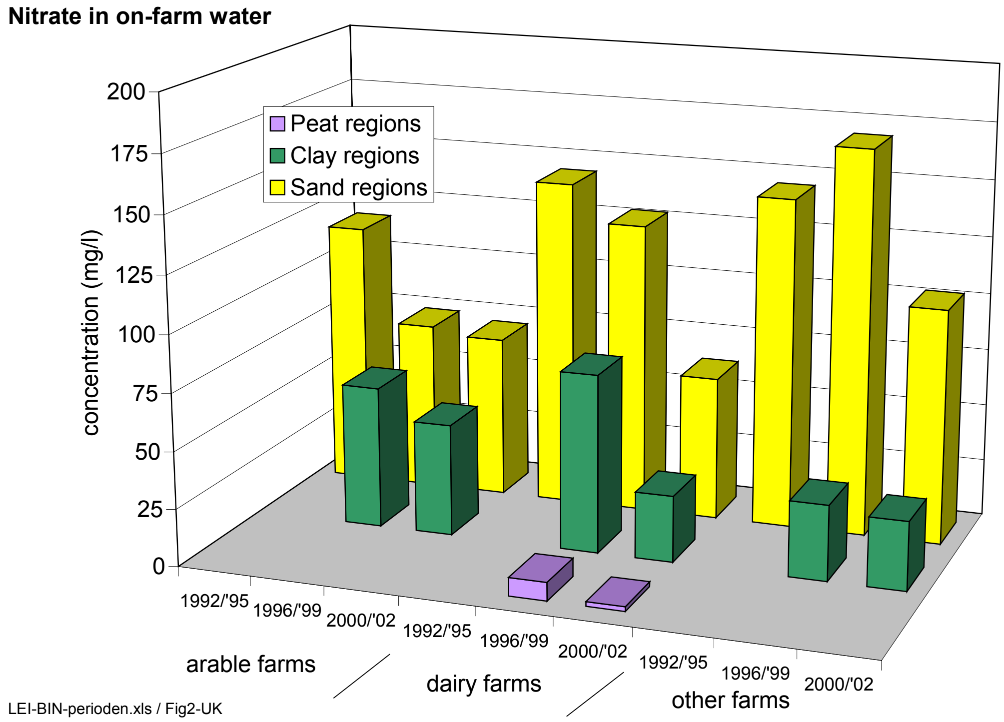

Figure 5: Average nitrate concentration in the upper metre of groundwater (peat, sand) or tile drain water (clay) of arable, dairy and other types of farms in the 1992-2002 period.

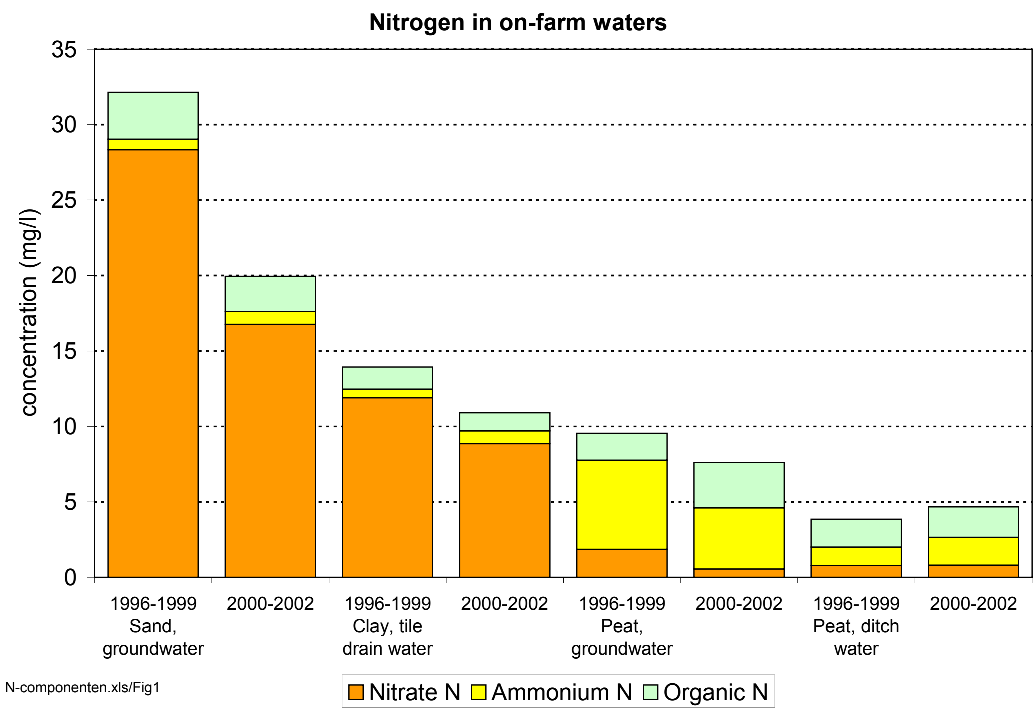

Figure 6: Nitrogen concentration (mg/l) in on-farm waters of farms in the sand, clay and peat regions of the Netherlands for the 1996-1999 and 2000-2002 period.

Measured nitrate concentrations in on-farm water in the sand and clay regions showed a clear decrease in the 1992-2002 period, see Figure 7. For farms in peat regions no clear trend can be seen. There was a large variation in average nitrate concentration between different years. These differences were mainly due to differences in precipitation surplus, which caused differences in the magnitude of dilution and the depth of the groundwater table (Boumans et al., 2001; 1997). Rise in the groundwater table leads to an increase in the magnitude of nitrate denitrification. Furthermore, there were changes in the group of farms monitored, due to farms ceasing operation and being replaced and farms being involved in the buying, selling and exchanging of land. These changes led to changes in the fraction of soil types, for example, an increase in the fraction of peat soils on farms within the sand regions led to a decrease in the measured nitrate concentrations. A statistical model approach has been developed to detect the effects of the Minerals Policy and to filter these out (the so-called confounding factors) from the effects of the change in farm practice on the nitrate concentration (see Annex 2).

There was a clear decrease in standardised nitrate concentration in on-farm water for farms in the sand regions from about 135 mg/l in the 1992-1995 period to about 95 mg/l in the 1999-2002 period. The standardised nitrate concentration in the clay regions also showed a decrease, although the series of data for representative farms is rather limited (see §2.3.2).

The percentage of farms with a nitrate concentration in on-farm water higher than the EU target value of 50 mg/l showed a similar tendency, see Figure 8. The target value was more frequently exceeded in the sand regions than in the clay regions and very rarely in the peat regions. There was a strong decrease in exceedance after 1998. This was partly due to confounding factors. Nevertheless, the computed exceedance of the target value based on the average annual standardised concentration also showed a decrease. The standardised exceedance in the sand regions decreased from about 95% in the 1992-1995 period to about 80% in the 2000-2002 period.

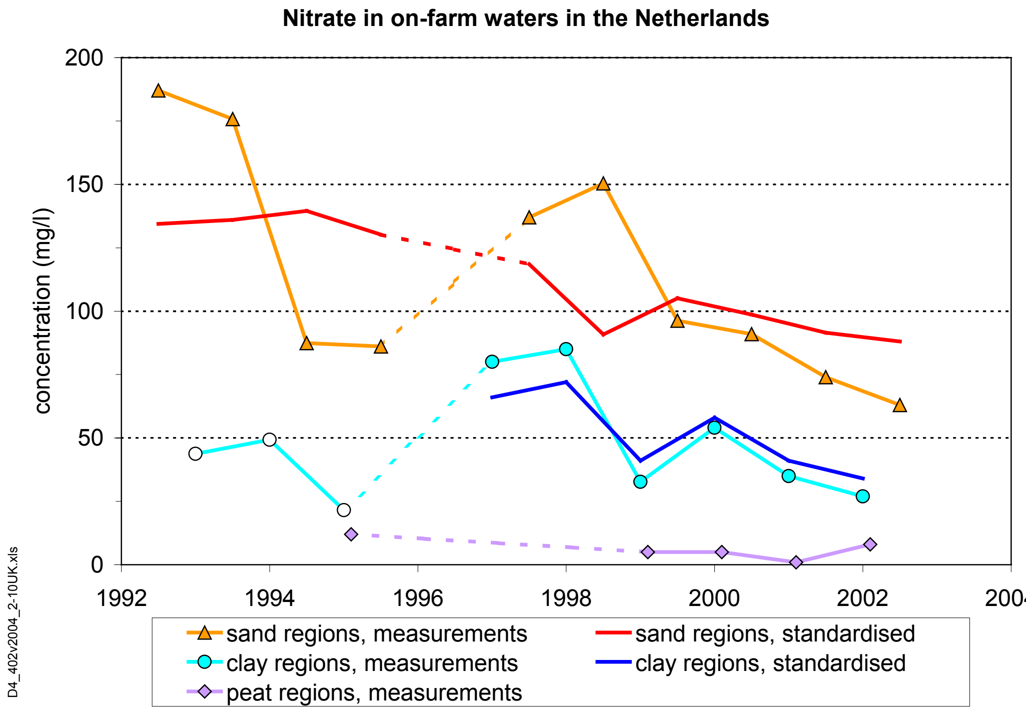

Figure 7: Nitrate concentration (annual average of measured concentration and computed standardised concentration) in the upper metre of groundwater within 5 m of the soil surface (peat, sand) or tile drain water (clay) of farms for the period 1992-2002.

The standardised concentration is corrected for variation in measured concentration due to the variation in precipitation, depth of groundwater table and composition of the sample group of farms and for changes in the ratio between the number of farms per farm type, see Annex 2. Data for 1993-1995 in clay regions are indicative, see §2.3.2.

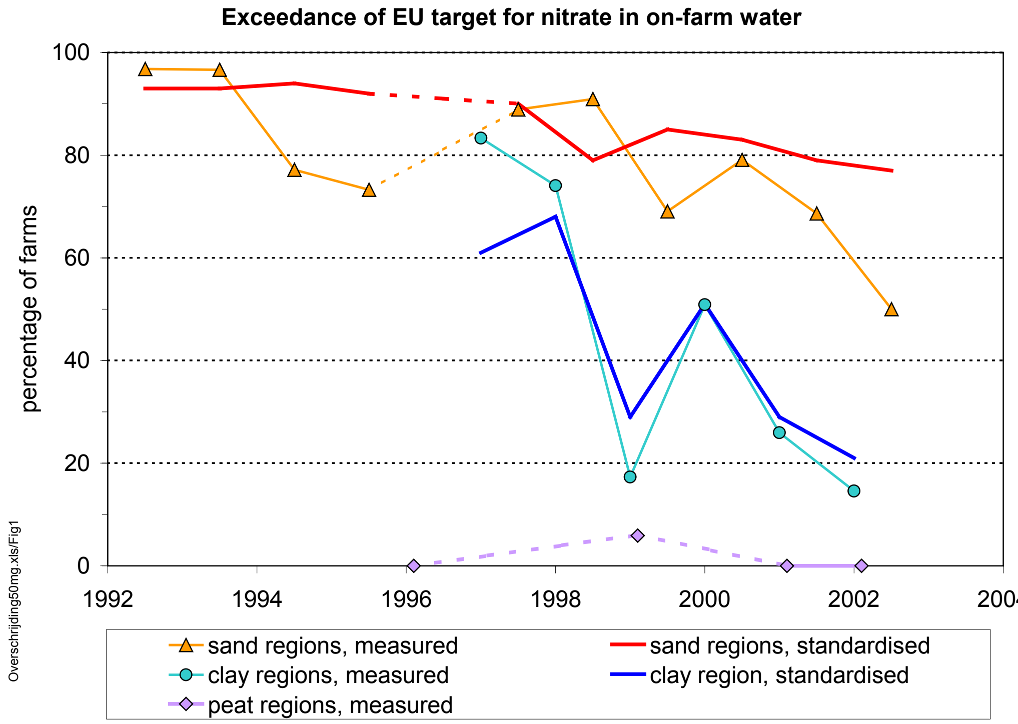

Figure 8: Exceedance the EU-target value of 50 mg/l for nitrate in the upper metre of groundwater within 5 m of the soil surface (peat, sand) or tile drain water (clay) of farms for the 1992-2002 period.

Exceedance of measured concentration and computed exceedance based on standardised concentration, see Annex 3.

The following sections provide details for each of the main soil-type areas using, for example, other cumulative frequency diagrams. Although this type of diagram is very informative, it needs some explanation. This section explains how to read such a diagram, using Figure 9 as an example. From the diagram it can be deduced that about 35% of the monitored arable farms show an average nitrate concentration lower than the EU target in the 2000-2002 period, while 65% show a higher concentration. Follow the horizontal 50 mg/l line (EU target) from the y-axis until it crosses the cumulative frequency line of symbols for the 2000-2002 period (diamonds). Then draw a vertical line perpendicular to the '50 mg/l-line' down to the x-axis. Here you read off what percentage of farms have a measured nitrate concentration in on-farm water that is lower than the 50 mg/l. It is also possible to deduce that 80% of the arable farms had an average concentration lower than 150 mg/l – and 20% a higher concentration – in the 1992-1995 period. Draw a line perpendicular to the x-axis starting at '80' until it crosses the cumulative frequency line of symbols for the 1992-1995 period (squares). Then draw a line perpendicular to this line until it crosses the y-axis. From the y-axis you can read off the concentration that is not exceeded by – in this case – 80% of the farms.

4.3.2 Sand and loess regions

Agriculture in the sand and loess regions accounts for about 49% of the agricultural area in the Netherlands. Dairy farming covers 50% of the area, arable farming about 9%, and pig and poultry farms and mixed husbandry farms about 9 %. About 32% of the area is used by farm types not included in the LMM, these are mainly horticulture, protected crop farming, arboriculture, and farms with less than 10 ha of land.

Nitrate concentrations in the upper groundwater of arable farms decreased between the first and second monitoring period and then stabilised, see Figure 9. The percentage of arable farms with a period-average concentration lower than the EU target increased from about 5% to about 35%. For dairy farms there was a continuous decrease in nitrate concentration, see Figure 10. The percentage of dairy farms with a concentration lower than the EU target increased from about 5% in the 1992-1995 period to about 45% in the period 2000-2002.

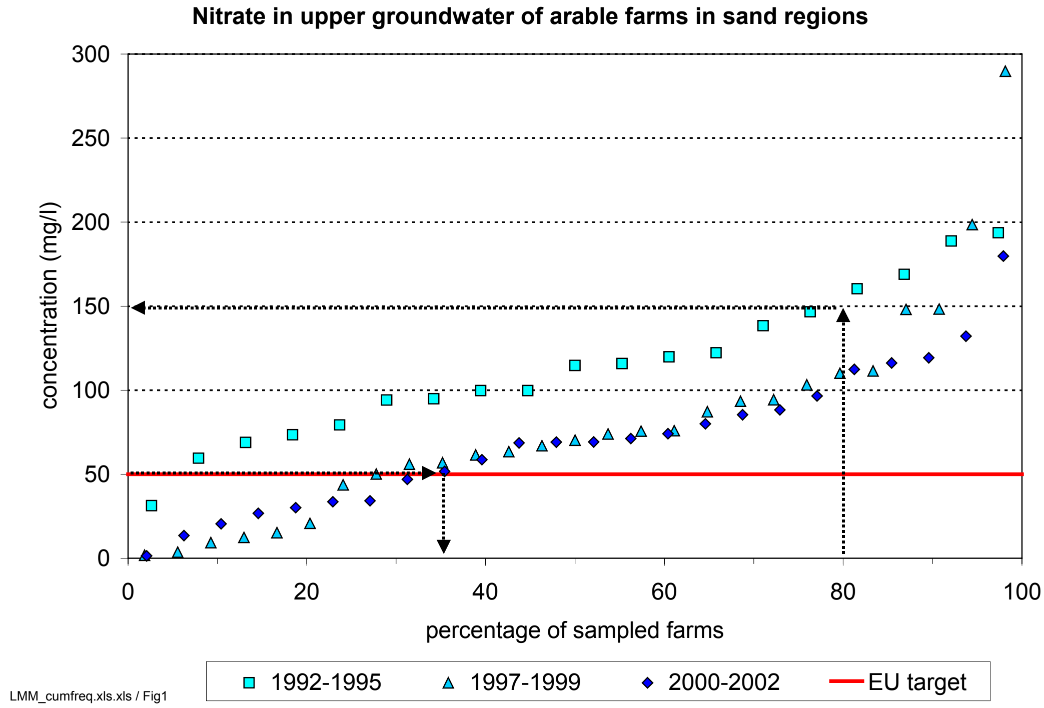

Figure 9: *Nitrate concentration in the upper metre of groundwater within 5 m of the soil surface for arable farms in the sand regions in a cumulative frequency diagram of farm average per period.*

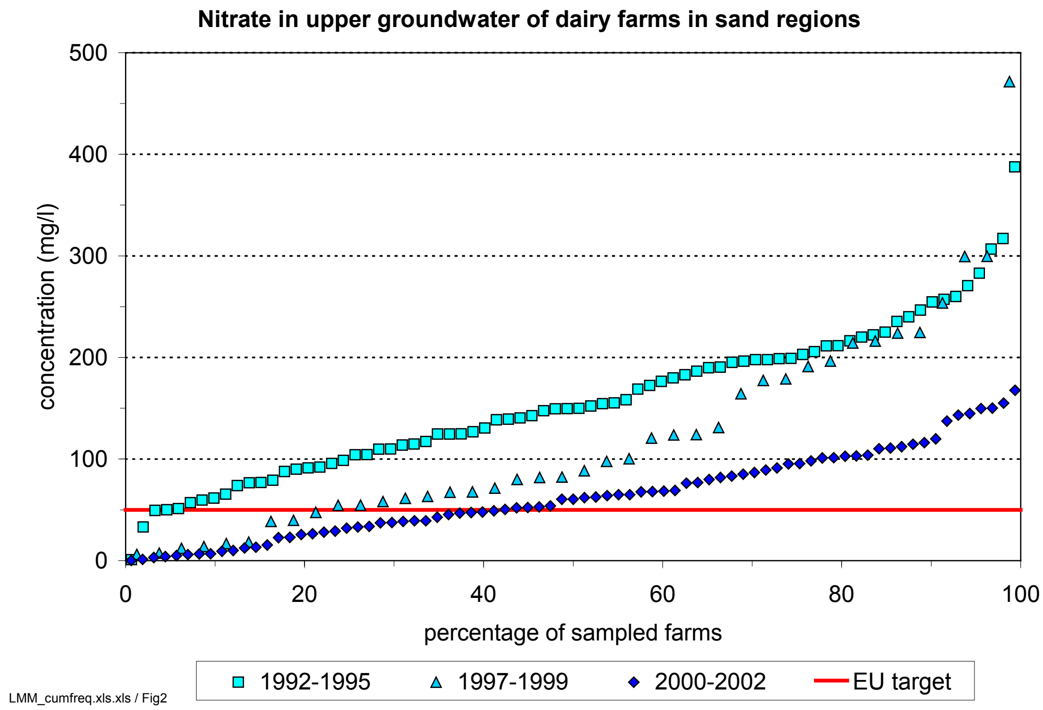

Figure 10: *Nitrate concentration in the upper metre of groundwater within 5 m of the soil surface for dairy farms in the sand regions, shown in a cumulative frequency diagram of farm average per period.*

The nitrate concentration in the upper groundwater of other farms decreased between the second and third monitoring period, see Figure 11. The percentage of other farms with a period-average concentration lower than the EU target increased from about 8% to about 20%.

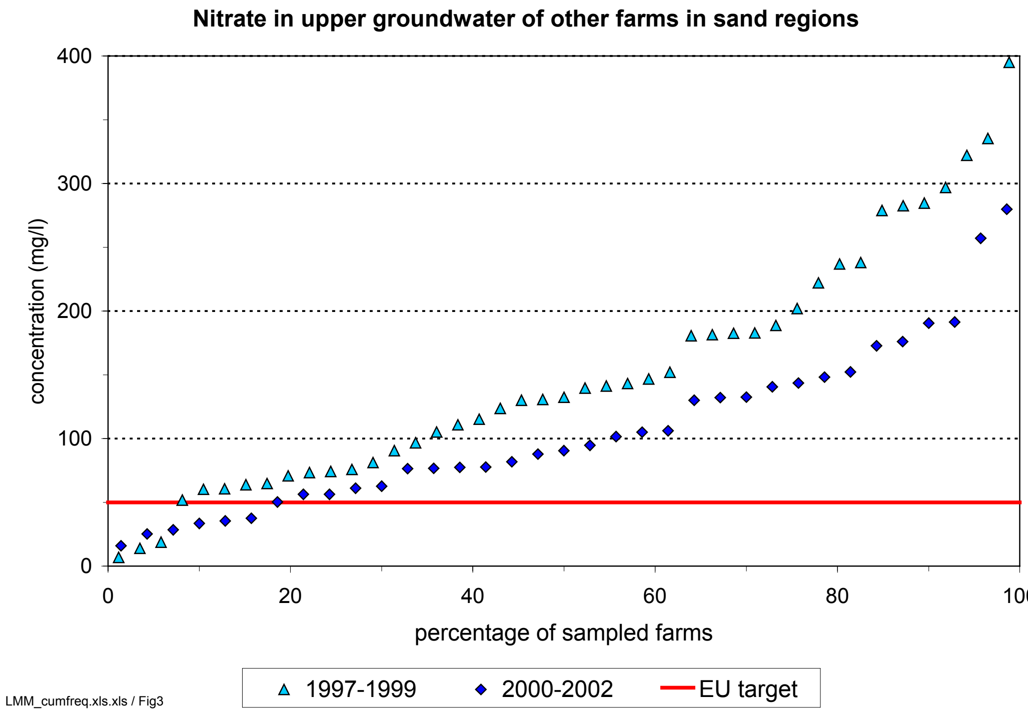

Figure 11: Nitrate concentration in the upper metre of groundwater within 5 m of the soil surface for other farms in the sand regions, shown in a cumulative frequency diagram of farm average per period.

The number of other farms for the first period (1992-1995) was too low to realise a cumulative frequency.

The trend in the nitrate concentration and the level of nitrate concentration under agricultural land in the loess region is similar to that in the sand regions, see Figure 12, although the data collection method employed differed somewhat (see §2.3). The percentage of locations with a nitrate concentration below the EU target value increased from about 12 % to about 23 %, see Figure 13. This is lower than in the sand regions, but this might be due to the sampling scale (farm versus parcel). Willems and Fraters (1995) showed that the scale level used for presenting the monitoring results will affect the percentage exceedance of the target value, if the total average nitrate concentration is the same.

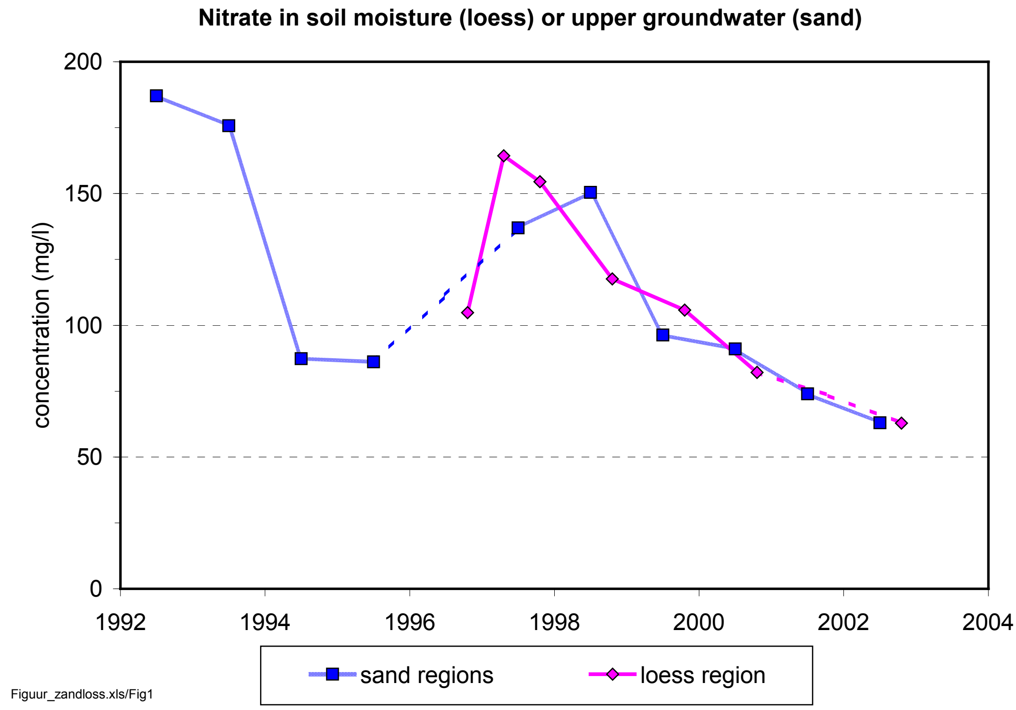

Figure 12: Nitrate concentration in the upper metre of groundwater within 5 m of the soil surface of farms (sand) and in soil moisture at 1.4 m below the soil surface of agricultural land (loess) for the 1992-2002 period.
Source: RIVM (sand); Province of Limburg (loess).

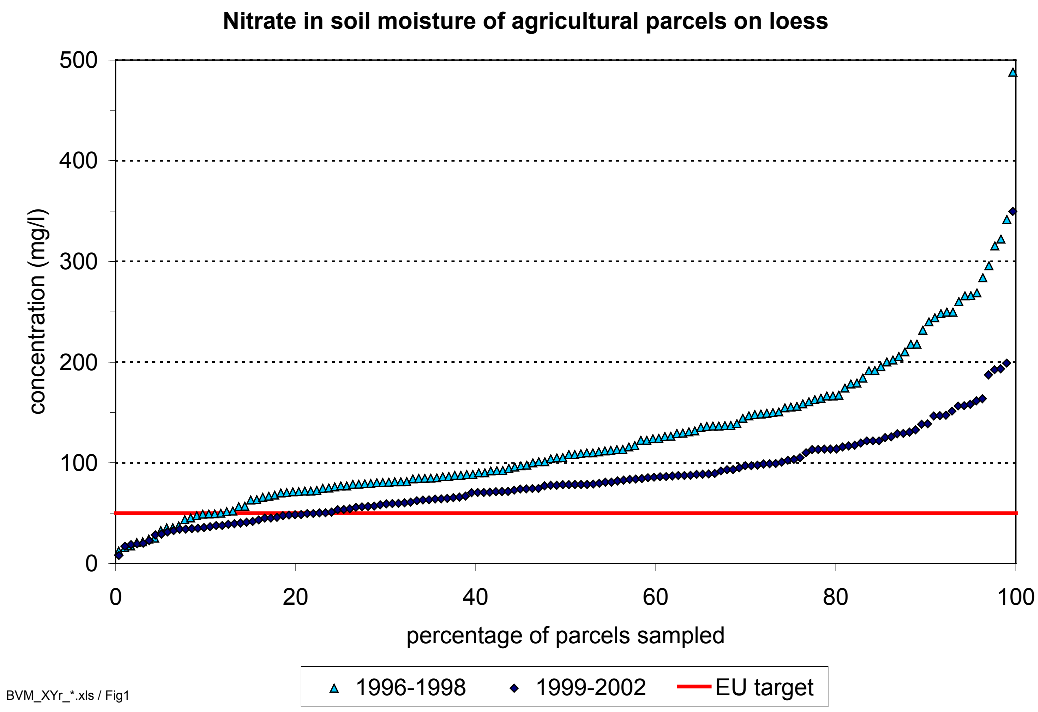

Figure 13: Nitrate concentration in soil moisture at 1.4 m below the soil surface for parcels used for agriculture in the loess region, shown in a cumulative frequency diagram of parcel average per period.
Source: Province of Limburg

4.3.3 Clay regions

Agriculture in the clay regions accounts for about 39% of the agricultural area in the Netherlands. Specialised dairy farming covers about 30% of the area, other forms of dairy farming cover about 6% and arable farming covers about 39% of that area. About 25% of the area is covered by other forms of agriculture not included in the LMM, these are mainly horticulture, different types of mixed farming, and farms with less than 10 ha of land.

The nitrate concentration in tile drain water of arable farms and dairy farms in the clay regions did not change between the 1997-1999 and 2000-2002 periods. The percentage of arable farms with a nitrate concentration below the EU target was about 55% and the percentage of dairy farms about 70%, see Figure 14 and Figure 15.

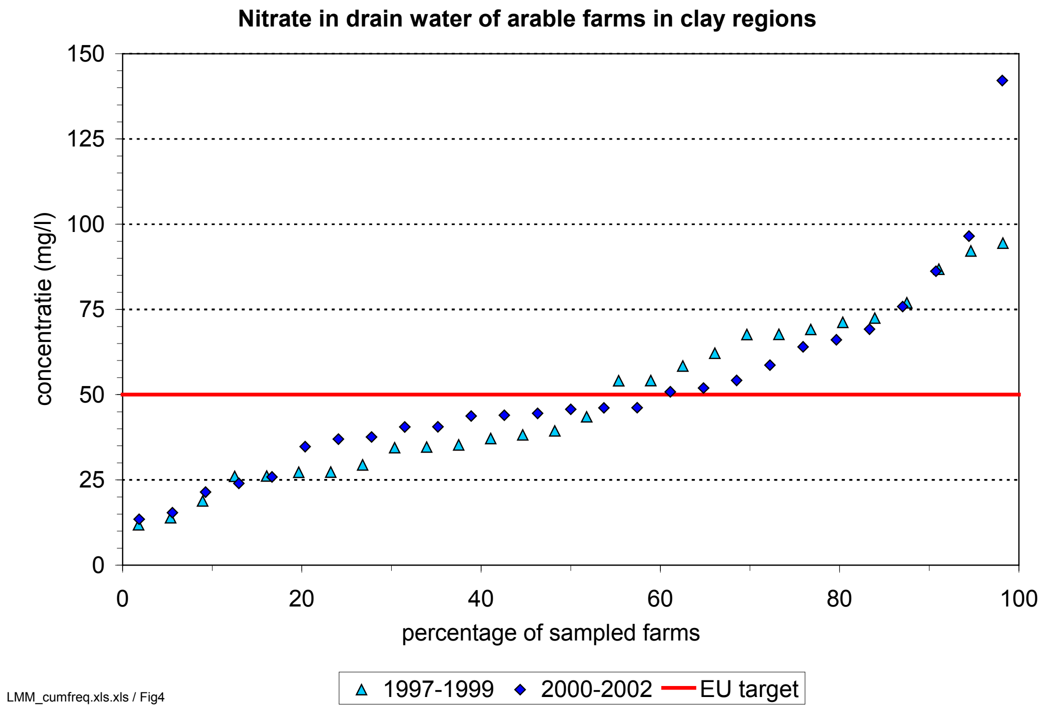

Figure 14: Nitrate concentration in tile drain water for arable farms in the clay regions shown in a cumulative frequency diagram of farm average per period.

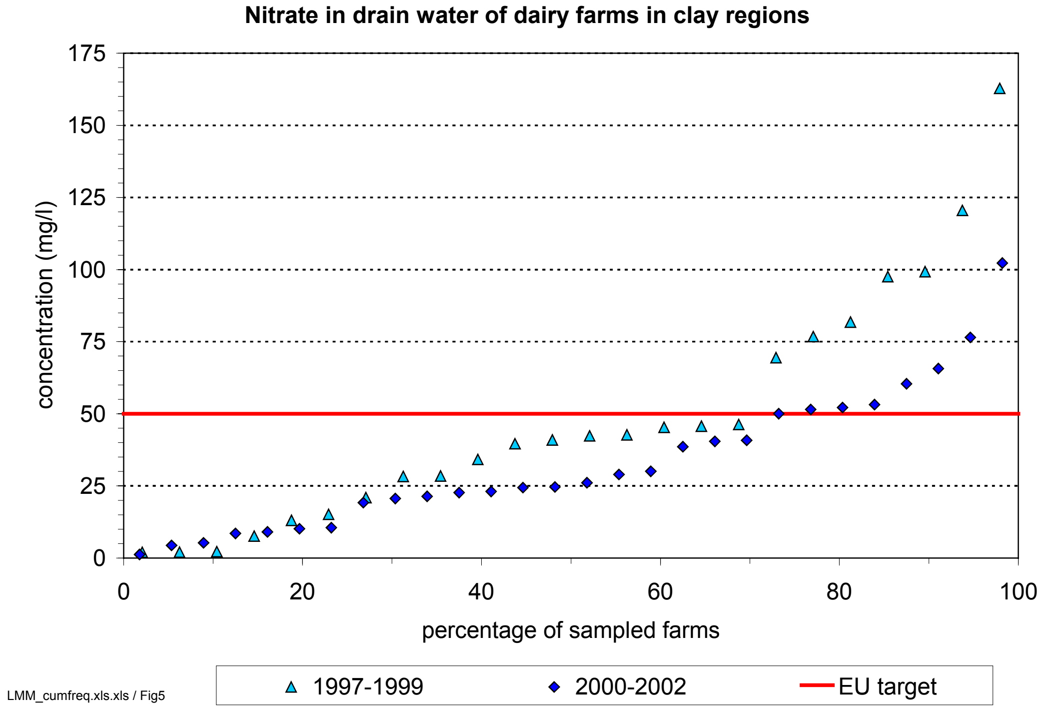

Figure 15: Nitrate concentration in tile drain water for specialised dairy farms in the clay regions shown in a cumulative frequency diagram of farm average per period.

4.3.4 Peat regions

Agriculture in the peat regions accounts for about 12.5% of the agricultural area in the Netherlands. About 75% of the area is covered by specialised dairy farming and the rest is covered by other farm types, mainly other forms of diary and cattle farming.

Period-average nitrate concentrations in the upper metre of groundwater were usually below 25 mg/l for dairy farms in the peat regions, see Figure 16. The EU target value of 50 mg/l was not exceeded in either monitoring period.

Period-average nitrate concentrations in ditch water were usually below 10 mg/l (NO_3), see Figure 17. The average total-nitrogen concentration in ditch water was 4.6 mg/l (N) in the 2000-2002 period, see Figure 6. Total-nitrogen farm average concentration ranged from 2.3 mg/l up to 9.7 mg/l for this period.

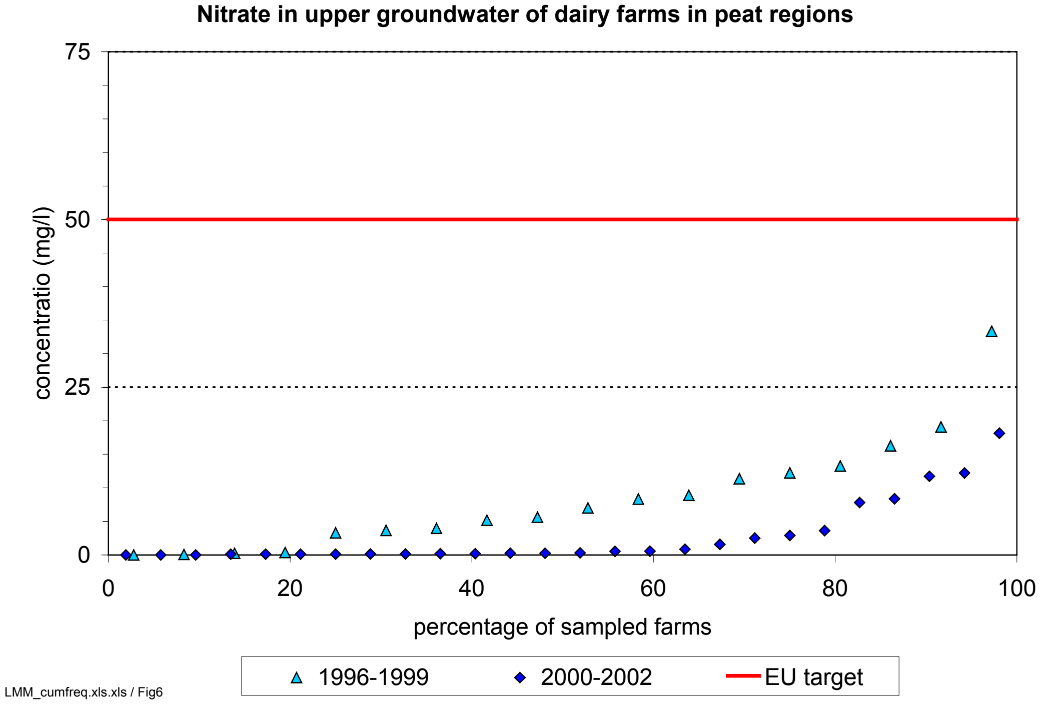

Figure 16: *Nitrate concentration in the upper metre of groundwater within 5 m of the soil surface for dairy farms in the peat regions, shown in a cumulative frequency diagram of farm average per period.*

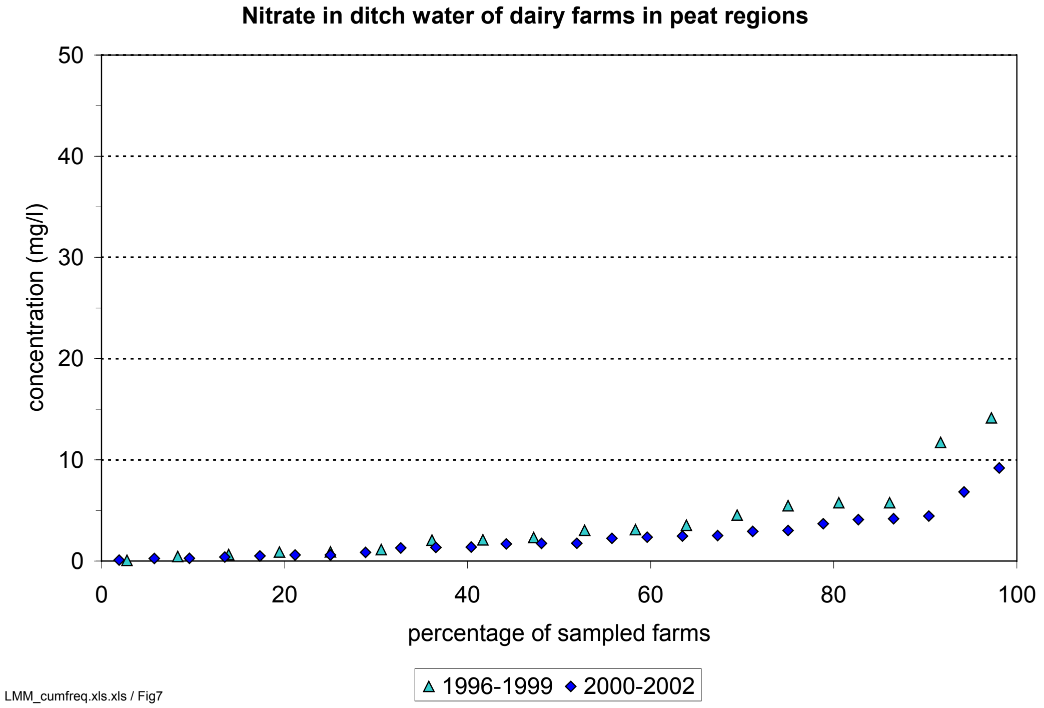

Figure 17: *Nitrate concentration in ditch water of dairy farms in the peat regions in winter, shown in a cumulative frequency diagram of farm average per period.*

4.4 Relationship between trend in farm management and nitrate concentration

There was a general decreasing trend in the use of manure and/or artificial fertilisers on farms participating in the LMM during the study period (Table 21 - Table 23). This led to a decrease in the nitrogen surplus (Figure 4). The nitrate concentrations measured in on-farm waters also showed a clear decrease, especially in the sand regions (Figure 5). A decrease in the nitrate concentration can also be seen, if the influence of confounding factors (change in precipitation surplus and in sample) is accounted for (Figure 7).

The decrease in the use of manure has mostly occurred on farms in the sand regions. There the livestock density on dairy farms has decreased from 3.0 to 2.7 LU/ha, and on other farms from 2.3 to 1.2 LU/ha. No decrease was observed on dairy farms in the clay and peat regions. These already had lower livestock densities than farms in the sand regions, 2.4 LU/ha in the clay regions and 2.2 LU/ha in the peat regions, respectively. On arable farms in the clay regions a slight increase in manure use has occurred. Fertiliser use decreased for all farm types in all regions.

Two main features are introduced here. Firstly, the average nitrogen surplus varies little between the main soil-type regions for each of the farm types. However, nitrate concentrations are low in the peat regions, higher in the clay regions and the highest in the sand regions. This is due to the increasing denitrification capacity of the soils from sand to clay to peat. Secondly, nitrogen surpluses are, on average, 1.5 to 2 times higher on dairy farms than on arable farms. However, in the last monitoring period the nitrate concentrations were found to be similar. This is partly due to higher nitrogen losses to the atmosphere (e.g. ammonia volatilisation during grazing) and partly due to the higher denitrification in grassland compared to arable land.

In the peat regions, nitrate concentrations in on-farm water on dairy farms are low, averaging less than 10 mg/l. Although the nitrogen surplus decreases, the effect on the nitrate concentration is hard to detect because these concentrations were already low, and the monitoring period was relatively short.

This relatively short monitoring period also gives problems when interpreting the data for the clay regions. Data for the period 1993-1995 are from non-representative farms and therefore the monitoring years that can be used for trend analysis was limited. Under this restraint, it is tentatively concluded that the nitrate concentration on farms in the clay regions has decreased due to a decrease in nitrogen surplus, especially on dairy farms.

Both the nitrogen surplus and nitrate concentration on farms in the sand regions decreased during the study period, especially on dairy farms. The most spectacular decrease for both nitrogen surplus and the nitrate concentration in on-farm water, occurred on other farms during the periods 1996-1999 and 2000-2002. Although this observation is real for the sample, care should be taken in extrapolating it because this specific type of farm covers a very heterogeneous group. The observed decrease might to a certain extent be due to differences in the representativeness between samples.

4.5 References

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5. Groundwater quality

5.1 Introduction

The groundwater in the Netherlands shows a large variation in nitrate concentration – in both space and depth – that is only partly accounted for by the variation in land use and differences in nitrogen load. Other key factors are year-to-year variation in net precipitation, soil type and geohydrological characteristics of the aquifer (see previous chapter).

In general, the nitrate concentration is low in groundwater below agriculture on peat soils, it is relatively high below agriculture on sandy soils, and on clay soils it has an intermediate level (Reijnders et al., 2004). With respect to depth, the general trend is a decrease in nitrate concentration with an increase in depth. This is caused by the reduction of nitrate in transport (denitrification), the mixing of waters of different age and source, and lateral transport due to the presence of layers that partially or completely inhibit downwards movement (semi-confined or confined aquifers).

The data in this chapter are presented in three sections, each of which is confined to the three levels of monitoring depths used in the Dutch groundwater and drinking-water monitoring system, i.e. groundwater at a depth of 5-10 m, 15-30 m and more than 30 m. In the first (§5.2) and second (§5.3) sections, the results are presented in figures and maps. The figures present average nitrate concentrations and exceedance of the EU target value for the different soil types (sand, clay, peat) and different forms of land use (agriculture, nature, others). The maps detail differences in groundwater age between wells as well as the nitrate concentration class. The third section (§5.4) details nitrate in groundwater used for drinking-water production. This water is obtained from sandy aquifers and usually originates from areas with a mixed land use. The tables, figures and maps only detail the differences between phreatic and confined aquifers.

5.2 Nitrate in groundwater at a depth of 5–15 m

In the 1992-2002 period, the average nitrate concentration in groundwater in the Netherlands at 5-15 m below the soil surface was about 21 mg/l. The average for agricultural land was 26 mg/l and fluctuated between 21 and 28 mg/l, see Figure 18. The highest concentration was measured in 1997, about ten years after the peak in nitrogen surplus in the national nitrogen balance (see Chapter 3, Figure 2). For nature and other land-use types the average concentration was about 14 mg/l and fluctuated between 9 and 15 mg/l.

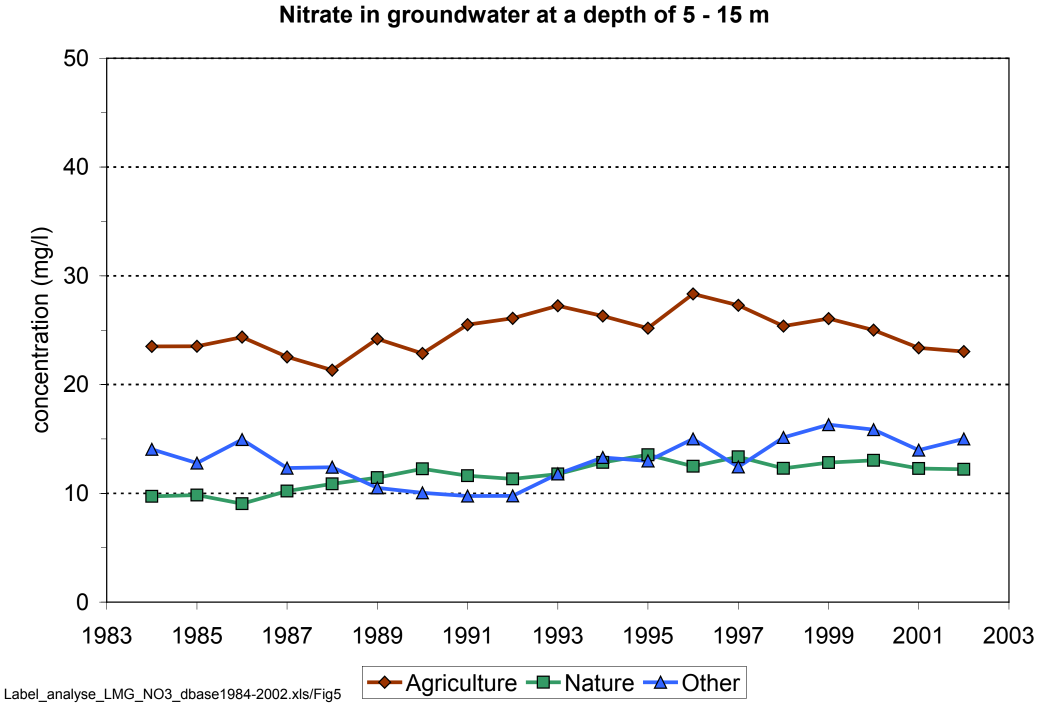


Figure 18: Average annual nitrate concentration (mg/l) in groundwater in the Netherlands at a depth of 5-15 m below the surface level per land-use type for the 1984-2002 period.

Other land uses include orchards and urban areas.

The nitrate concentration in groundwater derived from agriculture on sandy soils (43 mg/l) was higher than on clay (< 10 mg/l) and peat soils (< 5 mg/l), see Figure 19. Prior to 1992 the concentrations were mostly below 40 mg/l, whereas in the 1992-2000 period, the concentrations fluctuated between 42 and 47 mg/l. Since 2001 the average nitrate concentration has remained below 40 mg/l.

In the 1992-2002 period, the EU target value of 50 mg/l for nitrate was on average exceeded in 12% of the groundwater wells at a depth of 5-15 m. For agricultural sites this was 14%, for nature sites 8% and for other sites 12%, see Figure 20 and Table 24. There were slight differences between years.

For agricultural sites on sandy soils the target value was exceeded in 22% of the wells, whereas for clay and peat soils, this was the case for about 1% of the wells, see Figure 21.

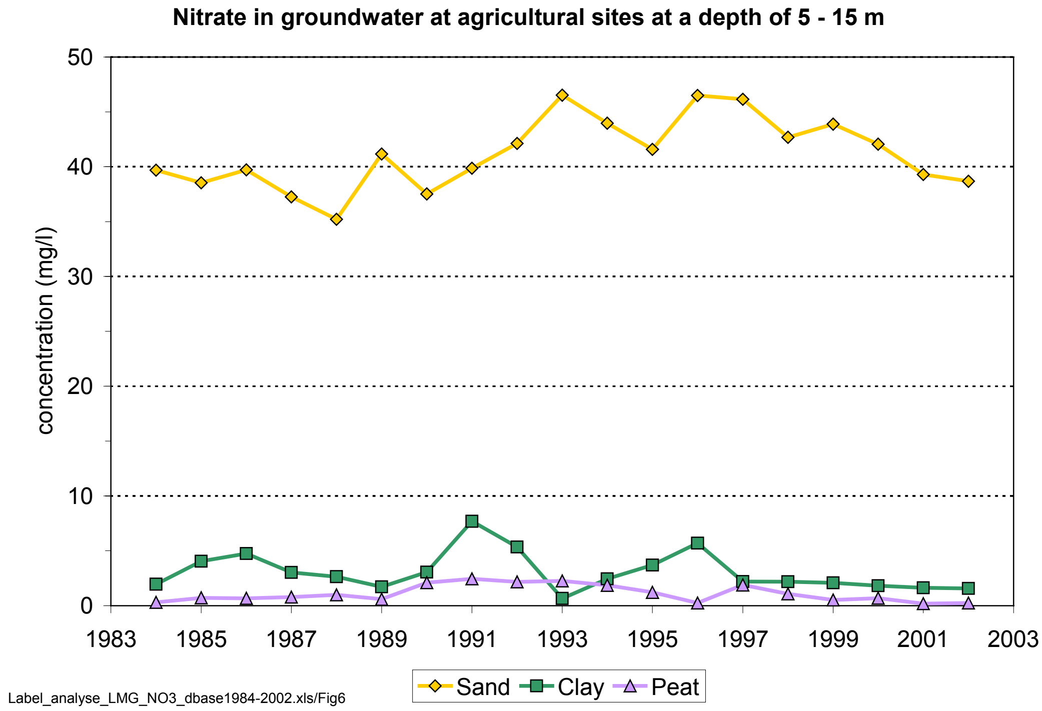


Figure 19: Average annual nitrate concentration (mg/l) in groundwater in the agricultural areas of the Netherlands at a depth of 5 – 15 m below the surface level per soil type for the 1984 – 2002 period.

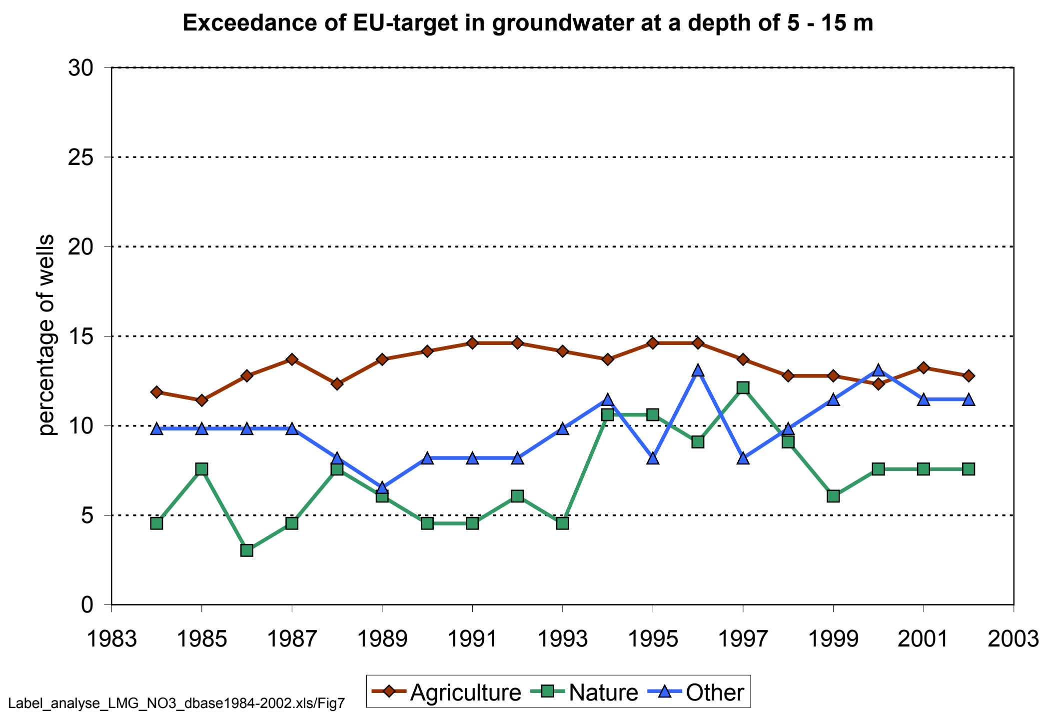


Figure 20: Exceedance of the EU target value of 50 mg/l for nitrate in groundwater in the Netherlands at a depth of 5-15 m below the surface level per land-use type for the 1984-2002 period.

Other land uses includes orchards and urban areas. Exceedance is expressed as a percentage of all monitored wells.

Most wells (about 70%) did not show a change in nitrate concentration between the reporting periods (1992-1994, 1996-1999 and 2000-2002), see Table 25. Between the first and second period the number of wells with a slight increase was slightly greater than those with a slight decrease, whereas between the second and third period the number wells with a decrease was slightly larger.

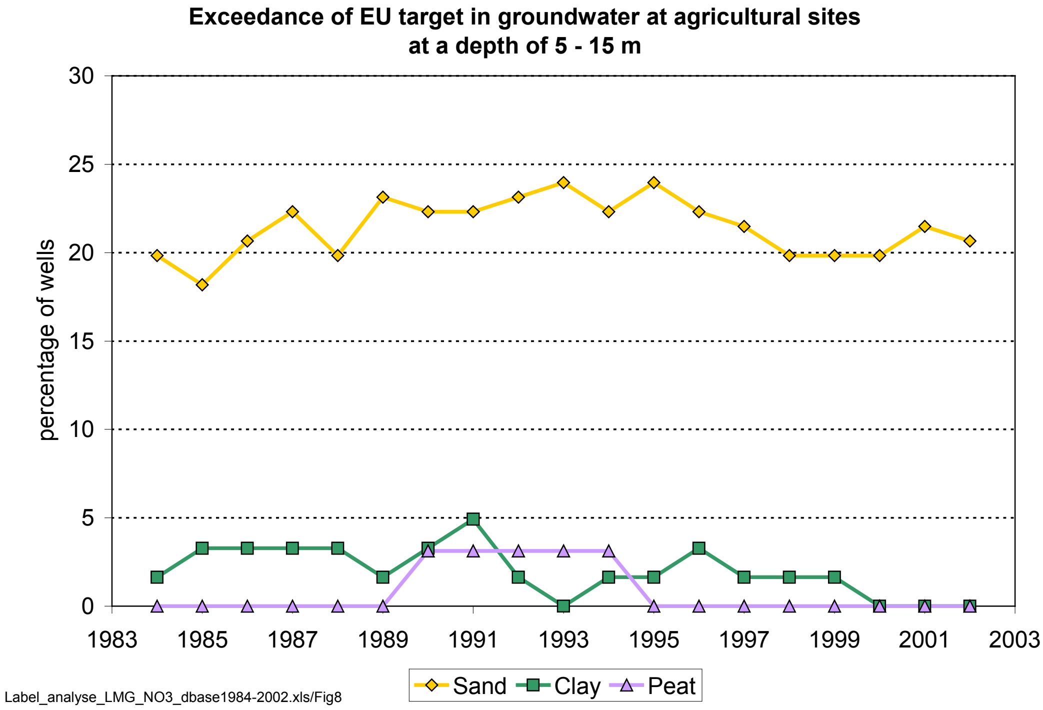


Figure 21: Exceedance of the EU target value of 50 mg/l for nitrate in groundwater in the agricultural areas of the Netherlands at a depth of 5-15 m below the surface level for the 1984-2002 period.

Exceedance is expressed as a percentage of all monitored wells.

Table 24: Nitrate in groundwater at a depth of 5-15 m for the 1992-2002 period (%)[*1].*

Concentration range	All monitoring wells 1992-1994	1996-1999	2000-2002	Agricultural wells 1992-1994	1996-1999	2000-2002
0–15 mg/l	79	81	81	81	82	83
15–25 mg/l	3	2	3	0	1	2
25–40 mg/l	3	2	3	2	2	1
40–50 mg/l	3	2	1	2	1	1
> 50 mg/l	12	13	12	15	14	13
Number of sites	346	346	346	219	219	219

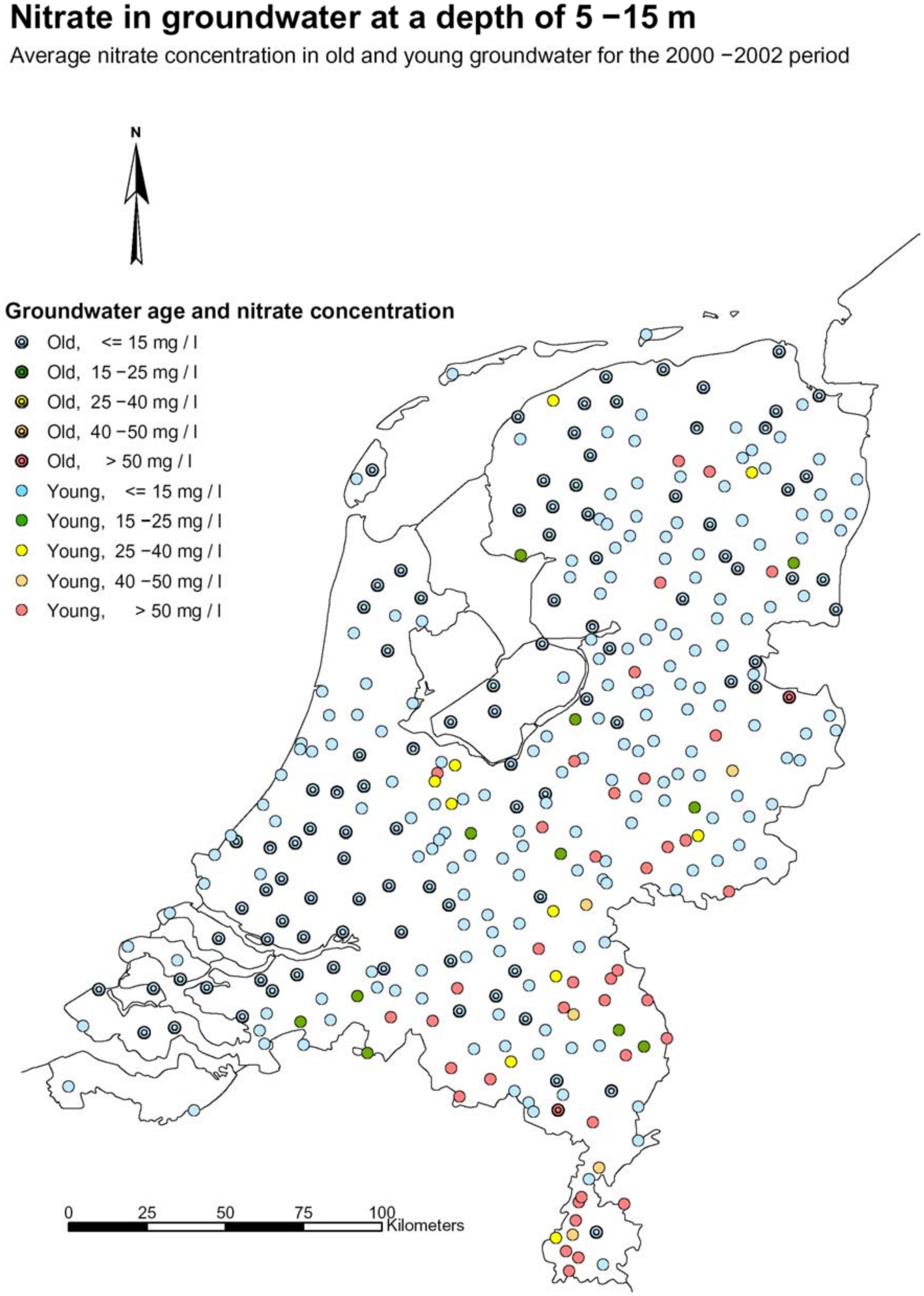
1) Percentage of monitoring wells with a period average within a given concentration range for all monitoring wells and for agricultural wells only. Total percentage may exceed 100 because of rounding off.

Table 25: Change in nitrate concentration in groundwater at a depth of 5-15 m for the 1992-2002 period (%)[*1].

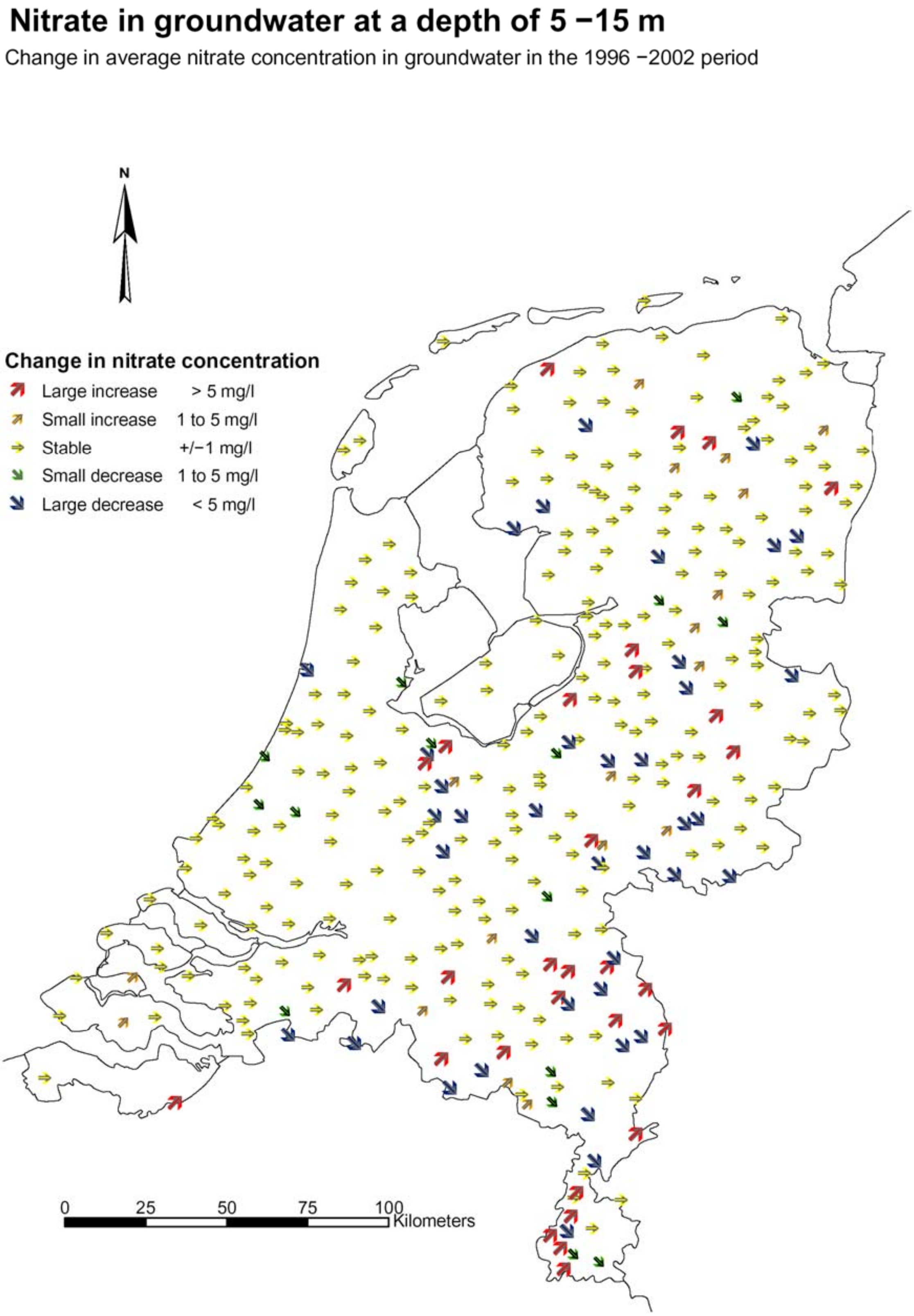
Rate of change	All monitoring wells		Agricultural wells	
	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	11	9	11	7
Small increase (% 1-5 mg/l)	5	5	4	6
Stable (% ± 1 mg/l)	69	70	74	71
Small decrease (% 1-5 mg/l)	4	4	1	4
Large decrease (% > 5 mg/l)	11	12	11	12
Number of sites	346	346	219	219

1) Percentage of wells with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for all monitoring wells and for agricultural wells only. Total percentage may exceed 100 because of rounding off.

Map 4 shows the average nitrate concentration for each monitoring well with a well screen between 5 and 15 m below the soil surface, for the 2000-2002 period. The wells are classified as those with old (> 25 years) and young (< 25 years) groundwater. The wells with old groundwater usually withdraw water from confined or semi-confined aquifers, while those with young groundwater usually withdraw water from phreatic aquifers. High nitrate concentrations (> 50 m/l) are found in young groundwater in the sand and loess regions (eastern and southern parts of the Netherlands). The change in nitrate concentration between the 1996-1999 and 2000-2002 periods is shown in Map 5. Most changes occurred in the sand and loess regions. Both increases and decreases in the nitrate concentration were found.



Map 4: Average nitrate concentration in groundwater in the Netherlands at a depth of 5-15 m for the 2000-2002 period.



Map 5: Change in average nitrate concentration in groundwater in the Netherlands at a depth of 5-15 m for 2000-2002 the period.

Change expressed as difference between averages for the 1996-1998 and 2000-2002 periods.

5.3 Nitrate in groundwater at a depth of 15–30 m

In the 1992-2002 period, the average nitrate concentration in groundwater in the Netherlands at 15-30 m below the soil surface was about 5.8 mg/l . The average for agricultural land was 6.5 mg/l and fluctuated between 5.0 and 7.7 mg/l, see Figure 22. For nature and other land-use types the average concentration was about 3.1 and 6.1 mg/l respectively. There is still no explanation for the increase in nitrate concentrations in groundwater for other land-use types since 1998.

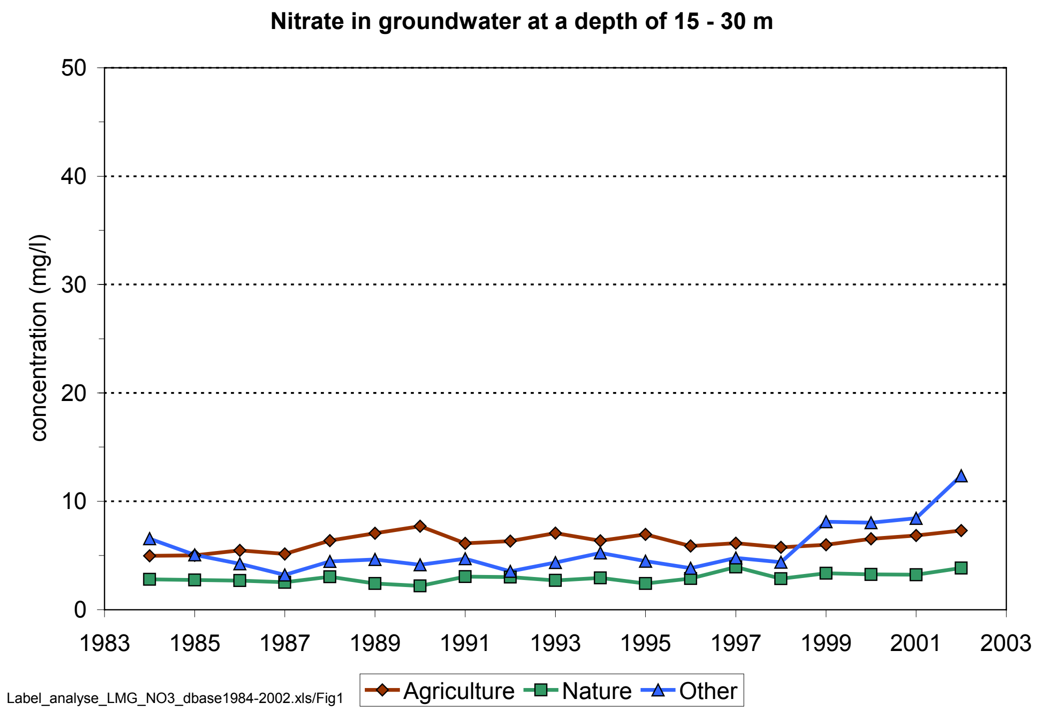


Figure 22: *Average annual nitrate concentration (mg/l) in groundwater in the Netherlands at a depth of 15–30 m below the surface level per land-use type for the 1984–2002 period.*

Other land uses include orchard and urban areas.

The nitrate concentration in groundwater derived from agricultural sites on sandy soils (10 mg/l) was higher than on clay and peat soils (< 1 mg/l), Figure 23. There was no trend in nitrate concentration.

In the 1992-2002 period, the EU target value of 50 mg/l for nitrate was on average exceeded in 3% of the groundwater wells at a depth of 15-30 m. For agricultural sites this was 4%, for nature sites 1% and for other sites about 4%, see Figure 24 and Table 26. There were slight differences between years.

For agricultural sites on sandy soils the target value was exceeded in about 6% of the wells, while on clay and peat soils this was the case in less than 1% of the wells, see Figure 25.

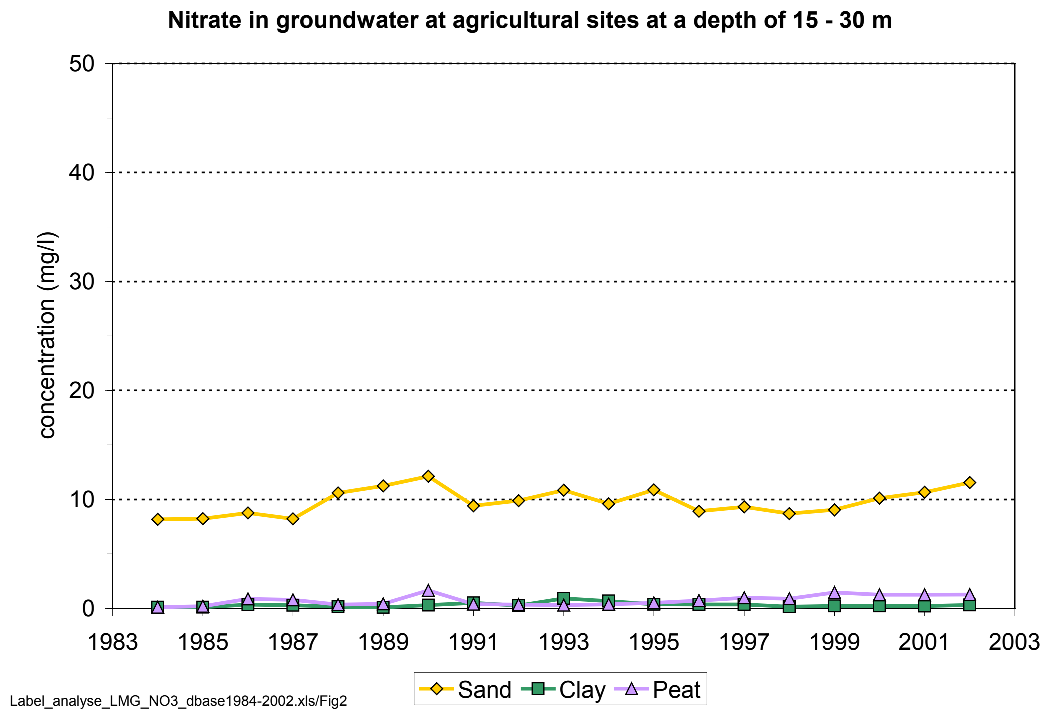


Figure 23: Average annual nitrate concentration (mg/l) in groundwater in agricultural areas of the Netherlands at a depth of 15–30 m below the surface level per soil type for the 1984–2002 period.

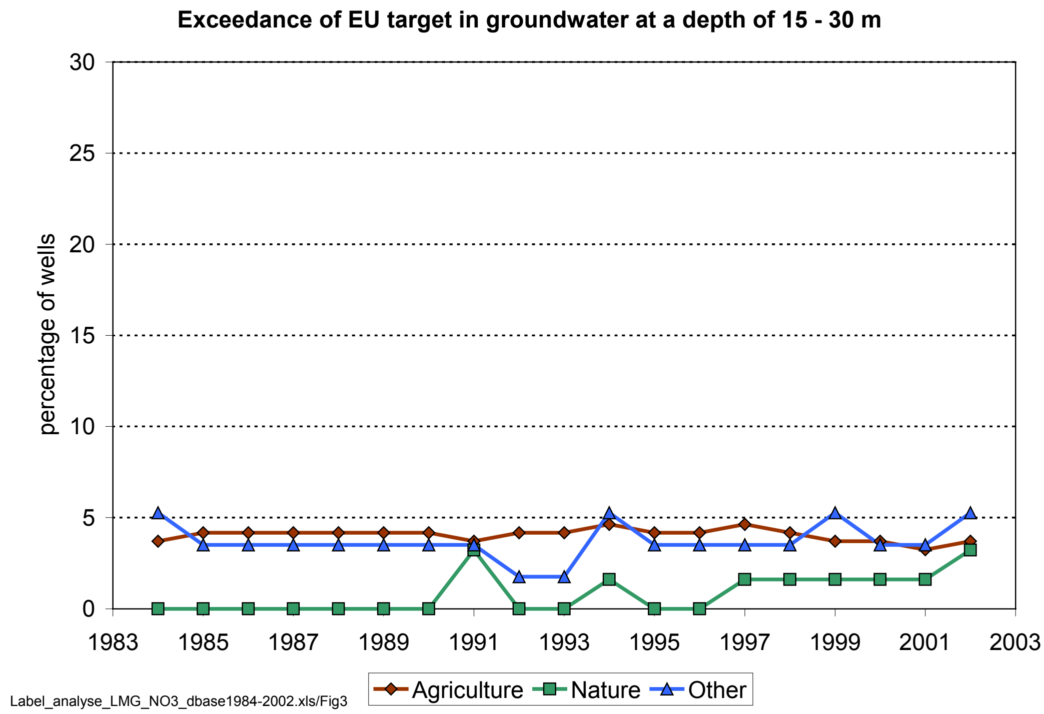


Figure 24: Exceedance of the EU target value of 50 mg/l for nitrate in groundwater in the Netherlands at a depth of 15-30 m below the surface level per land-use type for the 1984-2002 period.

Other land uses include orchard and urban areas. Exceedance is expressed as a percentage of all monitored wells.

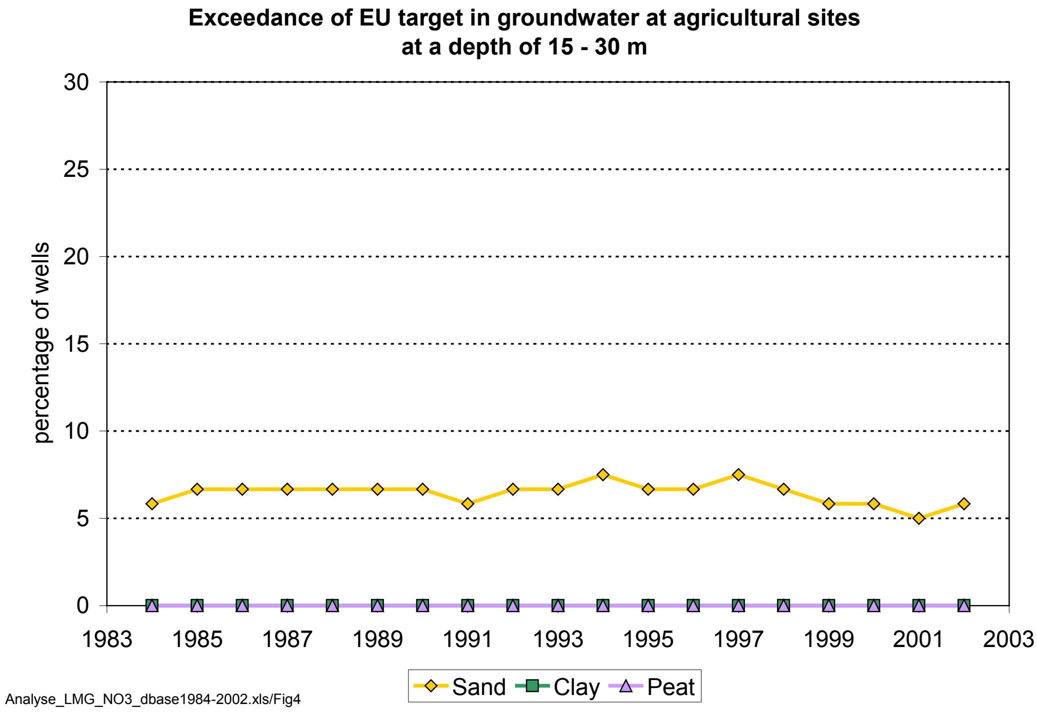


Figure 25: Exceedance of the EU target value of 50 mg/l for nitrate in groundwater in the agricultural areas of the Netherlands at a depth of 15-30 m below the surface level in the 1984-2002 period.

Exceedance as a percentage of all monitored wells.

Table 26: Nitrate in groundwater at depth of 15-30 m for the 1992-2002 period (%)[*1].*

	All monitoring wells			Agricultural wells		
Concentration range	1992-1994	1996-1999	2000-2002	1992-1994	1996-1999	2000-2002
0–15 mg/l	93	94	93	94	95	94
15–25 mg/l	1	1	1	0	0	1
25–40 mg/l	2	1	2	1	0	1
40–50 mg/l	1	0	1	0	0	1
> 50 mg/l	3	4	3	4	5	3
Number of sites	335	335	335	219	216	216

1) Percentage of monitoring wells with a period average within a given concentration range for all monitoring wells and for agricultural wells only. Total percentage may exceed 100 because of rounding off.

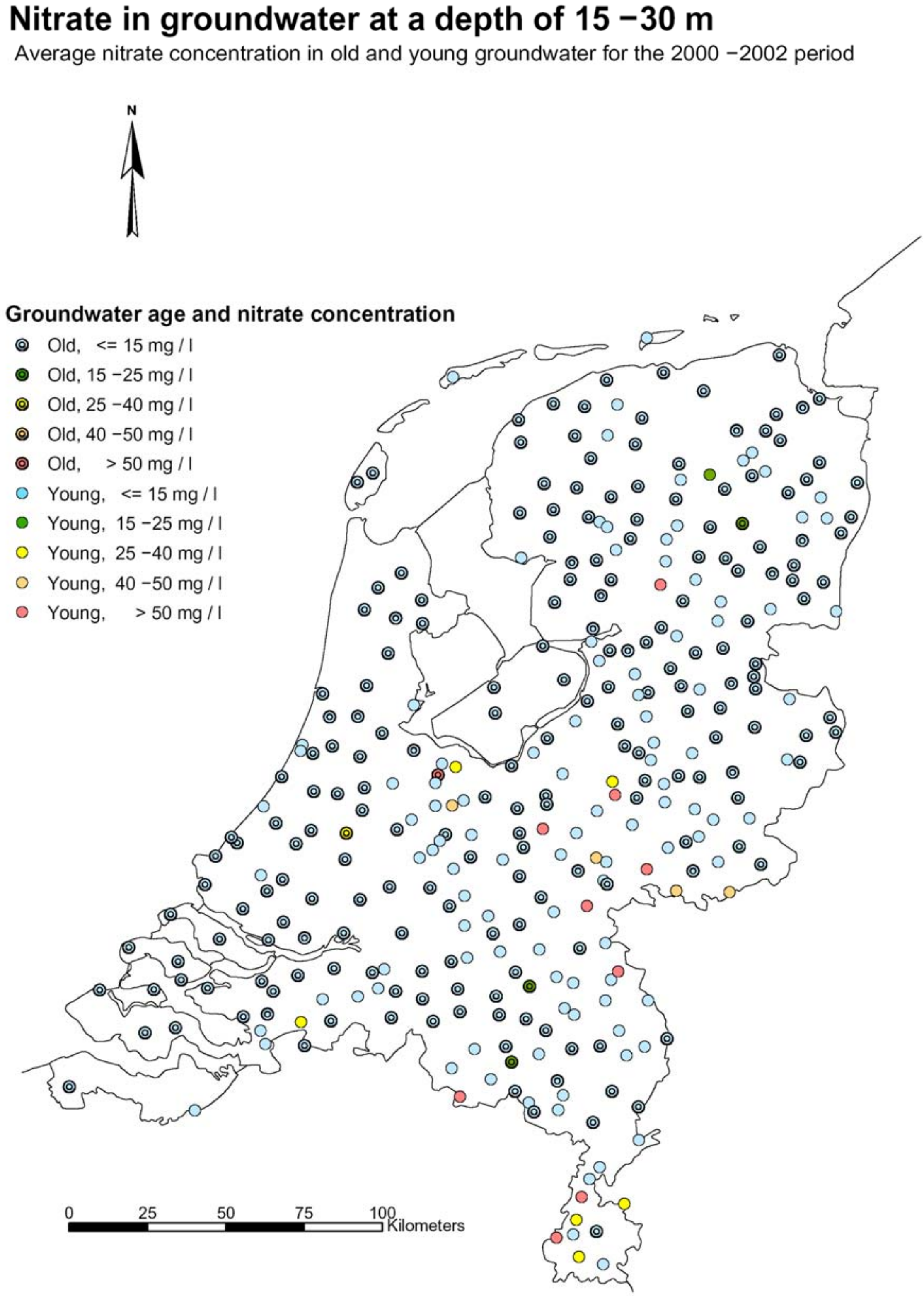
Most wells (> 80%) did not show a change in nitrate concentration between reporting periods (1992-1994, 1996-1999 and 2000-2002), see Table 27. Between the first and second period, the number of wells with a slight increase was slightly larger than those with a slight decrease, while between the second and third period, the number of wells with a decrease was slightly higher.

Table 27: Change in nitrate concentration in groundwater at a depth of 15-30 m for the 1992-2002 period (%)[*1]*.*

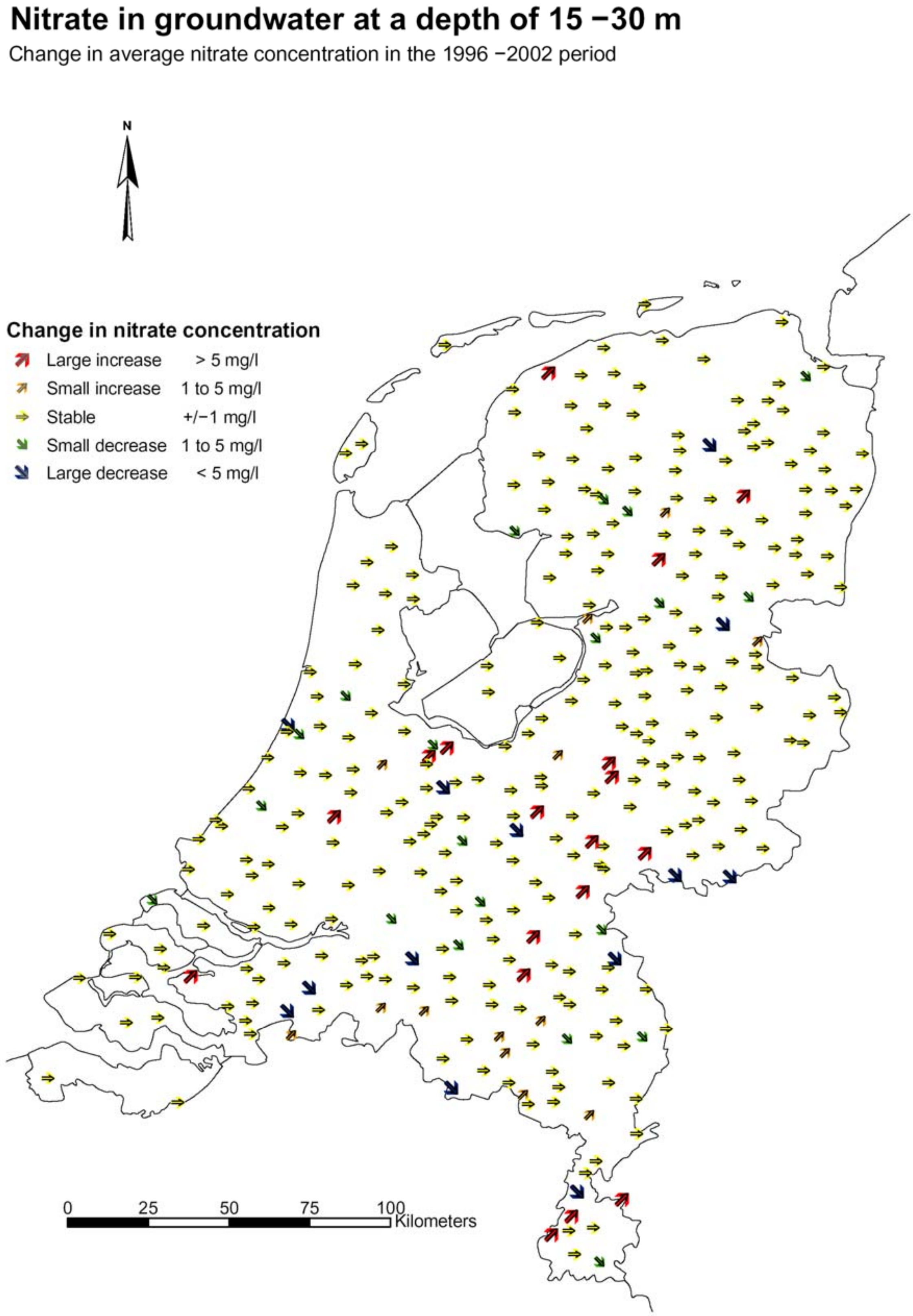
Rate of change	All monitoring wells		Agricultural wells	
	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	4	5	3	4
Small increase (% 1-5 mg/l)	7	4	6	4
Stable (% ± 1 mg/l)	83	81	85	83
Small decrease (% 1-5 mg/l)	3	6	3	6
Large decrease (% > 5 mg/l)	4	4	4	3
Number of sites	335	335	216	216

[1)] Percentage of wells with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for all monitoring wells and for agricultural wells only. Total percentage may exceed 100 because of rounding off.

Map 6 shows the average nitrate concentration for each monitoring well with a well screen placed between 15 and 30 m below the soil surface, for the 2000-2002 period. The wells are classified as those with old (> 25 years) and young (< 25 years) groundwater. The wells with old groundwater usually withdraw water from confined or semi-confined aquifers, while those with young groundwater usually withdraw water from phreatic aquifers. High nitrate concentrations (> 50 m/l) were found in young groundwater in the sand and loess regions (eastern and southern parts of the Netherlands). The change in nitrate concentration between the periods 1996-1999 and 2000-2002 is shown in *Map 7*. Most changes occurred in the sand and loess regions. Both increases and decreases in nitrate concentrations were found.



Map 6: Average nitrate concentration in groundwater in the Netherlands at a depth of 15-30 m for the 2000-2002 period.



Map 7: Change in average nitrate concentration in groundwater in the Netherlands at a depth of 15-30 m for the 2000-2002 period.

Change is expressed as the difference between averages for the 1996-1998 and 2000-2002 periods.

5.4 Nitrate in groundwater below a depth of 30 m

In the 1992-2002 period, the average nitrate concentration in groundwater used for drinking-water production (raw water) in the Netherlands was about 6.5 mg/l for phreatic aquifers and less than 1 mg/l for confined aquifers. The nitrate concentration in raw water from phreatic aquifers showed a slightly increasing trend, see Figure 26 (Versteegh and Biesebeek, 2002; Versteegh and Lips, 1998; Versteegh et al., 1997, 1996, 1995).

The percentage of drinking-water production sites with an average nitrate concentration in raw water above 50 mg/l was less than 2 %, see Figure 27 and Table 28. In the 2000-2002 period, less than 0.05% of the total volume of raw groundwater used for drinking-water production had a nitrate concentration higher than 50 mg/l.

The slow increase in nitrate concentration in raw water is also shown in Table 28 and Table 29. The percentage of wells with a nitrate concentration between 15 and 25 mg/l increased from 8% in 1992-1994 to 13% in 2000-2002 and the percentage of wells with a concentration of more than 25 mg/l increased from 6% to 9% in the same period.

The EU target value of 50 mg/l in distributed drinking water was hardly ever exceeded. In 2001, only one of the 224 drinking-water production stations had a nitrate concentration of more than 50 mg/l (maximum 52 mg/l) and this was only the case in 2 of the 25 inspections of off-station water (VROM, 2003).

In the 1992-2002 period, the average maximum nitrate concentration in groundwater used for drinking-water production in the Netherlands was about 13 mg/l for phreatic aquifers and less than 1 mg/l for confined aquifers. The nitrate concentration in raw water from phreatic aquifers showed a slightly increasing trend, see Figure 28 and Table 31. The percentage of drinking-water production sites with a maximum nitrate concentration in raw water above 50 mg/l was less than 10%, see Figure 29 and Table 30.

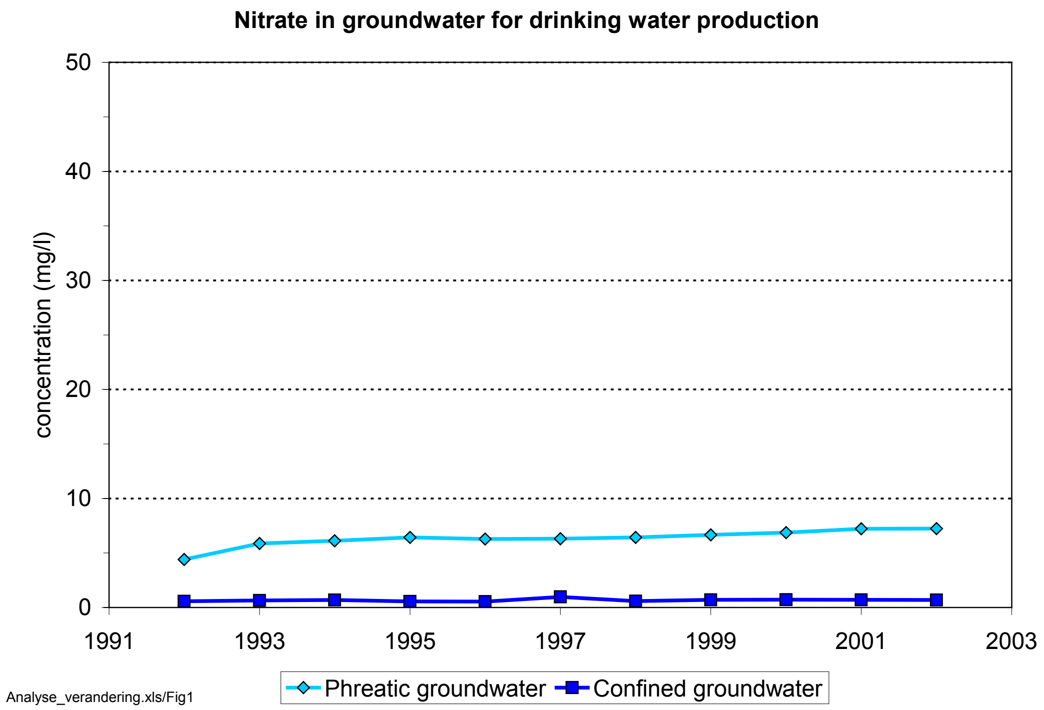


Figure 26: Average annual nitrate concentration (mg/l) in groundwater in the Netherlands at drinking-water production sites for phreatic groundwater and confined groundwater for the 1999–2002 period.

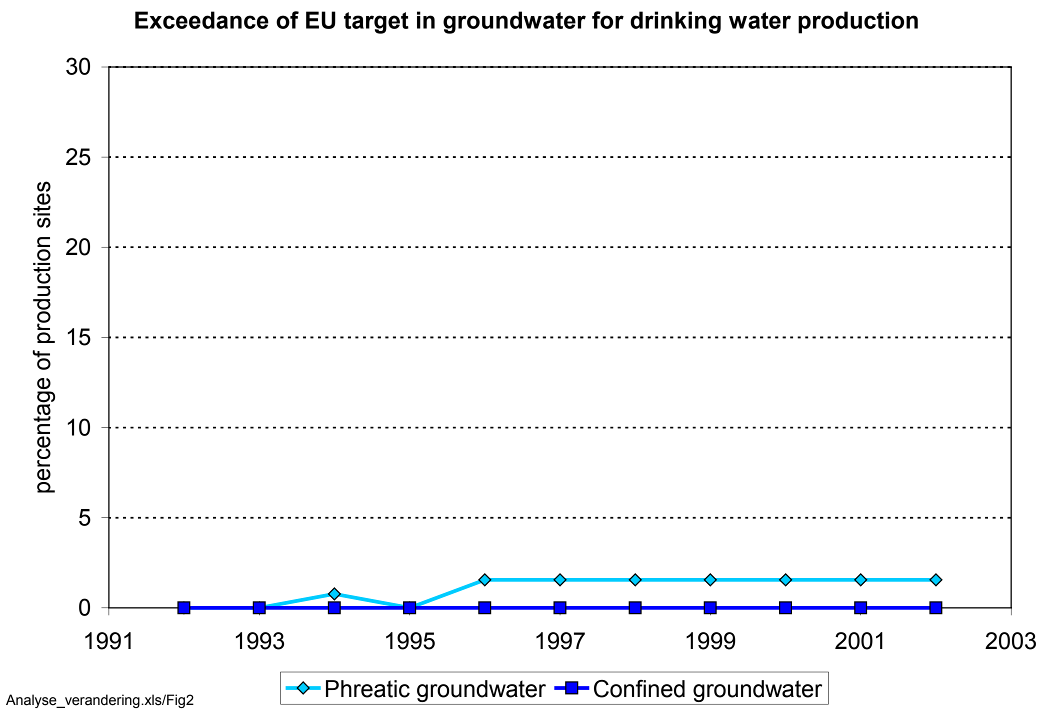


Figure 27: Exceedance of the EU target value of 50 mg/l for average nitrate concentration in groundwater in the Netherlands at drinking-water production sites for phreatic groundwater and confined groundwater for the 1992-2002 period.

Exceedance is expressed as percentage of all production sites.

Table 28: Average nitrate concentration in groundwater at a depth of more than 30 m for the 1992-2002 period (%)[*1].*

Concentration range	All production sites			Phreatic sites		
	1992-1994	1996-1999	2000-2002	1992-1994	1996-1999	2000-2002
0–15 mg/l	92	90	87	87	83	78
15–25 mg/l	5	6	7	8	10	13
25–40 mg/l	3	3	2	5	6	4
40–50 mg/l	0	0	2	1	0	3
> 50 mg/l	0	1	1	0	2	2
Number of sites	216	210	207	128	123	120

1) Percentage of drinking-water production sites using groundwater with a period average within a given concentration range for all production sites and for sites with phreatic groundwater only. Total percentage may exceed 100 because of rounding off.

Table 29: Change in average nitrate concentration in groundwater at a depth of more than 30 m for the 1992-2002 period (%)[*1].*

Rate of change	All production sites		Phreatic sites	
	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	4	5	5	8
Small increase (% 1-5 mg/l)	12	6	21	10
Stable (% ± 1 mg/l)	80	83	68	70
Small decrease (% 1-5 mg/l)	3	6	5	11
Large decrease (% > 5 mg/l)	1	1	1	1
Number of sites	196	196	111	111

1) Percentage of drinking-water production sites using groundwater with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for all production sites and sites with phreatic groundwater only. Total percentage may exceed 100 because of rounding off.

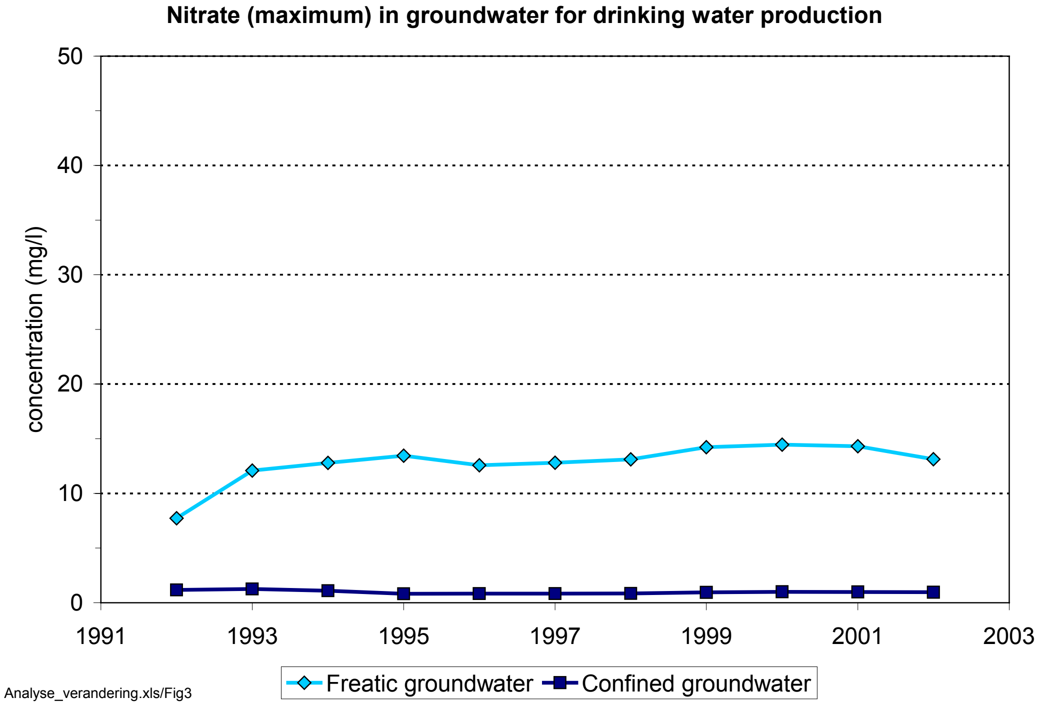


Figure 28: Maximum nitrate concentration (mg/l) in groundwater in the Netherlands at drinking-water production sites for phreatic groundwater and confined groundwater for the 1992–2002 period.

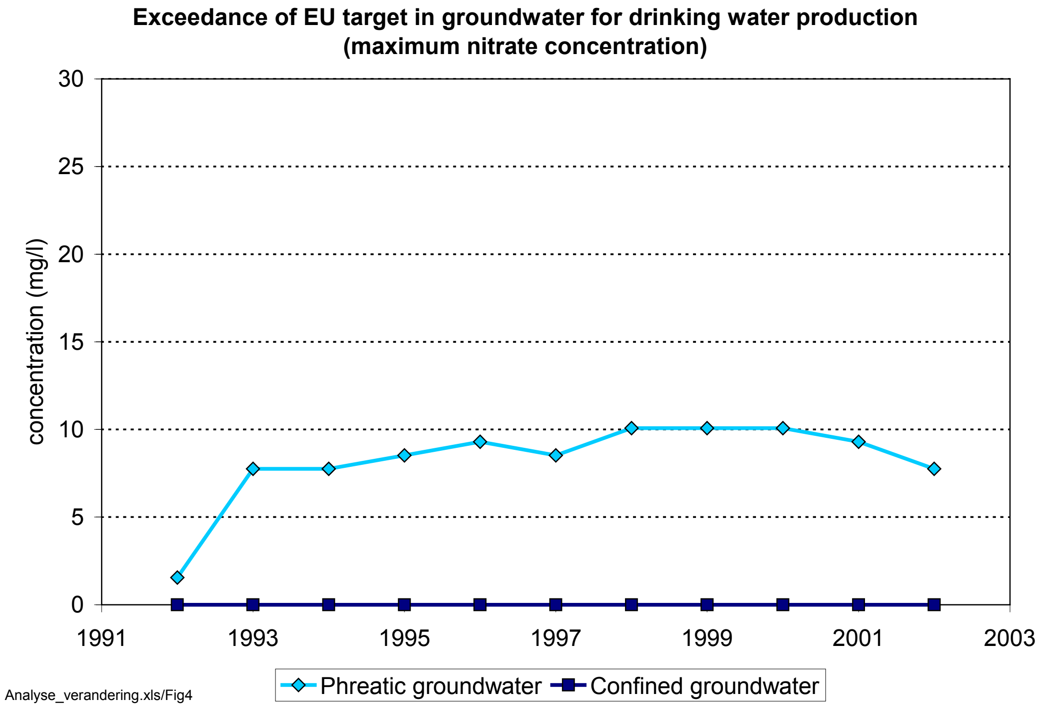


Figure 29: Exceedance of the EU target value of 50 mg/l for the maximum nitrate concentration in groundwater in the Netherlands at drinking-water production sites for phreatic groundwater and confined groundwater for the 1992-2002 period.

Exceedance is expressed as a percentage of all production sites.

Table 30: Maximum nitrate concentration in groundwater at a depth of more than 30 m for the 1992-2002 period (%)[*1]*

Concentration range	All production sites 1992-1994	1996-1999	2000-2002	Phreatic sites 1992-1994	1996-1999	2000-2002
0–15 mg/l	86	84	84	78	74	73
15–25 mg/l	3	5	3	5	7	4
25–40 mg/l	6	4	3	9	7	5
40–50 mg/l	2	1	5	4	2	8
> 50 mg/l	3	5	6	5	9	10
Number of sites	216	210	207	128	123	120

1) Percentage of drinking-water production sites using groundwater with a period average within a given concentration range for all production sites and for sites with phreatic groundwater only. Total percentage may exceed 100 because of rounding off.

Table 31: Change in maximum nitrate concentration in groundwater at a depth of more than 30 m for the 1992-2002 period (%)[*1]*.*

Rate of change	All production sites 1992/1995-1996/1999	1996/1999-2000/2002	Phreatic sites 1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	10	6	17	11
Small increase (% 1-5 mg/l)	10	10	18	14
Stable (% ± 1 mg/l)	72	73	56	57
Small decrease (% 1-5 mg/l)	5	7	5	12
Large decrease (% > 5 mg/l)	3	4	4	7
Number of sites	196	196	111	111

1) Percentage of drinking-water production sites using groundwater with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for all production sites and sites with phreatic groundwater only. Total percentage may exceed 100 because of rounding off.

Map 8 shows the average concentration per drinking-water station for the 2000-2002 period, while Map 9 shows the change between the 1996-1998 and 2000-2002 periods.
The highest nitrate concentrations occur in the southern part of the Netherlands, with mainly loess soils, and in the eastern part of the Netherlands near the German border with sandy soils. These parts of the Netherlands in particular are showing increasing trends.

Map 10 shows the maximum concentration per drinking-water station for the 2000-2002 period, while Map 11 shows the change in maximums between the 1996-1998 and 2000-2002 periods. The highest maximum nitrate concentrations also occur in the southern and the eastern parts of the Netherlands.

5.5 References

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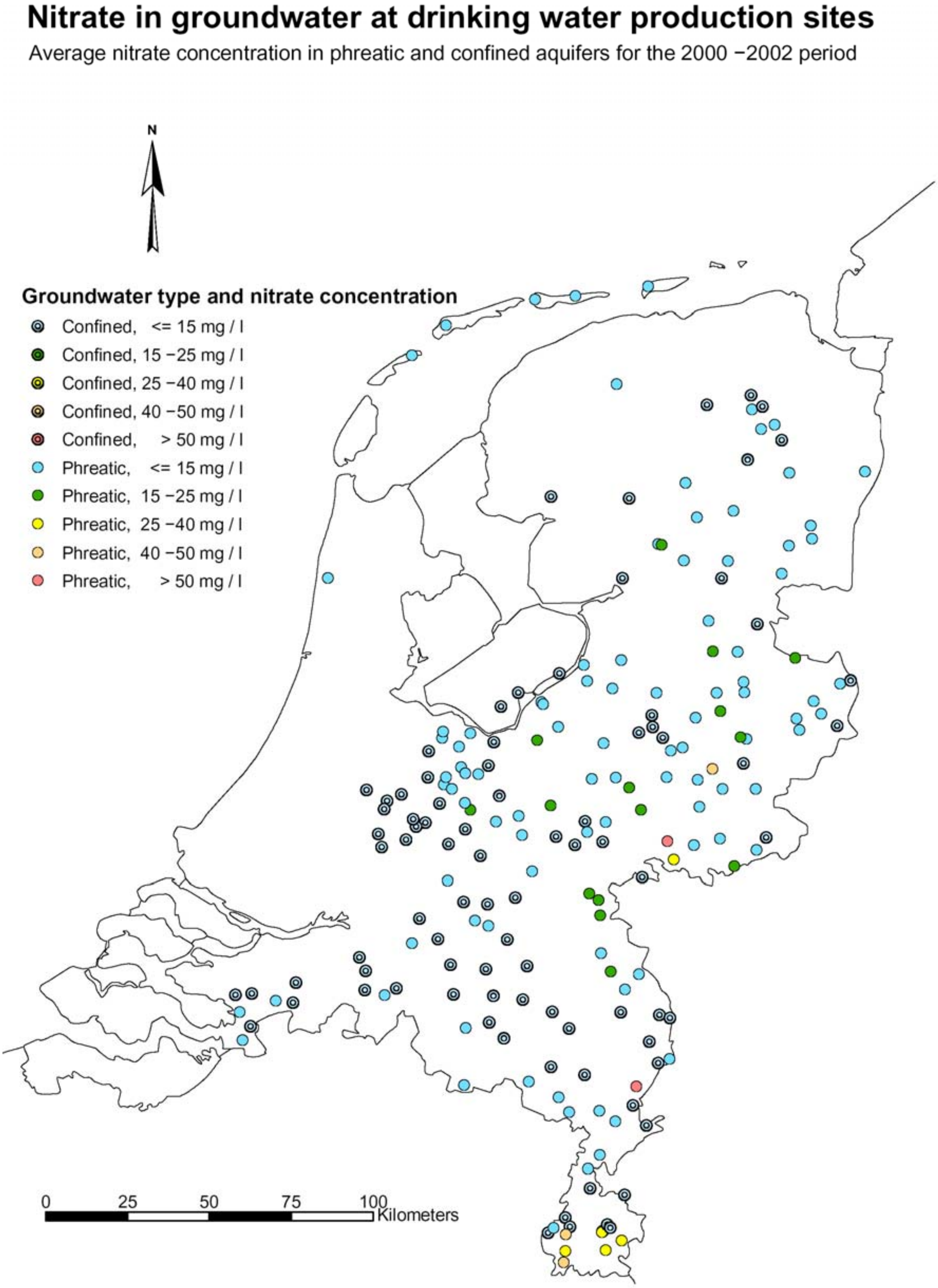
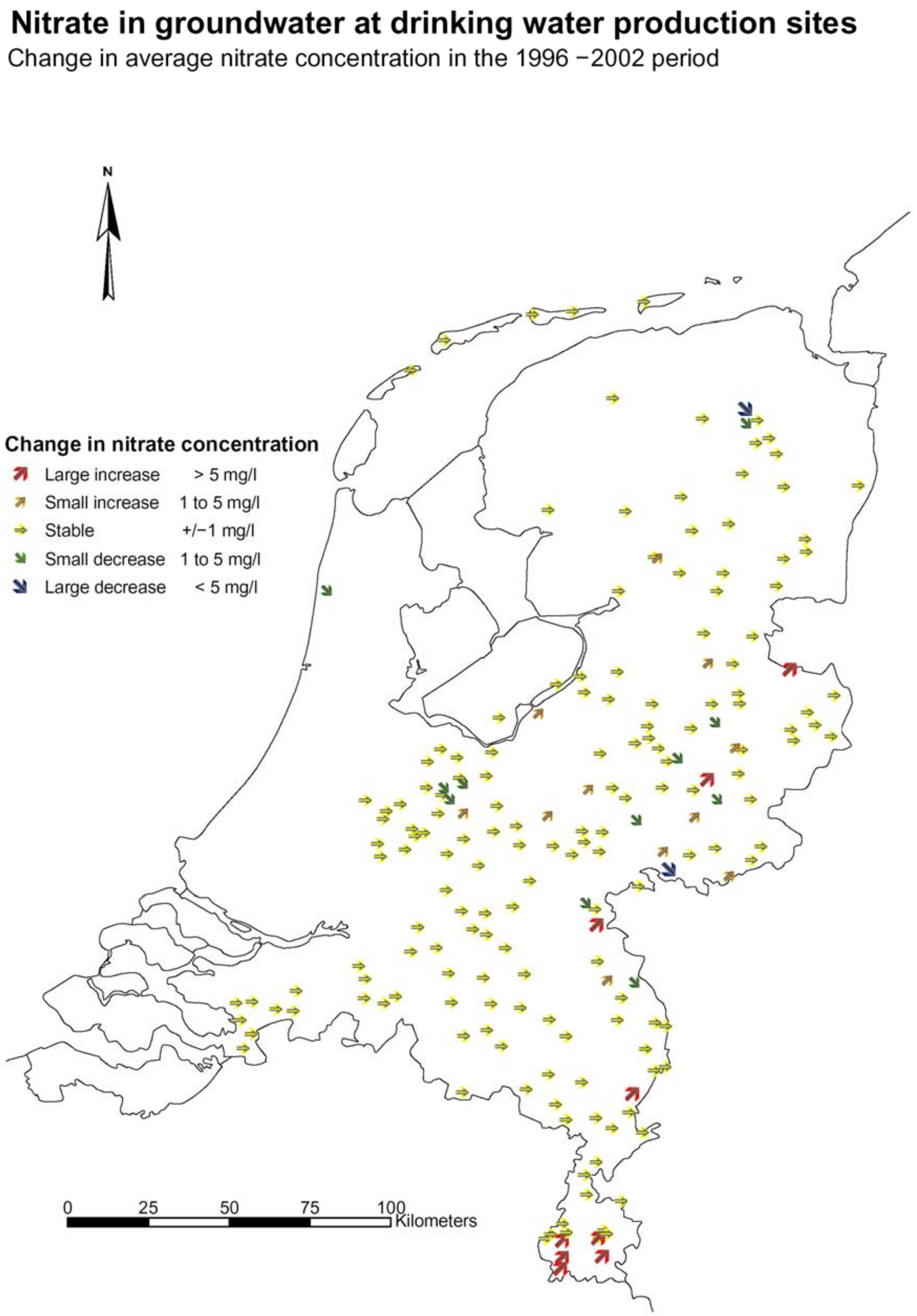
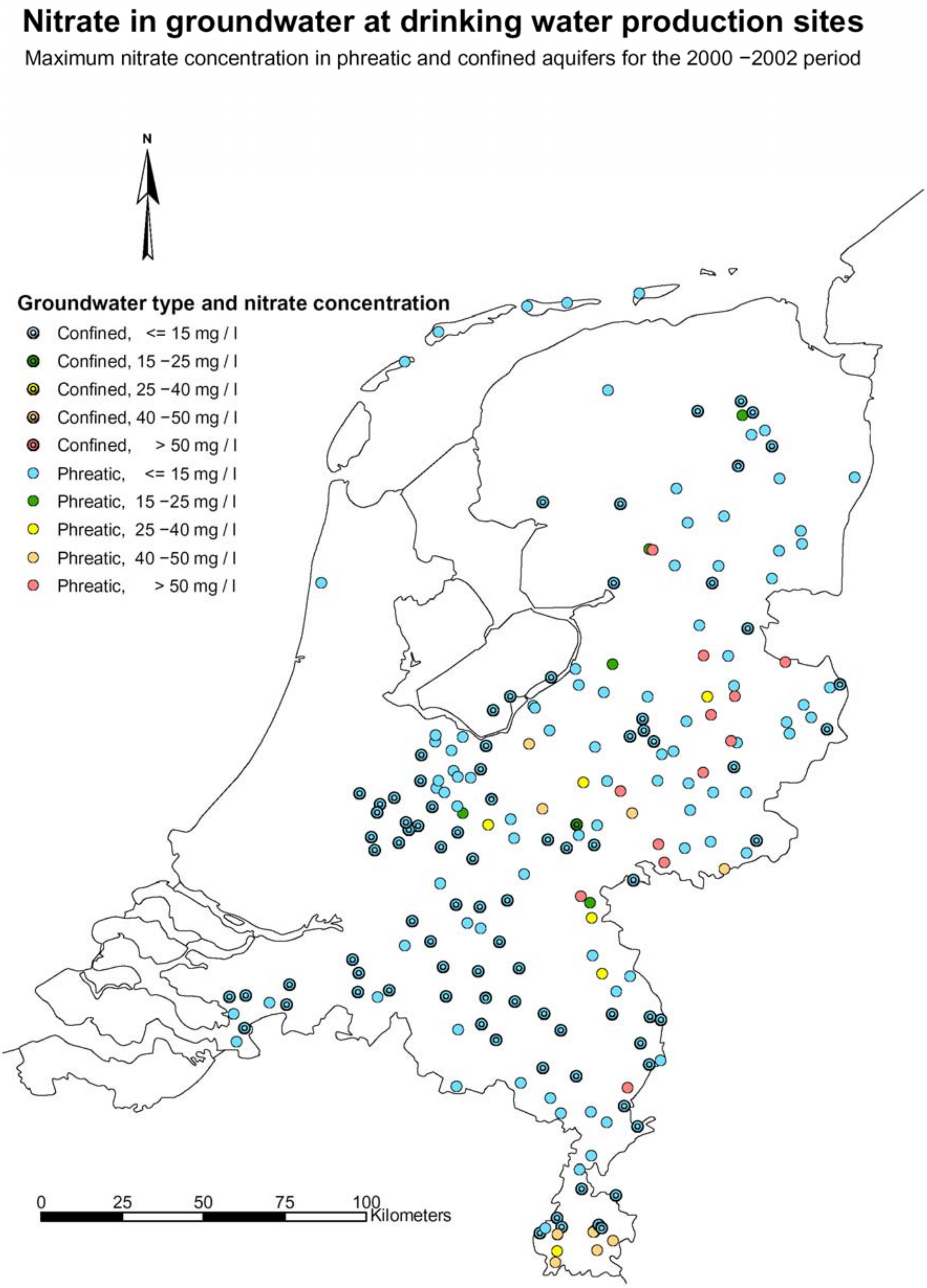


Map 8: Average nitrate concentration in groundwater used for drinking-water production in the Netherlands for the 2000-2002 period.

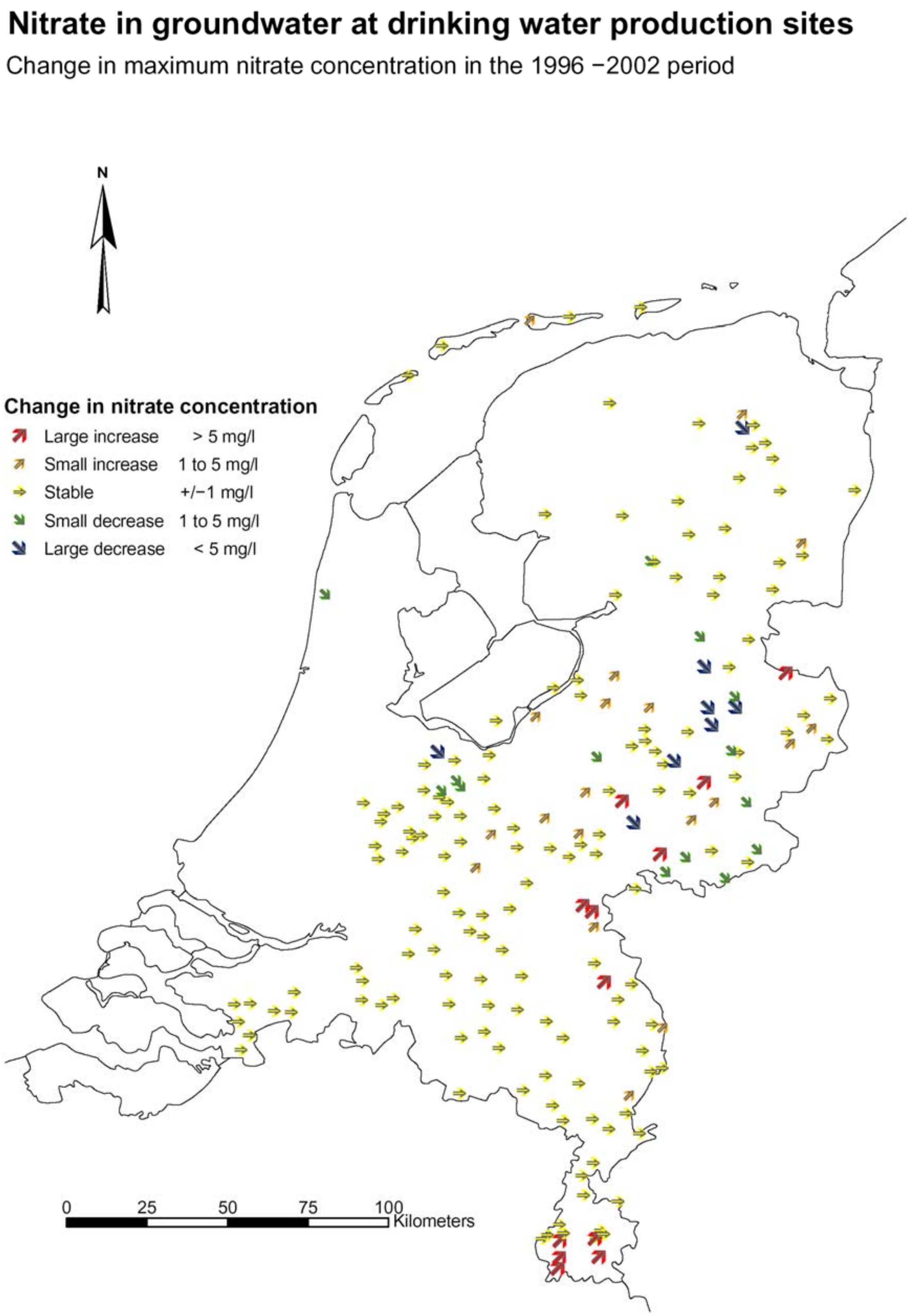


Map 9: *Change in average nitrate concentration in groundwater used for drinking-water production in the Netherlands for the 1996-2002 period.*

Change expressed as difference between averages for the 1996-1998 and 2000-2002 periods.



Map 10: Maximum nitrate concentration in groundwater used for drinking-water production in the Netherlands for the 2000-2002 period.



Map 11: Change in average nitrate concentration in groundwater used for drinking-water production in the Netherlands for the 1996-2002 period.

Change expressed as difference between averages for the 1996-1998 and 2000-2002 periods.

6. FRESH WATER QUALITY

6.1 Introduction

The opening section of this chapter (§6.2) outlines the load on fresh surface waters in terms of the nutrients nitrogen and phosphorus. Both substances affect the degree of eutrophication of surface waters, the subject of the last section (§6.4). The central section (§6.3) discusses the changing nitrate concentrations. The periods compared are the years 1992-1994, 1996-1998 and 2000-2002. The maps deal with the comparison between the last two periods.

The presentation of the data in §6.3 and §6.4 includes surveys of all waters and, in particular, of waters affected by agriculture. As explained in §2.5, three categories of fresh surface waters are distinguished: national waters, regional waters affected by agriculture and other regional waters. In §6.3 nitrate concentrations in surface waters used for drinking-water production are presented as well. The national waters are singled out as a separate category for two reasons: first, they give an indication of foreign influences on water quality and second because the effects of domestic sources on water quality in the coastal zone are transmitted through the national fresh waters. Details on the method of calculation can be found in Annex 5.

It should be emphasised that the Dutch standards are primarily concerned with eutrophication. The yardstick used in assessing signs of eutrophication is the chlorophyll-*a* concentration. The standards also allow for the fact that the six summer months are the most critical period with respect to eutrophication. That is why in eutrophication-sensitive stagnant waters (V&W, 1998; CIW 2000), the Dutch standard for chlorophyll-*a* (100 µg/l) is expressed as the average over the six summer months. The standards for total phosphorus (0.15 mg/l summer value) and total nitrogen (2.2 mg/l summer value) are derived from this (V&W, 1998; CIW, 2000). Total nitrogen gives a good indication of both the available nutrients and the algal biomass.

The EU standards are primarily aimed at assessing the effects of agriculture on surface water quality. Here the six winter months, the period in which leaching plays a significant role, are of particular importance. Nitrate nitrogen is considered to be the most important nitrogen component affected by agriculture. In contrast to the previous report (Fraters et al., 2000), in which yearly average nitrate concentrations were calculated, this report calculates and reports winter averages of nitrate. Thus the pattern of nitrate concentrations, and the conclusions, may deviate from those in national reports, most of which are based on summer average concentrations of eutrophication parameters (chlorophyll-*a*, total nitrogen and total phosphorus) for stagnant eutrophication-sensitive waters.

6.2 Nutrient load to fresh waters

In the 2000-2002 period, the Dutch contribution amounted to approximately one-quarter of the total nitrogen load, see Table 32. This included direct discharges into surface waters via the sewerage system and by industry, both with and without purification, as well as indirect sources that are more difficult to quantify, such as leaching and run-off from agricultural areas, and atmospheric deposition. The tabled data on preceding years may differ from those reported in 2000 (Fraters et al., 2000) due to recalculation and the use of new calculation methods (see remarks below Table 32 and Table 33).

In the 1992-2002 period, the total nitrogen load of domestic origin in fresh surface waters showed a slight decrease, from about 158,000 metric tons for the 1992-1994 period to about 122,000 metric tons per year for the 2000-2002 period. The fluctuations in nitrogen imports from other countries via the main rivers were related to weather conditions.

Agriculture accounts for the largest contribution to the nitrogen load of surface waters, through direct discharges and in particular through leaching and run-off (about 59% for 2000-2002). Leaching and run-off includes the contribution of non-agricultural land, natural load by seepage and the load due to oxidation of peat soils. Leaching and run-off of nitrogen from non-agricultural land is estimated at 9–10 million kg per year, i.e. about 15% of total leaching and run-off (RIVM, 2004). Estimations of the contribution of natural load by seepage and the load due to oxidation of peat soils are not available. On the other hand, atmospheric nitrogen deposition originates largely from agricultural sources (RIVM, 2004a).

In the 1992-2002 period, the nitrogen discharges by industry were more than halved, while the discharges via the sewerage system were reduced by one-quarter. The emissions by agriculture also decreased during this period. Given the slight decrease in the foreign contribution, the total nitrogen load of fresh surface waters in the Netherlands decreased between 1992 and 2002.

The phosphorus loads of fresh surface waters in the 1992-2002 period are shown in Table 33. For the 2000-2002 period, the domestic contribution to the phosphorus load of surface waters amounted to roughly 35% of the total, in contrast to the 1992-1994 period, when the contribution was about 40%. In the 1992-2002 period, the Dutch contribution decreased by about one-third, as a result of lower discharges via sewerage and industry. In this period the phosphorus discharges by industry were reduced significantly and the sewage discharges were almost halved. The changeover to phosphate-free detergents and the enhanced phosphate removal in sewage treatment plants were major factors that contributed to the lower sewage discharges.

For the 2000-2002 period, agriculture also contributed significantly (about 62%) to the phosphorus load of surface waters through leaching and run-off. Leaching and run-off includes the contribution of non-agricultural land, natural load by seepage and the load due to oxidation of peat soils. Leaching and run-off of nitrogen from non-agricultural land is estimated at about 0.4 million kg per year, i.e. about 7% of total leaching and run-off (RIVM, 2004b). Estimations of the contribution of natural load by seepage and the load due to oxidation of peat soils are not available. The total contribution of agriculture corrected for leaching and run-off of nitrogen from non-agricultural land is about 58%.

The almost 15% decrease in phosphorus imported from other countries via the main rivers is related to similar emission restrictions in other countries, and to weather conditions.

Table 32: Nitrogen load of fresh surface waters in the Netherlands (in million kg) for the 1992-2002 period.

Source	1992-1994	1996-1998	2000-2002	2002
Sewage*1	44	36	33	31
Agriculture*2				
Direct	8	6	5	5
Leaching and run-off	77	58	65	60
Industry*1	9	5	4	4
Atmospheric deposition*1,3	20	17	15	14
Total NL load	158	122	122	114
Total foreign load*4	406	336	370	380

Source: Pollution Release Transfer Register (PRTR, 2004)

[1)] Emission figures for 1993, 1997 and 2001 were used and no averages were calculated.

[2)] Data for 1992-1994 were calculated by interpolating data from 1990 and 1995.

[3)] Atmospheric deposition data recalculated in 2003. Total nitrogen consists of wet plus dry deposition on surface waters, including IJsselmeer and Western Scheldt, but excluding Wadden Sea. The 1993 and 1997 emissions were found by interpolation from the 1990, 1995 and 2000 emissions.

[4)] Imported via rivers, data retrieved from DONAR and converted to annual loads by means of the BEVER load module.

Table 33: Phosphorus load of fresh surface waters in the Netherlands (in million kg) for the 1992-2002 period.

Source	1992-1994	1996-1998	2000-2002	2002
Sewage[*1]	6.1	3.5	3.2	3.2
Agriculture[*2]				
Direct	0.5	0.4	0.4	0.4
Leaching and run-off	4.3	5.4	5.9	5.9
Industry[*1]	3.9	3.5	0.5	0.6
Atmospheric deposition[*1,3]	0.0	0.0	0.0	0.0
Total NL load	14.8	12.7	10.1	10.1
Total foreign load[*4]	23.0	18.6	19.7	26.8

Source: Pollution Release Transfer Register (PRTR, 2004)

1) Emission figures for 1993, 1997 and 2001 were used and no averages were calculated.

2) Data for 1992-1994 were calculated by interpolating data from 1990 and 1995.

3) Atmospheric deposition data recalculated in 2003. Total nitrogen consists of wet plus dry deposition on surface waters, including IJsselmeer and Western Scheldt, but excluding Wadden Sea. The 1993 and 1997 emissions were found by interpolation from the 1990, 1995 and 2000 emissions.

4) Imported via rivers, data retrieved from DONAR and converted to annual loads by means of the BEVER load module.

6.3 Nitrate concentration in fresh waters

The vast majority of fresh surface water locations have a winter-average nitrate concentration below the EU target value of 50 mg/l, see Table 34. Between the periods 1996-1999 and 2000-2002, the percentage of locations where the average nitrate concentration was higher than this EU target value dropped from 6% to 1%; in the case of waters affected by agriculture the drop was from 7% to 2%. During the preceding periods there was no decline.

*Table 34: Winter-average nitrate concentration in fresh surface waters for the 1992-2002 period (%)[*1].*

	All waters			Agricultural waters		
Concentration range	1992-1994	1996-1999	2000-2002	1992-1994	1996-1999	2000-2002
0–10 mg/l	26	30	55	30	28	62
10–25 mg/l	49	45	34	44	44	26
25–40 mg/l	14	15	8	13	17	7
40–50 mg/l	4	5	1	5	4	2
> 50 mg/l	6	6	1	8	7	2
Number of sites	580	598	747	239	230	325

1) Percentages of monitoring sites with a period average concentration within a given concentration range. Data is for all waters and for waters mainly influenced by agriculture. Total percentage may exceed 100 because of rounding off.

The winter-average nitrate concentrations for the 2000-2002 period are also shown on a map of the Netherlands (Map 12). Waters exceeding the EU target values of 50 mg/l occur in the west of Brabant, the southern part of Limburg, the Westland region and in the eastern part of the country. These include not only waters affected by agriculture, but a number of national waters as well. As in the preceding periods, relatively low nitrate concentrations were found in the Gelderse Vallei, a region with intensive stockbreeding.

In about 40% of all fresh surface water locations a decline in the winter-average nitrate concentration was observed in the late 1990s compared to the early 1990s; however, a rise in nitrate concentrations occurred in just under 40% of all locations over the same period, see Table 35. For the years 2000-2002 the picture is much more positive. A far larger percentage of locations, over 80%, exhibited a decrease in winter-average nitrate concentration, whereas an increase of the nitrate concentrations was only observed in a mere 5% of all locations. This applies both to all waters and to waters affected by agriculture.

Table 35: Change in winter-average nitrate concentration in fresh surface waters for the 1999-2002 period (%)[*1].

	All waters		Agricultural waters	
Rate of change	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	14	2	13	3
Small increase (% 1-5 mg/l)	20	3	26	2
Stable (% ± 1 mg/l)	25	13	16	10
Small decrease (% 1-5 mg/l)	29	35	30	32
Large decrease (% > 5 mg/l)	12	48	14	53
Number of sites	544	578	216	217

1) Percentages of waters with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for all waters and for waters mainly influenced by agriculture. Total percentage may exceed 100 because of rounding off.

The changes in winter-average nitrate concentration for all surface waters in the Netherlands in the 1996-2002 period are shown in Map 13. The figure shows that, generally speaking, there was a decrease in average nitrate concentration. However, some areas (Zeeland and the southern part of Limburg) still showed considerable increases (> 5 mg/l) in nitrate concentration.

In the 1998-2002 period, the winter-average nitrate concentration was almost halved in regional fresh surface water locations influenced by agriculture from slightly under 20 mg/l to just above 10 mg/l, see Figure 30. This represents a considerable decline compared to the entire preceding period (1985-1998), during which nitrate concentrations fluctuated between about 20 and 25 mg/l.

A comparable drop occurred for the other regional waters and for national waters during the same period. Nitrate concentrations in agriculturally-influenced regional waters were somewhat higher than those in other regional waters, which in turn were slightly above the nitrate concentrations in national waters. Degradation, conversion and dilution caused the nitrate concentrations in national waters to be lower than those in regional waters.

The nitrate concentrations in surface waters used by drinking water plants are clearly lower (about 7 mg/l). They showed a slight decline since 1997-1998, to approximately 5 mg/l in 2002.

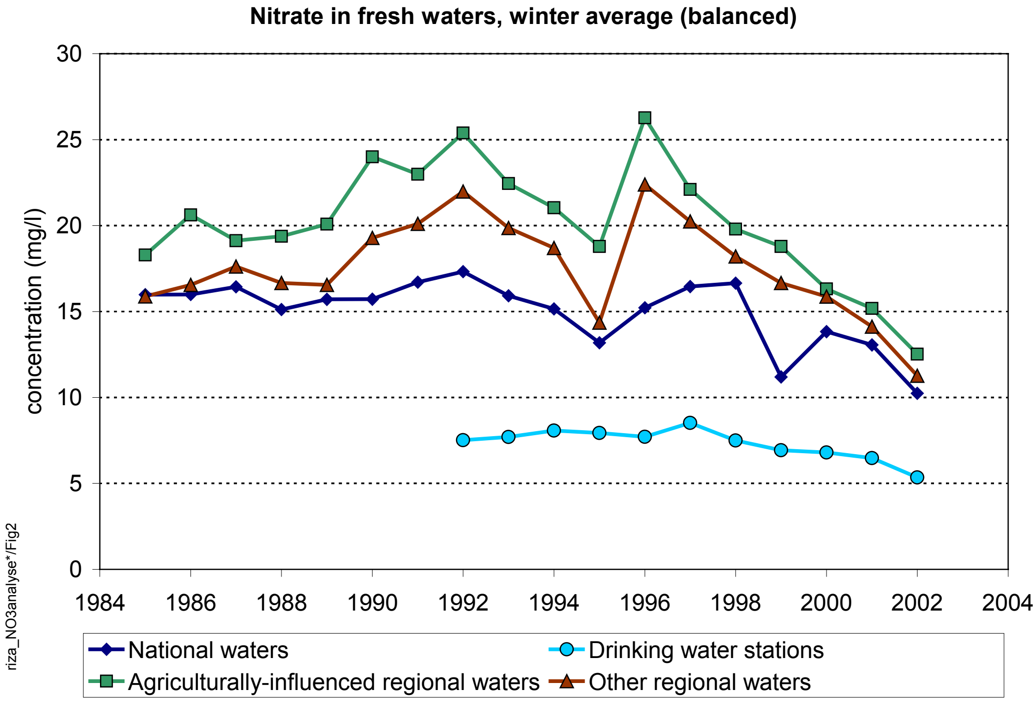


Figure 30: *Winter-average nitrate concentration in fresh surface waters (national waters, regional waters mainly influenced by agriculture and other regional waters) and for surface waters used for drinking water production in the Netherlands for the 1985-2002 period.*
Data is only from sites that were monitored throughout the whole period.

For the vast majority of fresh surface water locations the winter-maximum nitrate concentration was below the EU target value of 50 mg/l, see Table 36. The percentage of locations where the maximum nitrate concentration exceeded this EU target value dropped from well over 10% to about 4% in the 1996-2002 period, and in the case of agriculturally-influenced regional waters from about 20% to 6%. In the 1992-1999 period the decline had not yet taken place; in fact, a slight increase could be observed.

The winter-maximum nitrate concentrations in fresh surface waters in the Netherlands for the 2000-2002 period are shown in Map 14. As the figure shows, waters in which the maximum nitrate concentration exceeded the EU target value of 50 mg/l occur in Brabant, Limburg, the Westland region and in the eastern part of the country. These include not only agriculturally-influenced regional waters, but a number of national waters as well. In the northern part of the country the maximum nitrate concentrations were generally lower.

Table 36: Winter-maximum nitrate concentration in fresh surface waters for the 1992-2002 period (%)[*1].*

	All waters			Agricultural waters		
Concentration rate	1992-1994	1996-1999	2000-2002	1992-1994	1996-1999	2000-2002
0–10 mg/l	15	17	35	16	14	42
10–25 mg/l	42	38	42	38	34	37
25–40 mg/l	21	20	15	22	21	12
40–50 mg/l	8	7	4	7	9	4
> 50 mg/l	13	19	4	17	21	6
Number of sites	580	598	747	239	230	325

1) Percentages of monitoring sites with a period average concentration within a given range. Data is for all waters and for waters mainly influenced by agriculture. Total percentage may exceed 100 because of rounding off.

The winter-maximum nitrate concentrations (Table 37) show the same change over time as the average nitrate concentrations (Table 35). For the 2000-2002 period the percentage of locations with a nitrate concentration lower than that for the 1996-1999 period (almost 90%) far exceeded the percentage of locations with an increase in nitrate concentration (approximately 5%). In the preceding period (1992-1996) the percentage of locations showing an increase, roughly equalled those showing a decrease. For agriculturally-influenced regional water a similar pattern was found.

The winter-maximum nitrate concentrations in fresh surface water decreased in the 1998-2002 period, see Figure 31. The trend in maximum nitrate concentrations is similar to the one in average nitrate concentrations for all types of fresh surface waters (Figure 30). For all types of waters the concentrations almost halved in this period. In 2002, the maximum nitrate concentrations were about 17, 15 and 12 mg/l for agriculturally-influenced regional waters, other regional waters and national waters, respectively. For fresh surface waters used for drinking water production the maximum nitrate concentrations also decreased, albeit less clearly than for the other types of waters (from approximately 15 mg/l in the 1990s to 10 mg/l in 2002). In the periods preceding the 1998-2002 period, no clear decrease in maximum nitrate concentrations was observed for any of the types of waters.

Table 37: Change in winter-maximum nitrate concentration in fresh surface waters in the 1992-2002 period (%)[*1]*.*

Rate of change	All waters		Agricultural waters	
	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	29	2	34	3
Small increase (% 1-5 mg/l)	18	2	21	2
Stable (% ± 1 mg/l)	18	9	11	6
Small decrease (% 1-5 mg/l)	22	22	18	20
Large decrease (% > 5 mg/l)	14	65	17	68
Number of sites	544	578	216	217

1) Percentages of waters with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for all waters and for waters mainly influenced by agriculture. Total percentage may exceed 100 because of rounding off.

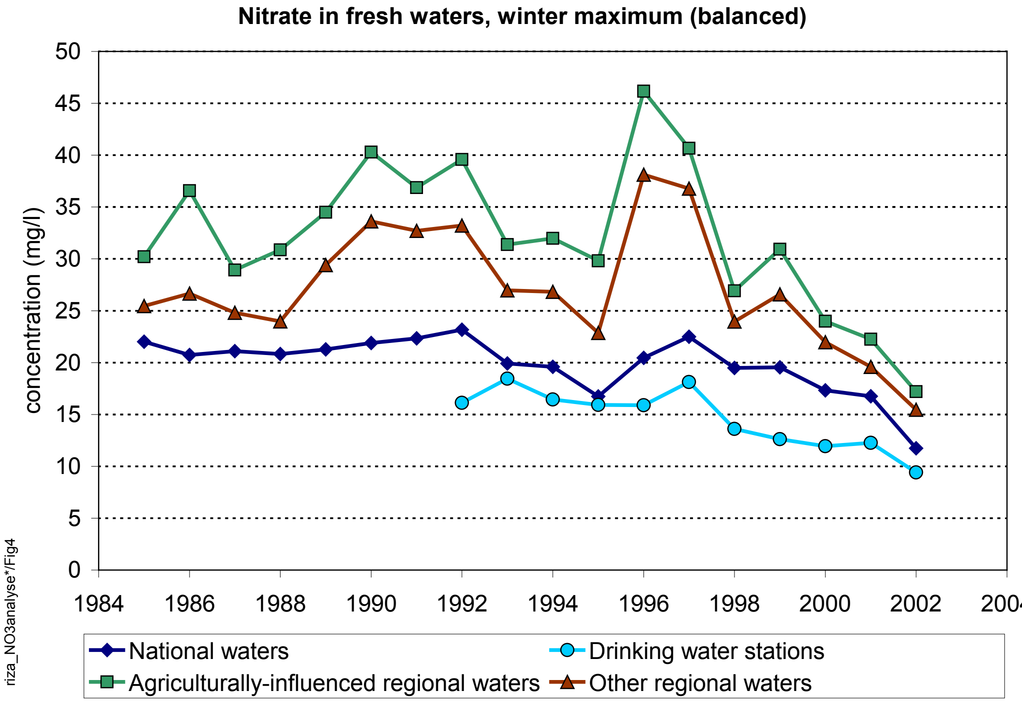


Figure 31: Winter-maximum nitrate concentration in fresh surface waters (national waters, regional waters mainly influenced by agriculture) and other regional waters, and for surface waters used for drinking water production in the Netherlands for the 1985-2002 period.

Data is only from sites that were monitored throughout the whole period.

The winter-maximum nitrate concentrations in agriculturally-influenced regional waters were somewhat higher than maximum nitrate concentrations in other regional waters, while these in turn slightly exceeded the maximum nitrate concentrations in national waters. This can be explained by the fact that agriculturally-influenced regional waters are more frequently exposed to high loads – resulting, for example, from leaching and run-off – than other regional waters and national waters. As these locations are near the sources of the loads, degradation, conversion and dilution hardly play a role in agriculturally-influenced regional waters, while these phenomena do have an affect in the other regional waters.

6.4 Eutrophication status of fresh water

6.4.1 Chlorophyll-*a*

In the Netherlands, the summer-average chlorophyll concentration is an important measure of eutrophication. However, the occurrence of eutrophication phenomena, expressed as chlorophyll, is not only determined by nitrate concentrations in surface waters. Other nutrients, especially phosphorus, as well as physical and meteorological conditions play a role. Chlorophyll is a measure of the amount of algae in water, and thus of the occurrence of eutrophication phenomena. The reporting guidelines define waters with a chlorophyll concentration of between 25 and 75 µg/l as eutrophic and above 75 µg/l as hypertrophic (EC/DGXI; 2000). The standard for chlorophyll used in the Netherlands is 100 µg/l (V&W, 1998). As is state above, the summer months are the most critical period with respect to eutrophication.

For all types of water there was a decline in the percentage of fresh surface water locations having a summer-average chlorophyll concentration higher than 75 µg/l, see Table 38. For agriculturally-influenced regional waters the percentage of locations with a chlorophyll-*a* concentration in excess of 75 µg/l remained higher than the average for all waters.

In about 40% of all fresh surface water locations the chlorophyll-*a* concentrations in the late 1990s had declined compared to the early 1990s; however, in a comparable percentage of locations the chlorophyll-*a* concentrations increased (33% for all waters and 44% for agriculturally-influenced regional waters), see Table 39. For the 1996-2002 period the picture was a little more positive. The percentage of locations exhibiting lower chlorophyll-*a* concentrations had risen to about 50% (46% for the category all waters and 55% for agriculturally-influenced regional waters), whereas higher chlorophyll-*a* concentrations were observed in about 25 % of the locations (both for the total of all types of waters and for agriculturally-influenced regional waters only).

*Table 38: Summer-average chlorophyll-a concentration in fresh surface waters for the 1992-2002 period (%)*1.*

Concentration range	All waters 1992-1994	All waters 1996-1999	All waters 2000-2002	Agricultural waters 1992-1994	Agricultural waters 1996-1999	Agricultural waters 2000-2002
0–2.5 µg/l	5	0	2	5	0	2
2.5–8.0 µg/l	6	8	6	7	5	6
8.0–25 µg/l	26	38	42	21	27	34
25–75 µg/l	36	35	37	29	32	39
> 75 µg/l	27	19	14	38	36	18
Number of sites	325	372	523	112	95	222

1) Percentages of monitoring sites with a period average concentration within a given concentration range. Data is for all waters and for waters mainly influenced by agriculture. Total percentage may exceed 100 because of rounding off.

*Table 39: Change in summer-average chlorophyll-a concentration in fresh surface waters for the 1992-2002 period (%)*1.*

Rate of change	All waters 1992/1995-1996/1999	All waters 1996/1999-2000/2002	Agricultural waters 1992/1995-1996/1999	Agricultural waters 1996/1999-2000/2002
Large increase (% > 10 µg/l)	21	15	29	17
Small increase (% 5-10 µg/l)	12	8	15	8
Stable (% ± 5 µg/l)	24	31	18	19
Small decrease (% 5-10 µg/l)	10	12	5	14
Large decrease (% > 10 µg/l)	34	34	34	41
Number of sites	282	312	80	83

1) Percentages of waters with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for all waters and for waters mainly influenced by agriculture. Total percentage may exceed 100 because of rounding off.

For all three types of fresh surface water the occurrence of eutrophication phenomena, expressed as the summer-average chlorophyll-*a* concentration, followed a slow, continuous decline from the early 1990s, see Figure 32. The regional waters, both the agriculturally-influenced regional waters and the other regional waters, generally have a more stagnant character than the national waters. Consequently, eutrophication phenomena or, alternatively, higher chlorophyll-*a* concentrations are more likely to occur in these waters. This can be seen in Figure 32: throughout the entire period the concentrations of chlorophyll-*a* in agriculturally-influenced regional waters were higher than those in other regional waters, while the lowest concentrations occurred in the national waters.

6.4.2 Other parameters for eutrofication

Since the late 1990s a decline in total nitrogen concentration has been observed in all three types of waters, see Figure 33. The decline has been particularly strong in agriculturally-influenced regional waters. Despite this, total nitrogen concentrations still exceed the Dutch target value of 2.2 mg/l (CIW, 2000; V&W, 1998). In agriculturally-influenced regional waters, where total nitrogen concentrations are highest, the level exceeds the target value by a factor of about 2.

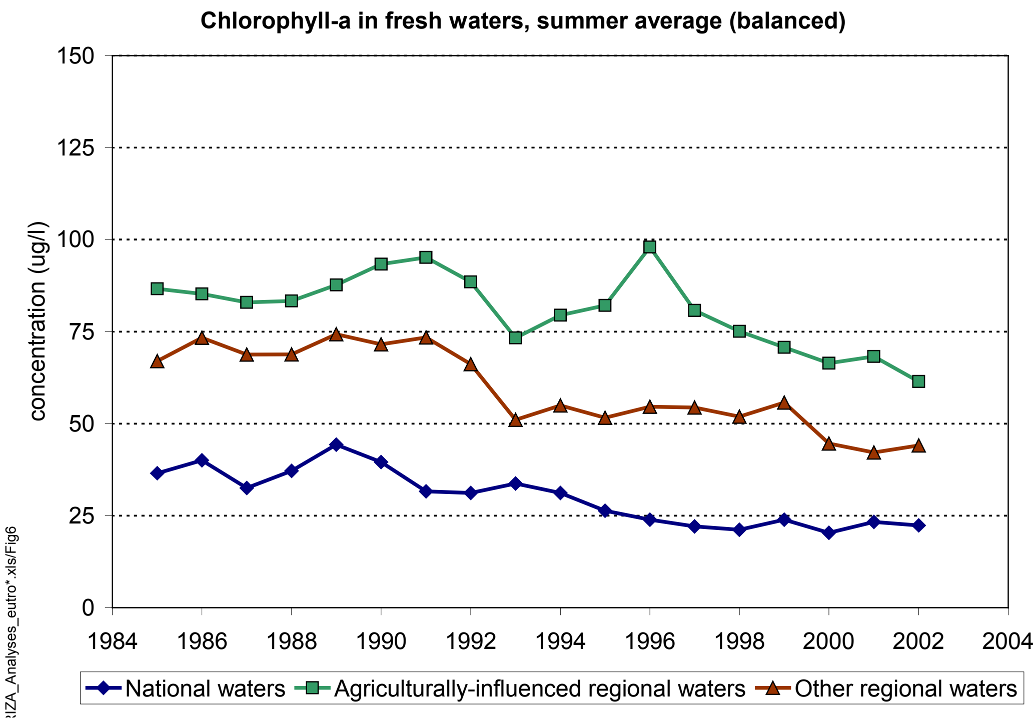


Figure 32: Summer-average chlorophyll-a concentrations in fresh surface waters (national waters, regional waters mainly influenced by agriculture and other regional waters) in the Netherlands for the 1985-2002 period.

Data is only from sites that were monitored throughout the whole period.

The decline in the total phosphorus concentrations that has clearly been observed in the national waters and in the other regional waters since the mid-1980s (concentration halved by 2002) is much less pronounced in agriculturally-influenced regional waters. Here it has only become noticeable since the mid-1990s, see Figure 34. In 2002, the summer-average total phosphorus concentrations in agriculturally-influenced regional waters was only slightly below the level in the 1980s, and was almost 4 times as high as the target value of 0.15 mg/l (CIW, 2000;V&W, 1998); The concentrations in the other regional waters still were a factor of 2 above the target value in 2002, while in the national waters the target value has now almost been met. The decline in the other regional waters and in the national waters reflects the decrease of the phosphorus load of the surface waters in this period (see Table 33). The fact that this decrease has not occurred in agriculturally-influenced regional waters might be due to a delayed emission of phosphorus from aquatic sediments.

6.5 References

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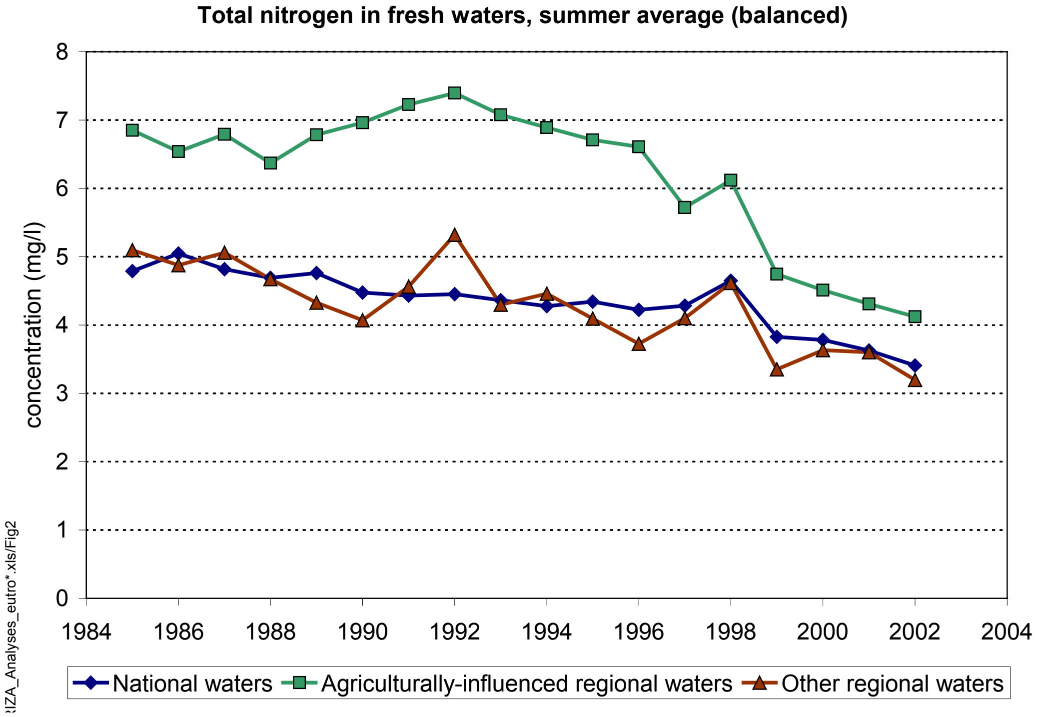


Figure 33: Summer-average total-nitrogen concentration in fresh surface waters (national waters, regional waters mainly influenced by agriculture and other regional waters in the Netherlands) for the 1985-2002 period.

Data is from sites that were monitored throughout the period.

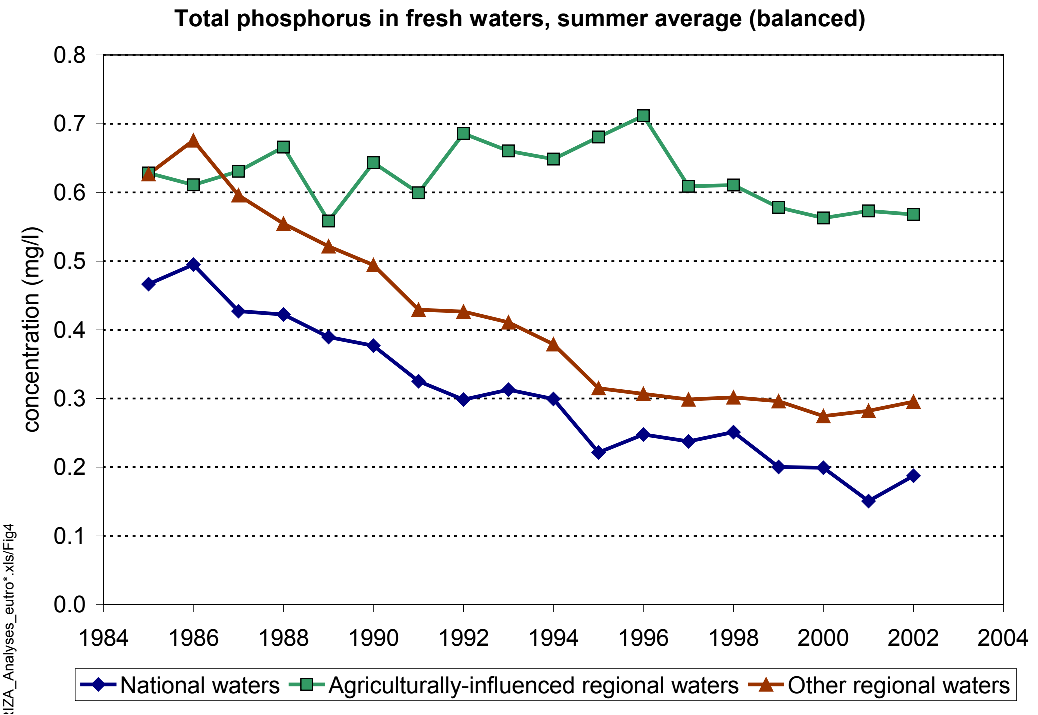
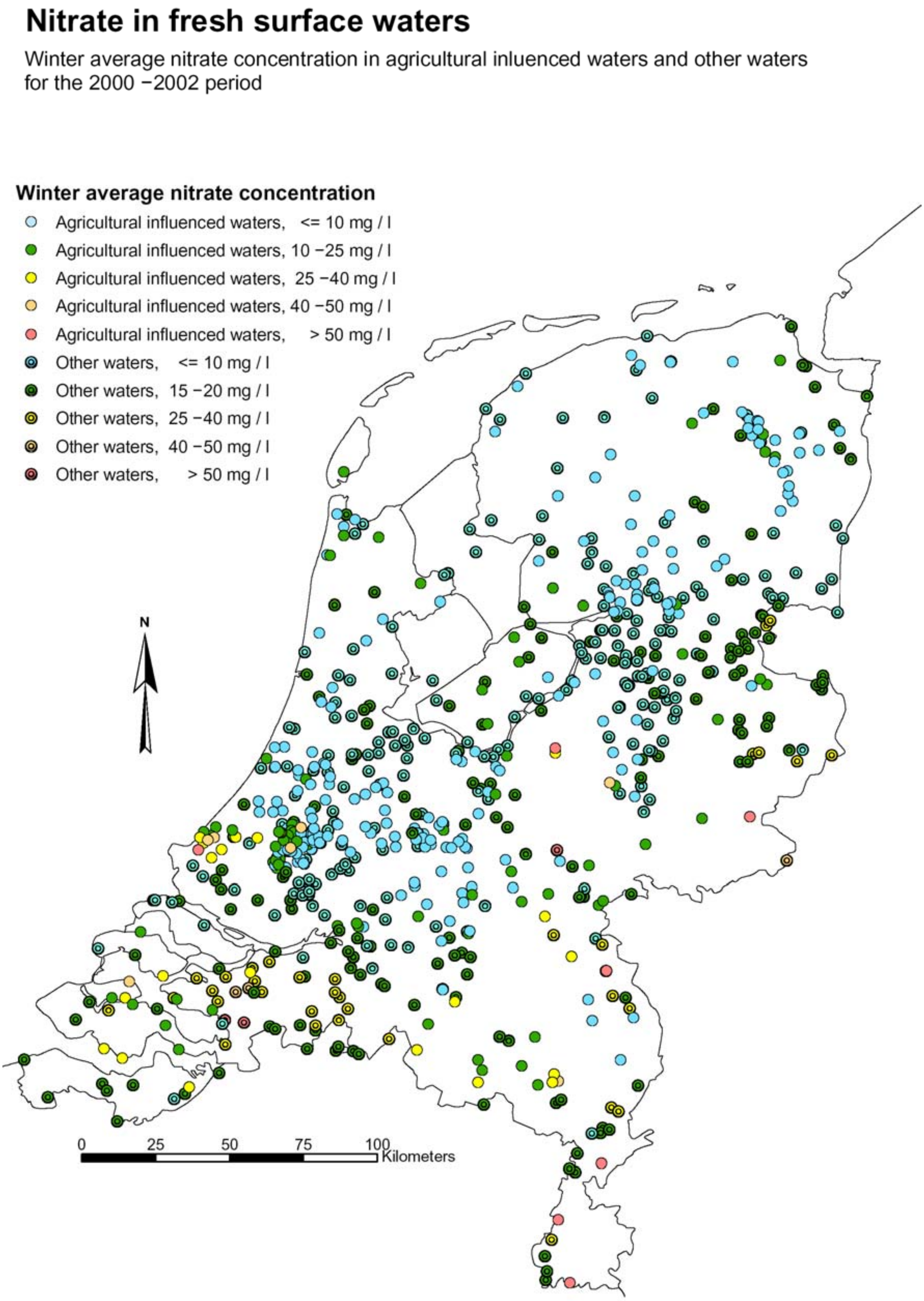
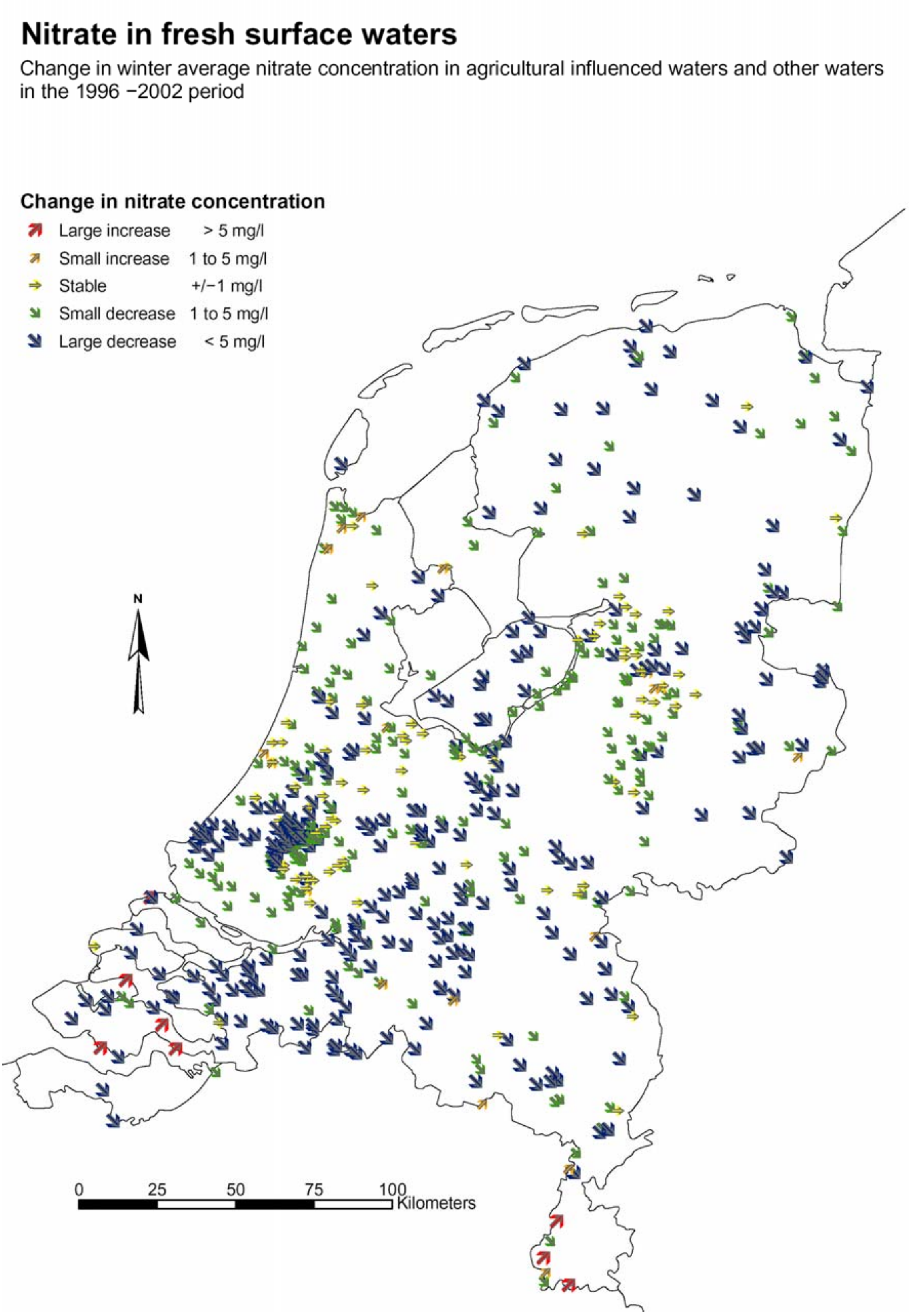


Figure 34: Summer-average total-phosphorus concentration in fresh surface waters (national waters, regional waters mainly influenced by agriculture and other regional waters) in the Netherlands for the 1985-2002 period.

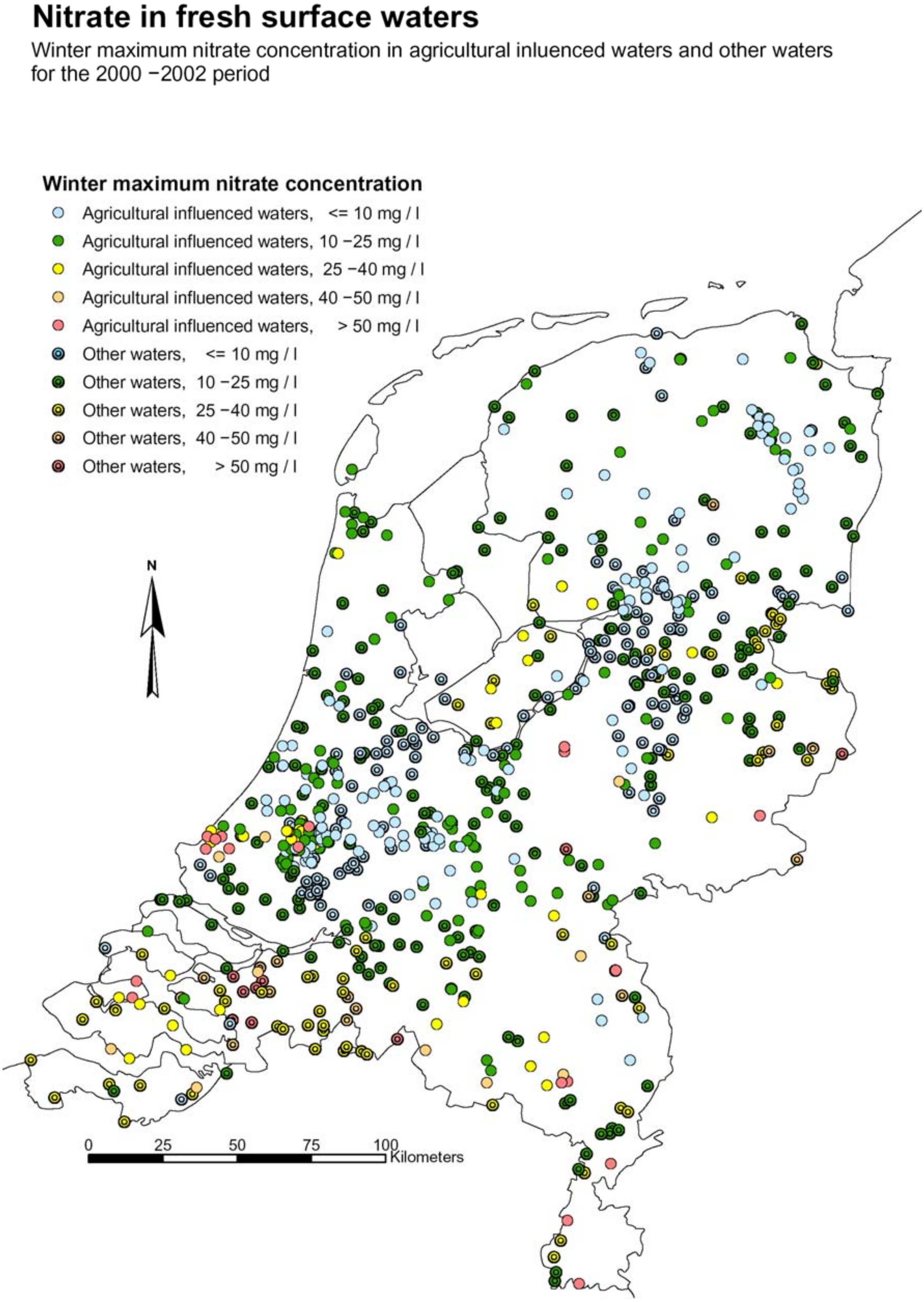
Data is from sites that were monitored throughout the period.



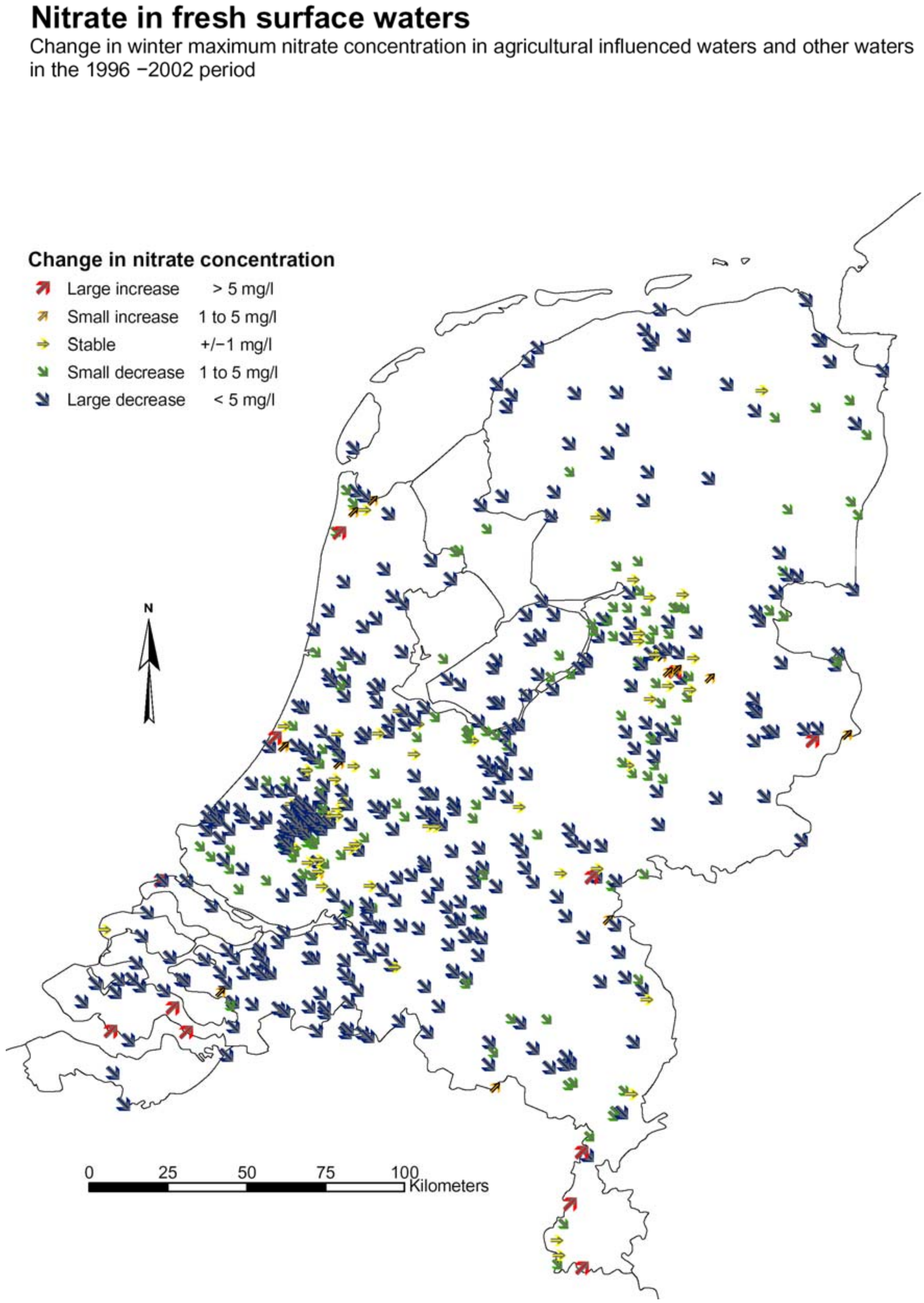
Map 12: Winter-average nitrate concentration in fresh surface waters of the Netherlands, agriculturally-influenced waters and other waters for the 2000-2002 period.



Map 13: Change in winter-average nitrate concentration in fresh surface waters of the Netherlands, agriculturally-influenced waters and other waters in the 1996-2002 period.



Map 14: Winter-maximum nitrate concentration in fresh surface waters of the Netherlands, agriculturally-influenced waters and other waters for the 2000-2002 period.



Map 15: Change in winter-maximum nitrate concentration in fresh surface waters of the Netherlands, agriculturally-influenced waters and other waters in the 1996-2002 period.

7. Marine and coastal water quality

7.1 Introduction

This chapter outlines the results of the monitoring activities on marine surface waters for the nutrients nitrogen and phosphorus. The periods compared are the years 1992-1994, 1996-1998 and 2000-2002. The maps in the last section of this chapter only deal with a comparison of the last two periods.

In a similar vein to the chapter on fresh water, the next section (§7.2) is an overview of nitrogen and phosphorus loads in surface waters. In §7.3 the nitrate concentrations in the open sea and in coastal areas are described. It should be noted that the results in this section are solely based on winter-average concentrations, since this period is characterised by the lowest biological activity and therefore the nitrate concentrations measured in winter are a better indicator for changes in nutrient loading than in summer. For inter-annual in-depth studies on trends in inorganic nitrogen concentrations, concentrations corrected for salinity, i.e. inter-annual differences in riverine water discharge, are presented as well, see §2.5.3. In §7.4 results of the eutrophication state in marine waters are presented, expressed as changes in summer average concentrations of chlorophyll-*a* and total phosphorus.

7.2 Nutrient load of marine and coastal waters

For the 2000-2002 period, the nutrient load of the North Sea and Wadden Sea via the Netherlands in million kg was calculated to be approximately 404 million kg nitrogen and 22 million kg of phosphorus, see Table 40. Direct discharges generally contribute little to the total load, the bulk originating from riverine loads.

Table 40: Total nitrogen and phosphorus load of the North Sea and Wadden Sea from and via the Netherlands in million kg for the 1992-2002 period[*1]*.*

	Nitrogen			Phosphorus		
	1992-1993	1996-1997	2000-2002	1992-1993	1996-1997	2000-2002
Discharge by rivers	375	290	398	20	19	21
Direct discharge	6	6	6	1	1	1
Total load from and via the Netherlands	381	296	404	21	20	22

Source: OSPAR, unpublished data.

[1)] Averages are presented for each period, i.e. 1992-1993, 1996-1997, 2000-2002; for the first and second period only data for two years available.

The nutrient loads via the Netherlands can fluctuate quite drastically from year to year, largely as a result of fluctuations in precipitation. In the period 1996-1998 nitrogen loads into marine waters via the Netherlands decreased by about 100 million kg compared to the 1992-1994 period and subsequently to increase again with about 100 million kg during the 2000-2002 period. This can be largely attributed to differences in rainfall. In contrast to this, phosphorus loads remained rather stable over the three periods monitored.

Table 40 and Table 41 show that the total nitrogen and phosphorus loads to the North Sea via waters originated for about one-third from riverine discharges via the Netherlands. The relative importance however cannot be determined exactly since several riparian North-Sea countries do not report on total nutrient loads.

Despite the inter-annual fluctuations in nitrogen deposition rates it seems that total Dutch nutrient loads and total atmospheric nutrient depositions to the North Sea continued to be of the same order of magnitude.

Table 41: Total nitrogen and phosphorus load of the North Sea in million kg for the 1992-2002 period[*1].*

	Nitrogen			Phosphorus		
	1992-1993	1996-1997	2000	1992-1993	1996-1997	2000
Discharge by rivers	1066	840	1007	61	51	61
Direct discharge	96	79	68	14	13	9
Total load via water	1162	919	1075	74	64	69
Atmospheric deposition	370	328	n.a.	n.a.	n.a.	n.a.

Source: OSPAR, unpublished data.

[1)] Averages are presented for each period, i.e. 1992-1993, 1996-1997, 2000; for the first and second period only data for two years available, only data for 2000 available for the 2000-2002 period.

n.a.: no data available.

7.3 Nitrate concentration in marine and coastal waters

In this section winter-average nitrate concentrations in the marine waters are presented, expressed as nitrate in mg per litre. The winter period is defined as the period from 1 December to the last day of February (see §2.5).

Table 42 details the percentage of monitored locations ranked according to different nitrate ranges, while Table 43 presents the percentages of monitored locations where an increase, a decrease or stability in concentrations was determined. When an absolute change of 1 mg per litre nitrate was noted, monitoring locations were classified as either decreasing or increasing.

At all monitoring locations in the open sea areas, nitrate concentrations remained stable over all three monitoring periods, i.e. absolute changes in concentrations were less than 1-mg nitrate per litre.

For coastal waters, however, changes were noted over the last two periods of monitoring. At almost half of all locations monitored, nitrate concentrations decreased between the early and late 1990s, while the remaining locations monitored remained rather stable. For the period 2000-2002 the situation was different, almost a quarter of all locations showed increasing nitrate concentrations compared to the late 1990s, while nitrate concentrations at all other locations remained virtually unchanged, i.e. no decrease in nitrate exhibited. The increases can be explained by the fact that 2000-2002 were relatively wet years compared to 1996-1998; e.g. the average annual river discharges at Lobith was more than 30% higher in the 2000-2002 period than in the 1996-1998 period.

Table 42: Winter-average nitrate concentration in marine waters for the 1992-2002 period (%)[*1].

Concentration range	1992-1994	1996-1999	2000-2002
0–10 mg/l	87	95	90
10–25 mg/l	13	5	10
25–40 mg/l	0	0	0
40–50 mg/l	0	0	0
> 50 mg/l	0	0	0
Number of sites	39	39	39

1) Percentage of the monitoring locations with a period average within a given concentration range. Total percentage may exceed 100 because of rounding off.

Table 43: Change in winter-average nitrate concentration in marine waters for the 1992-2002 period (%)[*1].

Rate of change	Open sea		Coastal water	
	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	0	0	0	3
Small increase (% 1-5 mg/l)	0	0	0	22
Stable (% ± 1 mg/l)	100	100	53	75
Small decrease (% 1-5 mg/l)	0	0	38	0
Large decrease (% > 5 mg/l)	0	0	9	0
Number of sites	7	7	32	32

1) Percentage of sites with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for the open sea and coastal waters. Total percentage may exceed 100 because of rounding off.

Figure 35 presents the trend in winter-average nitrate concentrations over the 1991-2002 period in the open sea and coastal waters. The figure shows that except for the drop in concentrations during the 1995-1996 period, winter averages in the coastal zones fluctuated between about 4 and 6 mg nitrate per litre, whereas concentrations in the open sea remained rather stable at far lower concentrations (< 0.5 mg/l). The lowered nitrate concentration in 1996 has already been attributed to the consequences of relatively dry years.

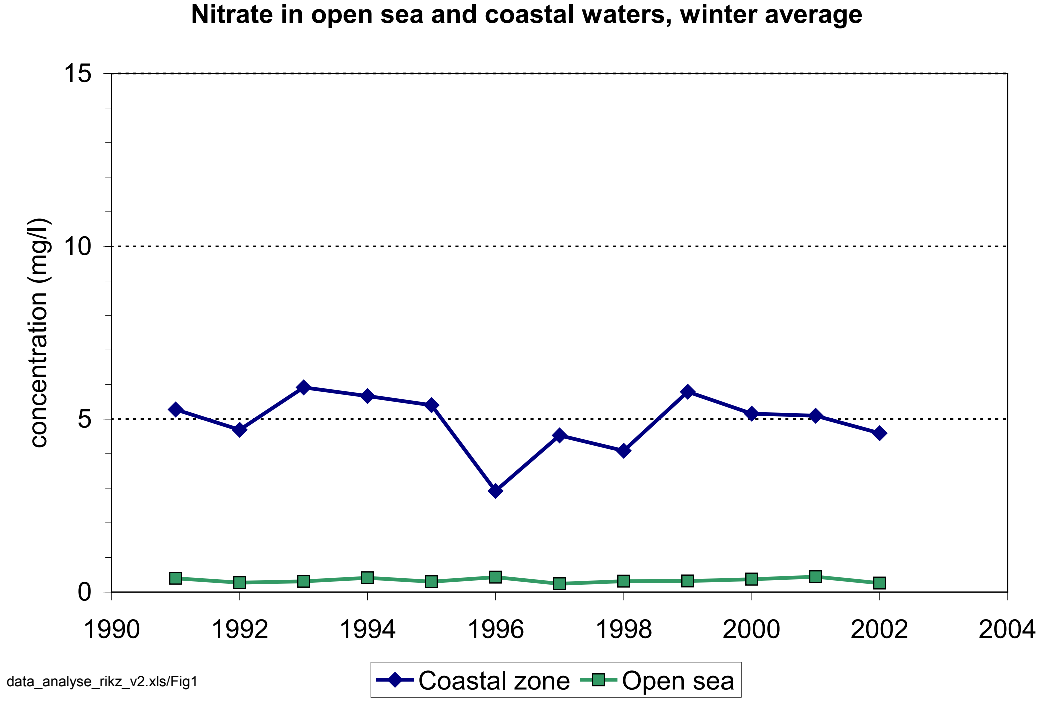


Figure 35: Winter-average nitrate concentration (mg/l) in the open sea and coastal waters of the Netherlands for the 1991-2002 period.

Map 16 shows the variations in winter-average nitrate concentrations in the open sea and coastal waters of the Netherlands for the 2000-2002 period. Winter average concentrations of nitrate only exceeded 15 mg/l in the Western Scheldt and the Ems-Dollard estuary. Other locations in the coastal zone were generally characterised by concentrations lower than 15 mg/l, whereas concentrations in open seawaters were lower than 10 mg/l.

The most pronounced increases in winter average concentrations of nitrate were encountered during 2000-2002 in the upper part of the Ems-Dollard estuary and the Western Scheldt, see Map 17. At all other locations, concentrations remained virtually unchanged.

Table 44 presents the percentages of monitored locations for various ranges of the maximum nitrate concentration measured during the three different reporting periods. For the vast majority of locations the maximum nitrate concentrations measured ranged from 0-10 mg/l. Although the number of locations falling in the lowest range of nitrate concentrations seemed to increase between the first and second half of the 1990s, recent data reveal that the conditions have returned to those present during the first half of the 1990s.

Table 44: Winter-maximum nitrate concentration in marine waters for the 1992-2002 period (%)[*1].*

Concentration range	1992-1994	1996-1999	2000-2002
0–10 mg/l	85	92	85
10–25 mg/l	15	8	15
25–40 mg/l	0	0	0
40–50 mg/l	0	0	0
> 50 mg/l	0	0	0
Number of sites	39	39	39

1) Percentage of the monitoring locations with a period average within a given concentration range. Total percentage may exceed 100 because of rounding off.

Table 45 presents the percentages of monitored locations where an increase, a decrease or stability in winter-maximum nitrate concentrations was determined. As in the previous section, only absolute changes of 1 mg per litre nitrate or more in the maximum nitrate concentrations determined, will classify monitoring locations as either decreasing or increasing. As noted earlier for winter-average nitrate concentrations (Table 43), all monitoring locations in the open sea showed nitrate concentrations that were stable over all three monitoring periods. For coastal waters however, changes were noted over the last two monitoring periods. At half of all the locations monitored, the maximum nitrate concentrations decreased between the early and late 1990s, while at the remaining locations monitored the concentrations remained fairly stable. For the period 2000-2002 the situation was different, as just over a third of all locations showed an increase in the maximum nitrate concentrations compared to the late 1990s, while the maximum nitrate concentrations at all other locations remained fairly stable, i.e. none showed a decrease in nitrate. As noted earlier, the increases can be explained by the fact that the 2000-2002 period was relatively wet period.

Figure 36 presents the trend in maximum winter-average nitrate concentrations for the period 1991-2002 in the open sea and coastal waters. The figure generally shows that except for the drop in concentrations during the period 1995-1996, winter averages in the coastal zones fluctuated between about 3 and 8 mg nitrate per litre, whereas concentrations in the open sea remained fairly stable at far lower concentrations (< 0.5 mg/l). Explanations for the lowered maximum nitrate concentration in 1996 have already been given, see text for Figure 35.

Map 18 shows the variations in winter maximum concentrations in Dutch open sea and coastal waters for the 2000-2002 period. In the Western Scheldt and the Ems-Dollard estuary, winter maximum concentrations of nitrate exceeded 15 mg/l. Other locations in the coastal zone were generally characterised by concentrations lower than 15 mg/l, whereas concentrations in open seawaters were lower than 10 mg/l.

Table 45: Change in winter-maximum nitrate concentration in marine waters for the 1992-2002 period (%)[*1].

Rate of change	Open sea		Coastal water	
	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 5 mg/l)	0	0	0	3
Small increase (% 1-5 mg/l)	0	0	0	31
Stable (% ± 1 mg/l)	100	100	50	66
Small decrease (% 1-5 mg/l)	0	0	31	0
Large decrease (% > 5 mg/l)	0	0	19	0
Number of sites	7	7	32	32

[1)] Percentage of sites with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for the open sea and coastal waters. Total percentage may exceed 100 because of rounding off.

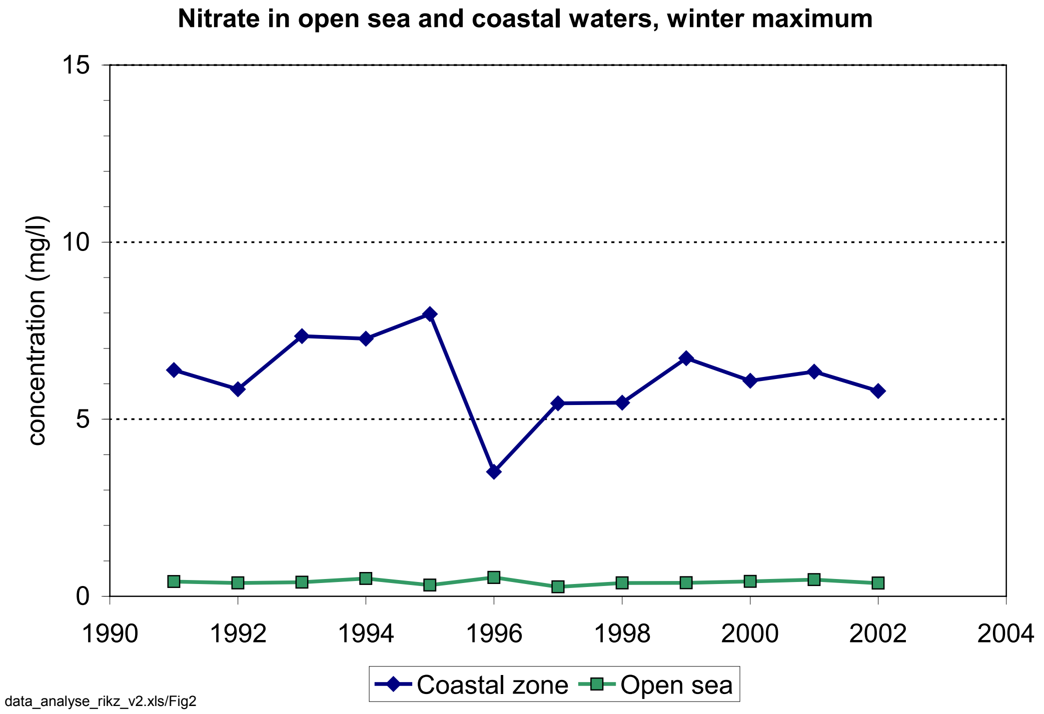


Figure 36: Winter-maximum nitrate concentration (mg/l) in the open sea and coastal waters of the Netherlands for the 1991-2002 period.

The most pronounced increases in winter maximum concentrations of nitrate were encountered during 2000-2002 in the Ems-Dollard estuary and the Western Scheldt, see Map 19. At all other locations the concentrations remained fairly stable.

The concentrations of nutrients in the coastal waters are determined by natural background concentrations and by direct and riverine discharges. During winter, biological activity is low and inorganic nutrient concentrations show a conservative behaviour and a negative linear relation with salinity. For a long-term analysis of changes in nutrient concentrations in relation to changes in nutrient loads, correction of the measured (winter) nutrient concentrations for changes in salinity at the fixed monitoring locations is required (see §2.5.3).

Here, salinity-corrected winter concentrations of dissolved inorganic nitrogen (DIN) are presented for the period 1980-2003 for the Dutch coastal zone off Noordwijk (Figure 37), and DIN concentrations are presented in comparison to 1985 (Figure 38). The results show that there is a slow, but gradual decrease in dissolved inorganic nitrogen concentrations, and concentrations in 2003 are approximately 20% lower than in 1985. This also illustrates the fact that the increases in uncorrected nitrate concentrations that were presented above are an artefact caused by differences in freshwater discharges.

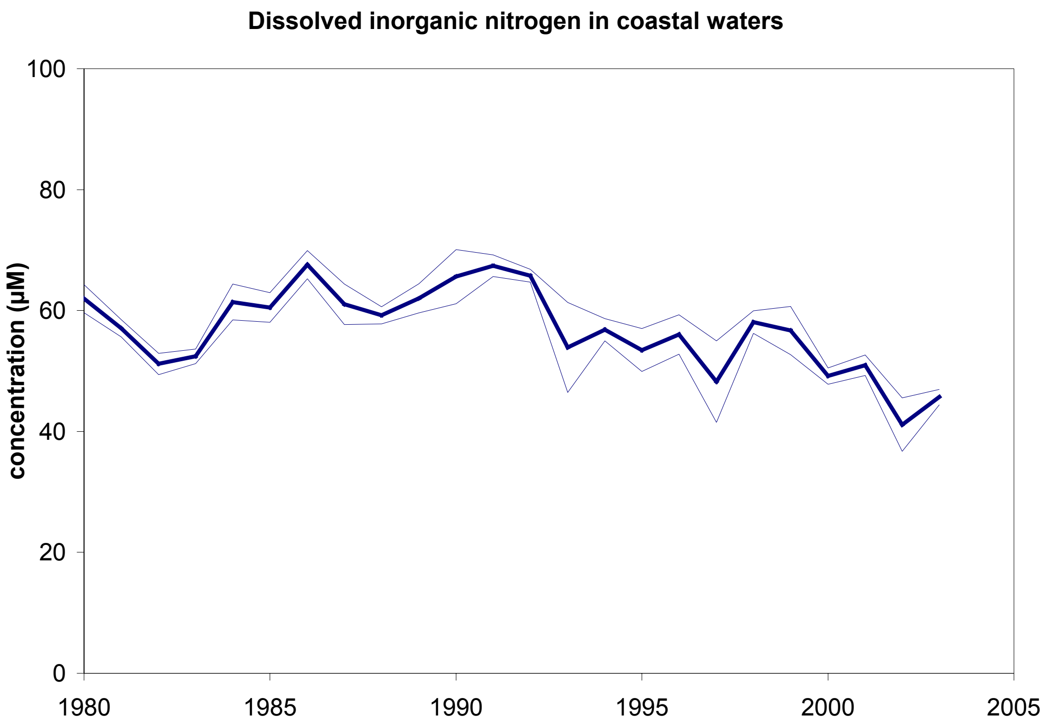


Figure 37: Winter-average dissolved inorganic nitrogen concentrations (DIN), standardised to a salinity of 30 psu, for the Dutch coastal zone off Noordwijk for the 1980-2002 period.

Narrow lines are 95% confidence limts of salinity corrected DIN concentrations

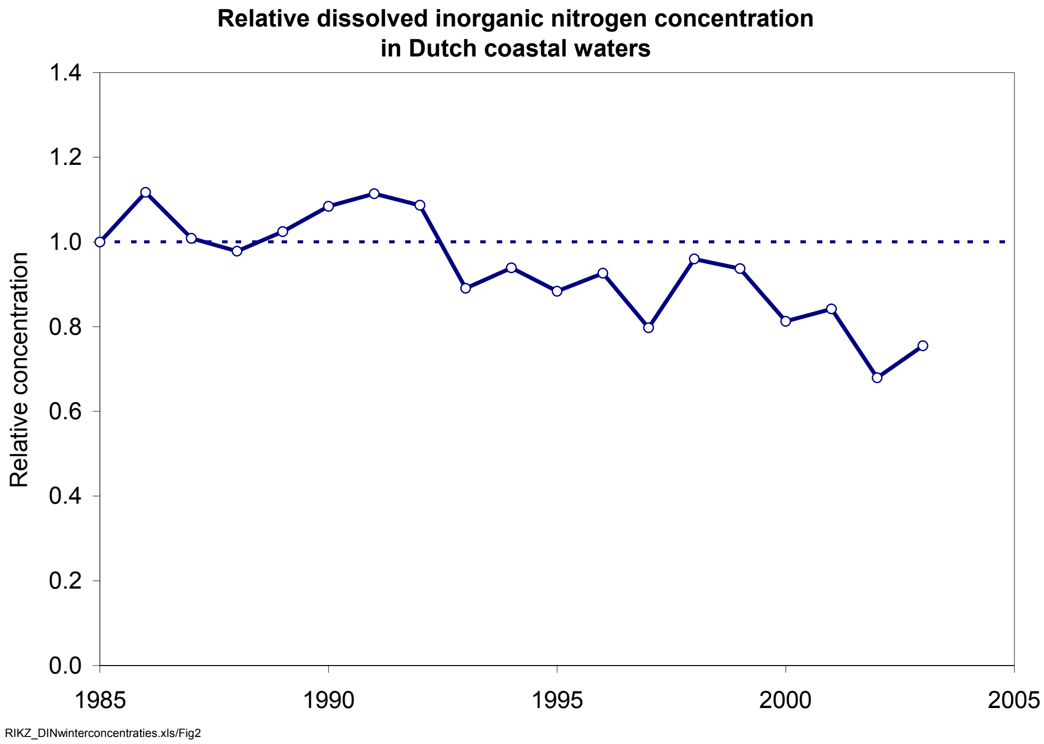


Figure 38: Relative winter-average dissolved inorganic nitrogen concentrations (DIN), standardised to a salinity of 30 psu, for the Dutch coastal zone off Noordwijk for the 1980-2002 period. DIN concentrations in comparison to concentrations in 1985.

7.4 Eutrophication status of marine and coastal waters

Eutrophication is a major topic within OSPAR (The Convention for the Protection of the Marine Environment of the Northeast Atlantic). Following a 2002 assessment of the Dutch marine waters it was concluded that the entire Dutch coastal zone was euthrophic (i.e. an eutrophication problem area). The larger part of the offshore waters was classified as a potential problem area, pending further research.

In this section summer-average chlorophyll-*a* concentrations, as a measure for the abundance of algae, are used to determine the occurrence of eutrophication phenomena. Summer is defined as the period from the 1 April to 30 September.

Table 46 shows the percentages of all locations for which the average chlorophyll-*a* concentrations observed were in given ranges, during the reporting period and preceding periods.

The percentage of locations in the marine waters having a summer-average chlorophyll-*a* concentration higher than 25 µg/l shows a decline, whereas the number of locations with concentrations ranging from 2.5 to 8.0 µg/l seemed to increase, see Table 46. In general, however, conditions over the whole remained fairly stable.

Similar conclusions can be drawn from Table 47. This table presents the results of possible changes in chlorophyll-*a* concentrations during the reporting period for open sea areas as well as coastal waters. Although it would appear that no change can be noted for open sea areas, in coastal zones there are indications that at a small percentage of the monitoring locations, chlorophyll-*a* concentrations have decreased while at a similar number of locations these concentrations increased somewhat.

*Table 46: Summer-average chlorophyll-a in marine waters for the 1992-2002 period (%)[*1].*

Concentration range	1992-1994	1996-1999	2000-2002
0–2.5 µg/l	10	11	11
2.5–8.0 µg/l	22	24	28
8.0–25 µg/l	66	62	61
25–75 µg/l	2	3	0
> 75 µg/l	0	0	0
Number of sites	41	37	36

[1)] Percentage of the monitoring locations with a period average within a given concentration range. Total percentage may exceed 100 because of rounding off.

*Table 47: Change in summer-average chlorophyll-a concentration in marine waters in the 1992-2002 period (%)[*1].*

Rate of change	Open sea		Coastal water	
	1992/1995-1996/1999	1996/1999-2000/2002	1992/1995-1996/1999	1996/1999-2000/2002
Large increase (% > 10 µg/l)	0	0	3	0
Small increase (% 5-10 µg/l)	0	0	0	4
Stable (% ± 5 µg/l)	100	100	90	86
Small decrease (% 5-10 µg/l)	0	0	7	7
Large decrease (% > 10 µg/l)	0	0	0	4
Number of sites	8	8	29	28

[1)] Percentage of sites with given rates of change in concentration between the first and second and between the second and third reporting periods. Data is for the open sea and coastal waters. Total percentage may exceed 100 because of rounding off.

Figure 39 presents the pattern of chlorophyll-*a* concentrations for the 1991-2002 period for the open sea and coastal waters. Although concentrations of chlorophyll appear to have been elevated during the early 1990s, in general chlorophyll summer average concentrations remained fairly stable over the whole period reported. In coastal zones concentrations ranged from 10-17 µg/l, whereas in open sea areas concentrations ranged between 1 and 4 µg/l.

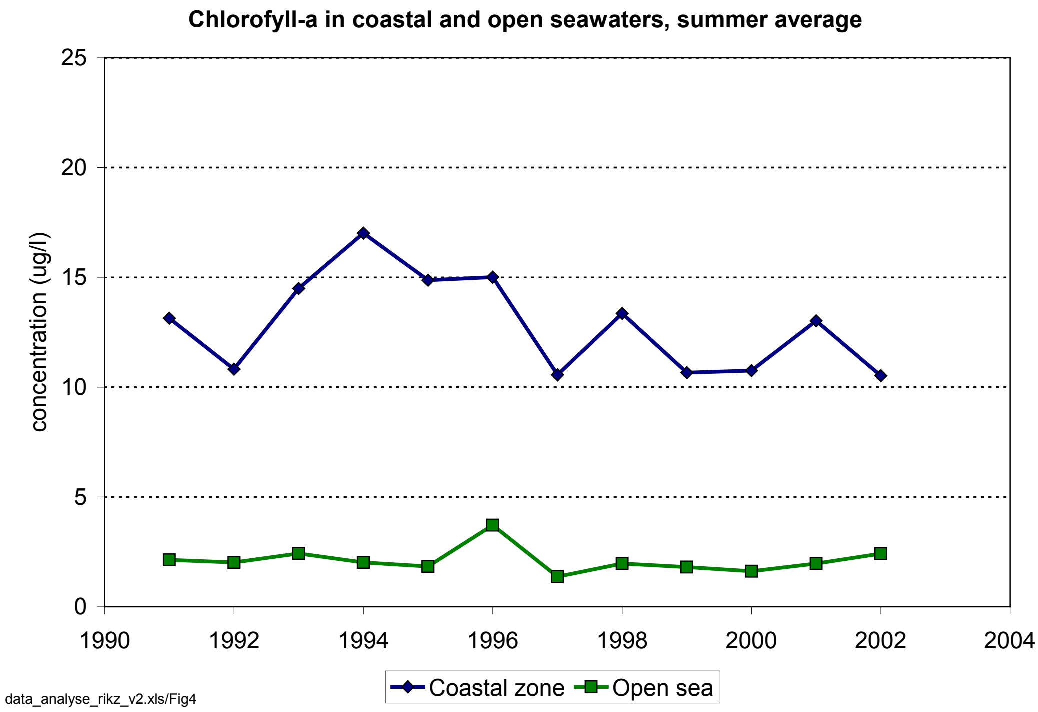


Figure 39: Summer-average chlorophyll-a concentration (µg/l) in the open sea and coastal waters of the Netherlands in 1991-2002 period.

Figure 40 presents summer average concentrations of total-phosphorus in the open sea and coastal waters of the Netherlands for the 1991-2002 period. The total-phosphorus concentrations showed a downward trend over the monitored period.

The marine waters of the Netherlands are characterised by elevated concentrations of nitrogen and phosphorus. There is a slow, but gradual decrease in dissolved inorganic nitrogen concentrations, and concentrations in 2003 are approximately 20% lower than in 1985. Phosphorus concentrations in the open sea areas and coastal waters have shown a downward trend over the last 12 years. Chlorophyll-*a* concentrations did not show any clear trend in marine waters and remained stable.

A further reduction of indirect and direct nutrient loading is necessary to achieve the OSPAR target of 2010, i.e., ‘to obtain a healthy marine environment with increased nutrient enrichment and eutrophication effects do not occur’.

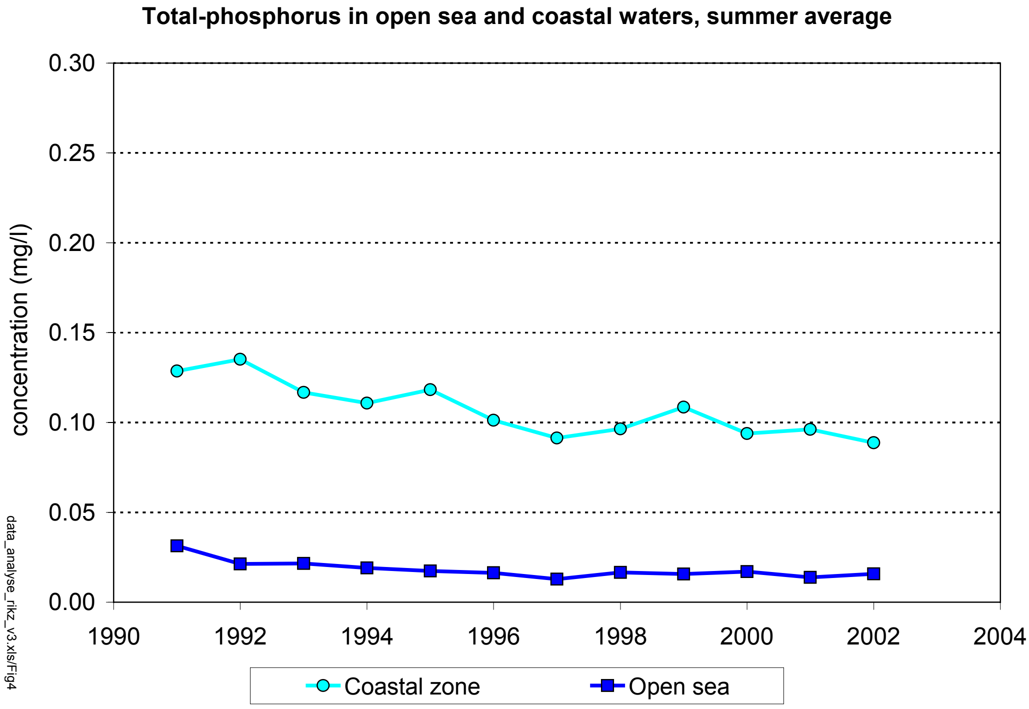
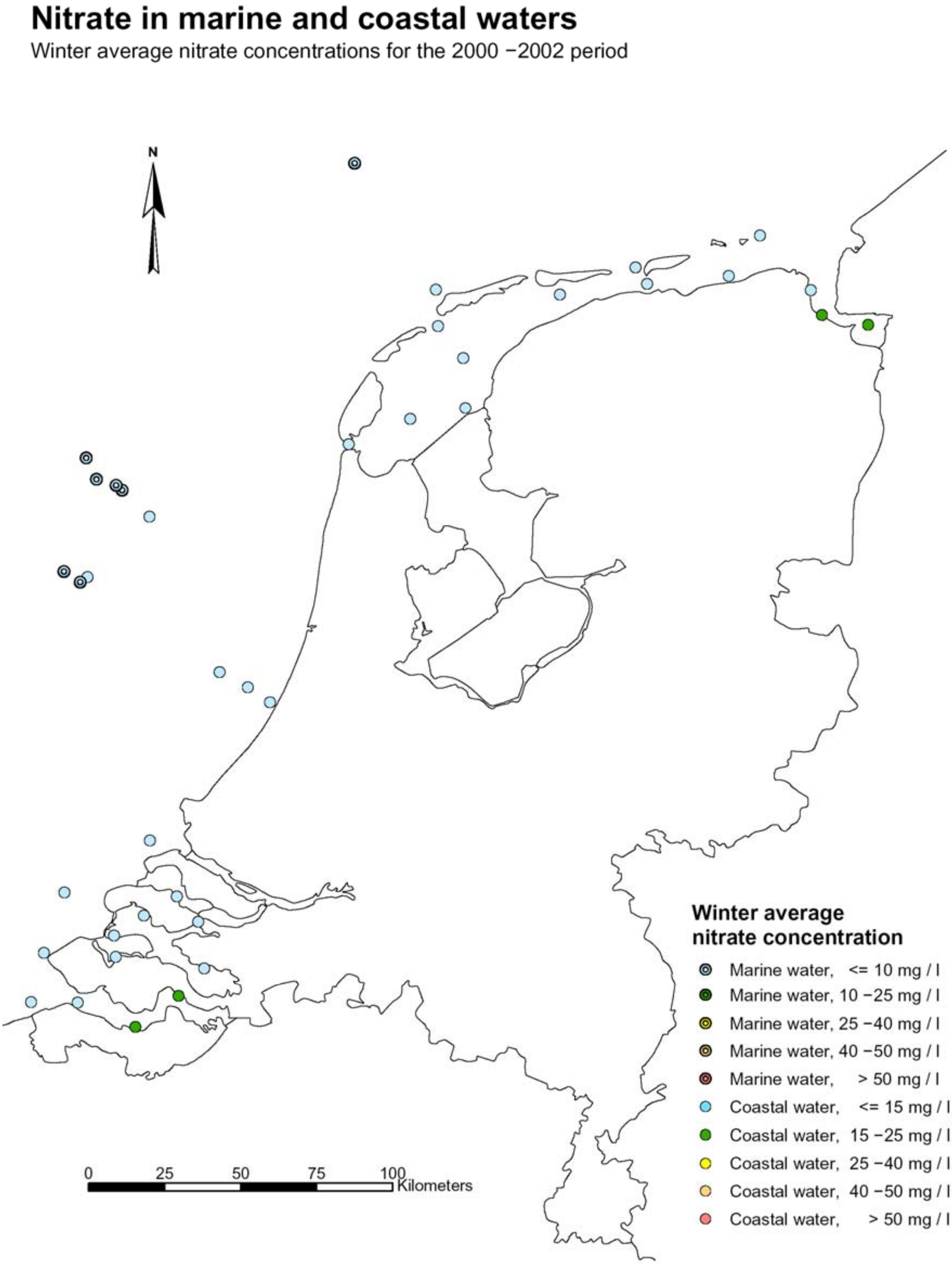
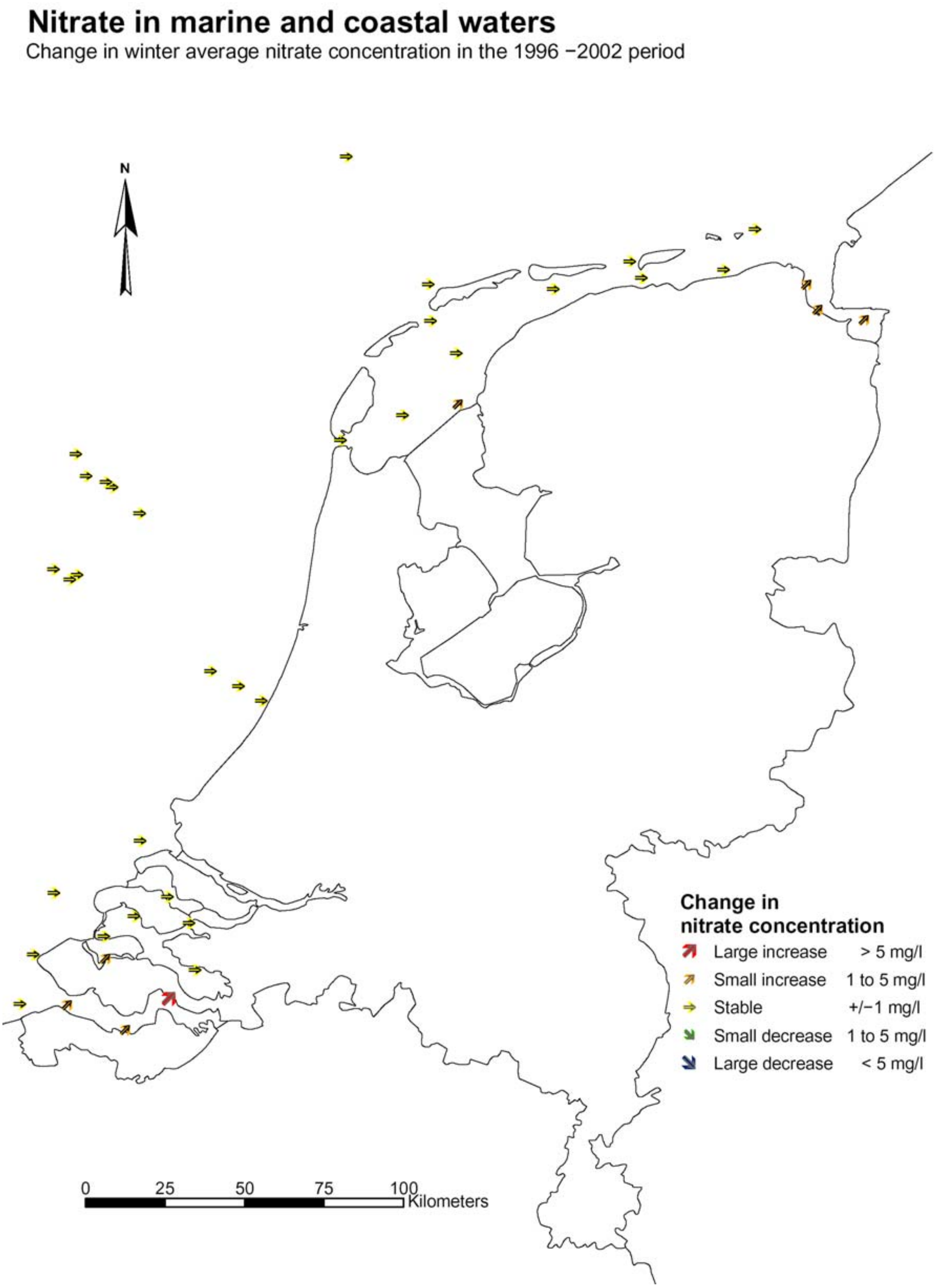


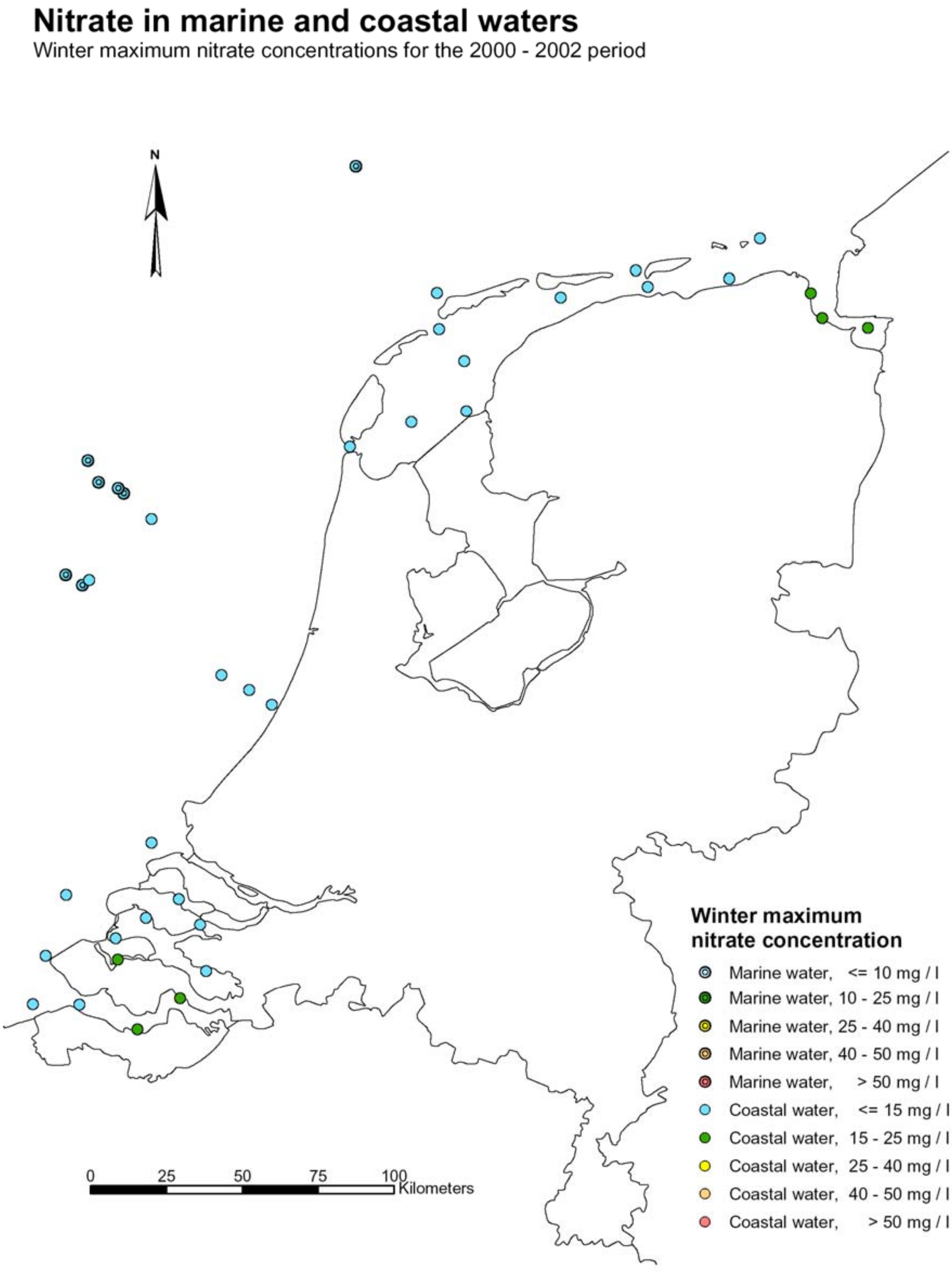
Figure 40: Summer-average total-phosphorus concentration (mg/l as P) in the open sea and coastal waters of the Netherlands in the 1991-2002 period.



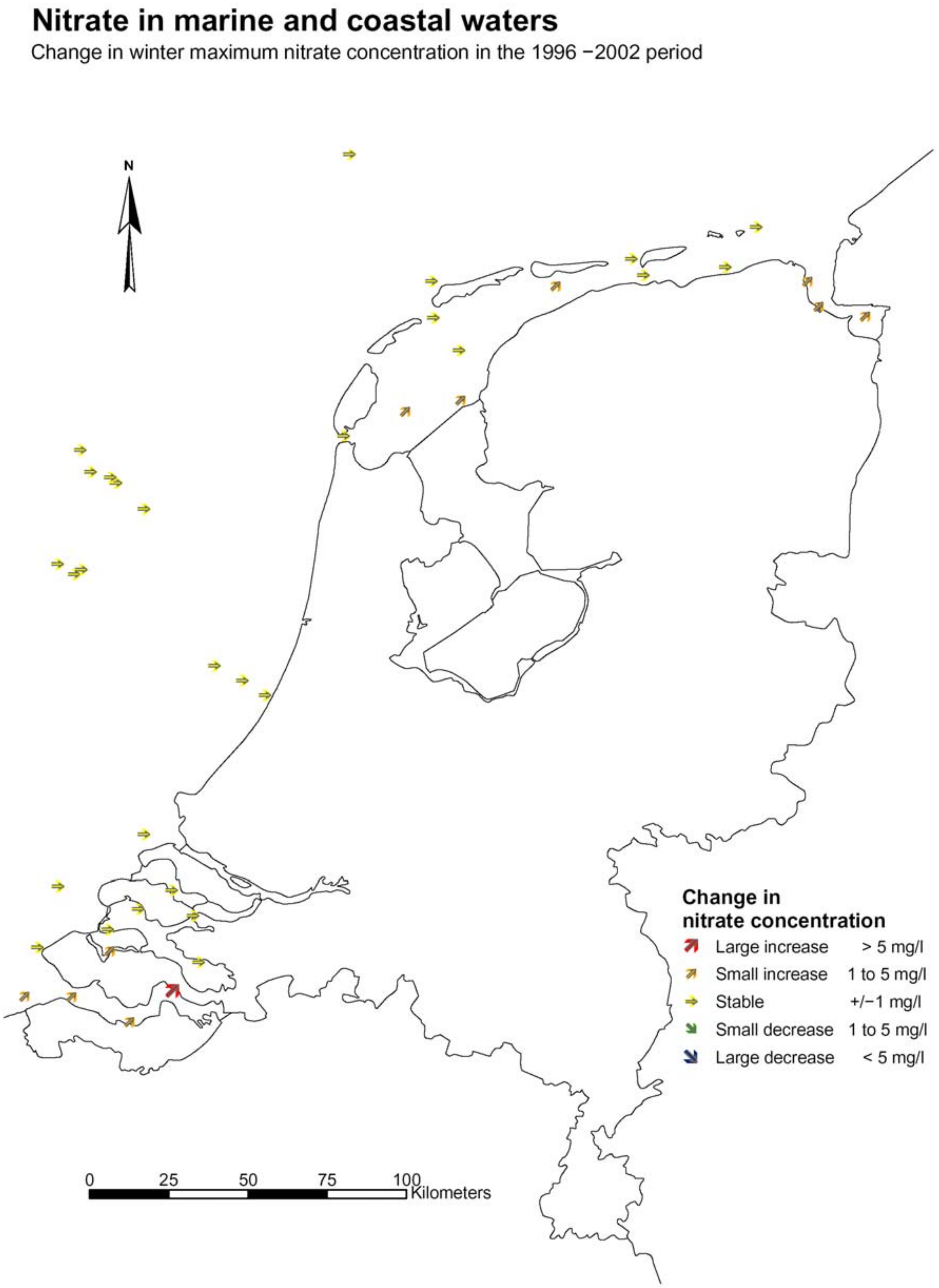
Map 16: Winter-average nitrate concentration in Dutch marine and coastal waters for the 2000-2002 period.



Map 17: Change in winter-average nitrate concentration in Dutch marine and coastal waters in the 1996-2002 period.



Map 18: Winter-maximum nitrate concentration in Dutch marine and coastal waters for the 2000-2002 period.



Map 19: Change in winter-maximum nitrate concentration in Dutch marine and coastal waters in the 1996-2002 period.

8. FUTURE WATER QUALITY DEVELOPMENT

An assessment of the time scale for change in water quality as a consequence of changes in farm practice is ridden with uncertainty. Groundwater travel times increase with depth and show a large variation at a given depth. Moreover, chemical processes (e.g. denitrification, ammonification) and physical processes (e.g. dispersion, diffusion, dilution) change water quality in time and space due to large variations in the physico-chemical characteristics of the vadose zone, aquifers and aquitards. Regional surface waters receive groundwater from different origins (agriculture, nature, urban area) and age and are also fed by rainwater and sometimes effluents of, for example farm yards, waste water plants or even industrial plants.

Travel times of on-farm waters sampled in the LMM are estimated to be less than 5 years (Meinardi and Schotten, 1999; Meinardi et al., 1998a, 1998b). Therefore it is assumed that the measures of the third Action Programme (2004-2007) will show their effect on on-farm water quality between 2008 and 2013.

Travel times of groundwater in the sand regions at a depth of 5-15 m are on average 12 years, but range from less than 5 years to over 30 years (Meinardi, 1994), see Figure 41. Travel times of groundwater at a depth of 15-30 m are on average 36 years, and range from less than 25 years to over 80 years (Meinardi, 1994), see Figure 42. In clay and peat regions travels times are usually much longer as aquifers are often confined or semi-confined.

It will be at least a decade before we can see the effects of measures on nitrate concentrations in groundwater at a depth of 5-15 m. Due to the large variation in travel times at a specific depth, nitrate concentrations will only decrease slowly. In areas with confined aquifers and/or a high denitrification capacity of the aquifers, nitrate concentrations are already low and there will be no change.

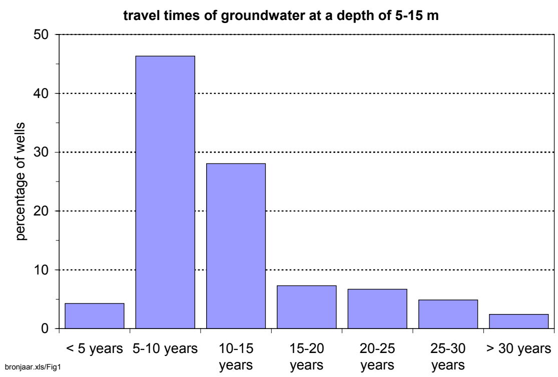


Figure 41: Travel times distribution of groundwater in the sand regions in the Netherlands at a depth of 5–15 m.

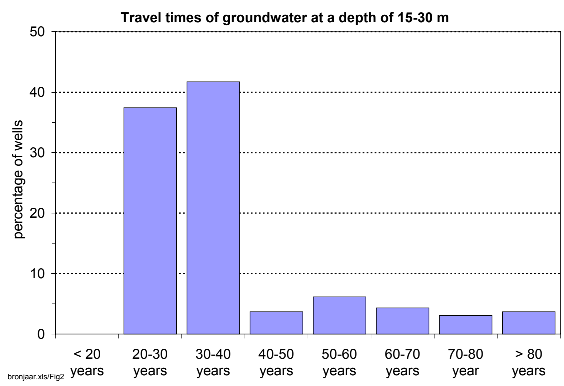


Figure 42: Travel times distribution of groundwater in the sand regions in the Netherlands at a depth of 15-30 m.

It will take at least several decades before we can see the effects of measures on nitrate concentrations in groundwater at a depth of more than 15 m, and certainly at a depth of more than 30 m. Nitrate concentrations will only change slowly due to the large variation in travel times at a specific depth.

Lags in observing the effects of measures on nitrate concentration in fresh surface waters are assumed to be relatively short compared with groundwater at a depth of more than 5 m and to be in the same order of magnitude as on-farm waters. Surface water quality in clay and peat regions will be similar to that in on-farm waters and will also show the same effects of the third Action Programme. The contribution of recent (1-5 years) groundwater in surface water in the sand regions varies from less than 10% to more than 70%. This suggests that the effects of the Action Programme will become visible anywhere between 2008 and 2013.

Therefore, it is assumed that the effects of measures from the third Action Programme (2004-2007) on nitrate concentrations in fresh waters will become apparent between 2008 and 2013. As a result of mixing, it will probably be hard to distinguish the effects of the measure on nitrate concentrations from the effects of natural variation in nitrate concentrations. This is due to factors such as the variation in precipitation.

Estimating future evolution in relation to agricultural practice is for eutrophication even more difficult than for nitrate concentrations. Main reasons are:
1. the differences in surface waters with regard to their sensitivity to eutrophication.
2. phosphorus levels and other factors such as hydromorphology, which play an important part in the eutrophication process as well.
3. the contribution by other sources of nutrient input, notably urban waste water and transboundary rivers.
4. the very poor predictability of the lag of response of aquatic ecosystems to a substantial reduction of nutrient inputs and nutrient concentrations.

In addition to source-oriented measures, regional effect-oriented measures such as fish stock management have been taken in several cases where prospects were good and will be pursued further. In some cases the ecological restoration process was accelerated substantially (for example, for the Veluwe border lakes).However, as Figure 32 (page 127) and Figure 39 (page 144) show, , the ecological restoration processes in Dutch surface waters are seen to take place at a relatively slow pace, and a general, clearly observable acceleration of these restoration processes is not expected.

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Meinardi C.R., Van den Eertwegh G.A.P.H. and Schotten C.G.J. (1998a). Grondwateraanvulling en oppervlakkige afstroming in Nederland. Deel 2: De afwatering van kleigronden [Groundwater recharge and surface run-off in the Netherlands. Part 3: Drainage of clay soils. Stromingen, 4 (4): 5-19.

Meinardi, C.R., Schotten, C.G.J., De Vries, J.J. (1998b). Grondwateraanvulling en oppervlakkige afstroming in Nederland. Langjarig gemiddelde voor de zand- en leemgebieden [Groundwater recharge and surface run-off in the Netherlands. Long term average for sand and loess areas]. Stromingen, 4 (3): 27-41.

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ANNEX

Annex 1: Fact sheet 'Nitrate in on-farm waters'

1	**Data**	Nitrate concentrations in on-farm waters in the Netherlands in the 1992-2002 period, status and trends
2	**Filled in by / date**	D. Fraters and L.J.M. Boumans: 30-3-2004
3	**Source**	Making of database by: H.F. Prins Making of indicators by B. Fraters, L.J.M. Boumans
4	**Description**	The data are collected in the framework of the National Monitoring programme for effectiveness of Minerals Policy (LMM) established between 1992 and 1997. In the 1992-2002 period in the sand regions the upper metre of groundwater was sampled at 272 different farms one to four summers (on average 2.1 summers). One time per summer 16 or 48 locations per farm groundwater was sampled. In the 1997-2002 period tile drain water was sampled at 66 different farms in the clay regions during one up to five winters (on average 3.7 winters). One to four times per winter 16 tile drains were sampled on each farm. In the 1996-2002 period the upper metre of groundwater and ditch water were sampled on 28 different farms in the peat regions in one to four winters (on average 2.5 winters). One time per winter at 16 locations per farm groundwater was sampled and at 4 locations ditch water. Samples were analysed in the field (or directly after arrival in the lab for tile drain water) for nitrate (nitrachek), pH and electric conductivity. Groundwater level and temperature were recorded. Samples were acidified and stored at 4°C in the dark till analyses. In the lab one to four mixed samples were made and analysed for macro and trace elements. Additional information about soil type and groundwater regime class distribution are derived from the Soil and Groundwater Regime Class maps. Precipitation and evaportranspiration data of the Royal Dutch Meteorological Institute are used.
5	**Calculation**	Mean values are calculated for all parameters for each farm per water type per year. Average values for selections per year are calculated based on mean annual farm values. Average values for selections per period year are calculated based on mean period farm values.

		For evaluation of effect measured concentrations in on-farm waters are related to farm practice information of the preceding farming season. A statistical approach is used to discern the effects of the minerals policy, as well as to discern a decrease in the exceedance of EU standard nitrate concentration in on-farm waters. These are described in Annex 2 and Annex 3, respectively.
6	**Uncertainty**	Standard errors of annual mean nitrate concentrations per main soil-type region are less than 5 mg/l for peat and clay regions and 10 mg/l for sand regions for most years (Figure 7). Standard errors for annual means per farm type per main soil-type region per sub-period; i.e. 1992-1995, 1997-1999 and 2000-2002, are less than 5 mg/l for peat and clay regions and 15 mg/l for sand regions for most years (Figure 5).
7	**Input**	The nitrate concentrations are measured both in the field (Nitrachek, individual sample) and in the laboratory (mixed sample). No systematic errors are expected. Data on farm practice are collected in the framework of the Farm Accountancy Data Network. Weather data are provided by the Royal Dutch Meteorological Institute.
8	**Remarks**	
9	**References**	Fraters, B., Boumans, L.J.M., Van Leeuwen, T.C., De Hoop, D.W. (2003). Results of 10 years of monitoring nitrogen in the sandy regions in the Netherlands. In: Proceedings of the 7th International Conference on Diffuse Pollution. Dublin, Ireland, 17 - 22 August 2003, 7: 1-5. Fraters, B., Boumans, L.J.M., Van Leeuwen, T.C., De Hoop, D.W. (2002a). Monitoring nitrogen and phosphorus in shallow groundwater and ditch water on farms in the peat regions of the Netherlands. In: Proceedings of the 6th International Conference on Diffuse Pollution. Amsterdam, the Netherlands, 30 September – 4 October 2002, pp. 575-576. Fraters, B., Boumans, L.J.M., Reijnders, H.F.R., Van Leeuwen, T.C., De Hoop, D.W. (2002b). Monitoring the effectiveness of the Dutch Mineral Policy on nitrate in groundwater. In: Steenvoorden, J., Cleassen, F.and Willems, W.J. (Eds.), Publication 273, Proceedings of the International Conference on Agricultural effect

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Annex 2: Discerning the effects of the Minerals Policy

Leo Boumans & Dico Fraters

May, 2004

Version 3.1

GENERAL

Nitrate concentration in shallow groundwater on farms has been monitored in the framework of the National Monitoring Programme for the effectiveness of the Minerals Policy for more than ten years. The measured nitrate concentrations vary with the year (see, for example, Fraters et al., 1998). The variations in nitrate can be attributed to variation in the following influencing variables (see, for example, Boumans et al, 2001):

1. Precipitation and evapotranspiration (groundwater recharge) (section 2.1)
2. Actual groundwater depth (sand regions) or flow rate (clay regions)
3. Soil type (section 2.2)
4. Soil drainage class (section 2.2)
5. Farm type (section 2.3)
6. Minerals Policy

A statistical approach was used to discern the effect of the Minerals Policy (Boumans et al., in prep, 2001; 1997). Measured nitrate concentrations were modelled by the residual maximum likelihood method (Payne, 2000). The influencing variables mentioned were incorporated as fixed effects (known 'a priori'). The individual measurement on farms were included as a random effect (effects are considered noise) one effect being the interaction of groundwater recharge and the farm. Several of the interactions between the most important variables were tested.

The effect of the Minerals Policy was modelled by incorporating the year of measurement as a categorical variable with a class for each year having a fixed effect. Nitrate concentrations for each year were calculated by the model using equal weights for all farm types. However, since the acreage between farm types differs and gradually changes in time, the annual nitrate concentrations estimated by the model were re-calculated by weighting according to the acreage of each farm type in each year (see section 2.4). A systematic decrease in time of re-calculated estimated nitrate concentrations per year was interpreted as an effect of the Minerals Policy.

INFLUENCING VARIABLES

Precipitation excess or groundwater recharge

Precipitation excess or groundwater recharge is calculated by modelling the concentration in the upper part of groundwater of a hypothetical tracer applied every 10 days to the soil at a rate of 10 mg/m^2. The computer code ONZAT (OECD, 1989) was used to calculate the so-called index concentration over 10-day periods for nine districts in the sandy regions and five districts in the clay regions. The Royal Netherlands Meteorological Institute (KNMI) provided data on precipitation and total Makking evapotranspiration (Makking, 1957) over 10-day periods for each district.
Variations in the index concentrations are indicative for variations in groundwater recharge. The index concentration was calculated for only one soil type (surface soil no. 1 and sub-surface soil no. 1 in Table 3 from Wösten et al., 1987) and one vegetation type (grass).
For the sand regions the index concentration in the upper metre of groundwater was calculated for 10 drainage levels (0.50, .1.00, 1.50, etc. up to a depth of 5 m). For the clay regions the index concentration was only calculated for the upper 0.5 m of groundwater for a drainage level of a 1-m depth.
The uppermost metre of groundwater was sampled in the sand regions and in the tile-drain water in the clay regions. Each sample (usually 16 per farm per year) is related to an index concentration on the basis of district, sampling date and groundwater table depth at the time of sampling (sand regions only).

Soil type and drainage class

GIS and digital soil and groundwater regime class maps were used to determine the fraction of different soil types (7) and drainage classes (3) for each farm (Boumans et al., in prep.; 2001; Fraters et al., 1998).

Farm type

Seven farms types are distinguished in the sand regions and three in the clay regions (see Table 48). This is because farm type can influence the relationship between nitrogen load or surplus, and nitrate concentration in on-farm waters.

Table 48: Definition of farm types used in the analysis according to definitions of Statistics Netherlands (Poppe, 1992)

Farm type	Sand regions	Clay regions
Dairy farms	NEG 4[a], less than 10% arable crops (excluding maize)	NEG 4110, 4120 and 4370 [b]
Less intensive	< 2.8 LU/ha	-
Intensive	> 2.8 LU/ha	-
Dairy farms with intensive livestock farming	NEG 7	-
Less intensive	Manure production < 225 kg/ha P_2O_5	-
Intensive	Manure production > 225 kg/ha P_2O_5	-
Arable farms	NEG 1	NEG 1
Other farms	NEG 8 and partly NEG 4 & 7	NEG 4 and 8, excluding 4110, 4120, 4370, 4380
Factory farms	NEG 8	-
Mixed farms	NEG 4 and 7, more than 10% arable crops (excluding maize)	-

[a] may include farms with other cattle, sheep and goats
[b] only dairy farms

Within the clay region, two sub-regions, the marine clay sub-region and the river-clay sub-region, are distinguished. The reason for this is the clearly different leaching behaviour between the two (Fraters et al., 2001).

RECALCULATION OF AVERAGED YEARLY NITRATE CONCENTRATIONS BY WEIGHING ESTIMATED YEARLY AVERAGE NITRATE CONCENTRATIONS WITH THE ACREAGE PER FARM TYPE IN A YEAR.

The models resulting from the statistical analyses (one for each main soil type region) estimated an average nitrate concentration for each farm type, with equally weighting for each year, and average values for the influencing variables. The models also estimated an average nitrate concentration for each year that was equally weighted per farm type and average values for the influencing variables. These data were used to calculate an average annual nitrate concentration per farm type per year. These calculated annual nitrate concentrations per farm type were averaged again for each year, but weighted with the acreage per farm type per year. Acreage per farm type per soil type region is given for the 1992-2002 period in Annex 2.A.

New yearly averages were calculated in four steps. First, the relative contribution of farm types to each annual average was calculated by dividing the estimated annual average nitrate concentration by the sum of the estimated farm-type average nitrate concentrations, see Equation 1. Secondly, the relative acreage of each farm type in each year was calculated by dividing each yearly farm-type acreage by the total acreage per year for all farm types considered, i.e. monitored. The outcome was multiplied by the number of farm types, see equation 2. Third, a weight for each farm type per year was calculated by multiplying the outcome of step 1 with the outcome of step 2 for each farm type and year. Fourth, new yearly average nitrate concentrations were calculated as a weighted (step 3) average of estimated farm-type average nitrate concentrations, see equation 3.

1. $I_{year=i} = NO_{3,est\ [y=i]} / \Sigma_{x=1,n}(NO_{3,est\ [farm\text{-}type=x]})$, with

$I_{year=i}$ = relative contribution of the farm types to annual average of year [i]

$NO_{3,est\ [y=i]}$ = estimated annual average nitrate concentration for the entire group of farms using a period average for influencing variables

$\Sigma_{x=1,n}(NO_{3,est\ [farm\text{-}type=x]})$ = sum of estimated farm-type average nitrate concentration for the entire period considered, using a period average for influencing variables

2. $I_{farm\text{-}type[x,i]} = N_{farm\text{-}type} * A_{farm\text{-}type[x,i]} / \Sigma_{x=1,n}(A_{farm\text{-}type\ [x,i]})$, with

$I_{farm\text{-}type[x,i]}$ = relative acreage of farm-type [x] in year [i]

$N_{farm\text{-}type}$ = number of different farm types

$A_{farm\text{-}type[x,i]}$ = acreage of farm land used by farm type [x] in year [i]

$\Sigma_{x=1,n}(A_{farm\text{-}type\ [x,i]})$ = total acreage of farm land used by all farm type considered

3. $NO_{3,\ std.\ [y=i]} = \Sigma_{x=1,n}\left(NO_{3,est\ [farm\text{-}type=x]} * I_{farm\text{-}type[x,i]} * I_{year=i}\right)$, with

$NO_{3,\ std.\ [y=i]}$ = standardised nitrate concentration for year I

$NO_{3,est\ [farm\text{-}type=x]}$ = estimated farm-type average nitrate concentration for the entire period considered using a period average for influencing variables

$I_{farm\text{-}type[x,i]}$ = relative contribution of the farm-types to annual average of year [i]

$I_{year=i}$ = relative acreage of farm-type [x] in year [i]

MODELS

The models for the two soil-type regions (sand and clay) that arose from the statistical analyses as best models are:

(1) $NO_3^{sand} = f(\text{farm-type}, C_{index}, C_{index}*fD_{poor})$, $[P(\chi^2_{variables}) < 0.001]$ with

NO_3^{sand} = nitrate concentration in the upper metre of groundwater

farm-type = seven different types of farming as defined in Table 48

C_{index} = index concentration

fD_{poor} = fraction of acreage with drainage class ‘poor’, i.e. GRC classes 1-4.

(2) $NO_3^{clay} = f(\text{farm-soil-type}, C_{index}, \text{flow-rate}), [P(\chi^2_{variables}) < 0.001]$ with
NO_3^{clay} = nitrate concentration in tile drain water.

Farm-soil-type = four types; three different types of farming as defined in Table 48, where, in analyses, dairy farms in marine clay region and river clay region are considered as different farm-soil types. Arable and other farms only occurred in the marine clay region.

The models were used to estimate a farm-type average nitrate concentration for the entire period considered (see Table 49) and an annual average nitrate concentration for the entire group of farms (see
Table 50) using a period average C_{index}, fD_{poor} (sand regions) and flow-rate (clay regions).

Table 49: Estimated period-average nitrate concentration in on-farm water per farm type using average values for model parameters

	Sand regions	Clay regions	
Farm type		Marine	River
Dairy farms		42	42
Less intensive	99		
Intensive	136		
Dairy farms with intensive livestock farming			
Less intensive	127		
Intensive	151		
Arable farms	99	61	
Other farms		38	
Factory farms	165		
Mixed farms	122		

Table 50: Estimated annual average nitrate concentration in on-farm water using average values for model parameters

	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002
Sand	144	146	151	142	131	101	118	112	104	101
Clay					58	63	37	51	36	30

The calculated relative influence of each year (see Equation 1) is given in Table 51. The calculated relative influence of each farm type in each year (see Equation 2) for the sand regions is given in Table 52 and for the clay regions in Table 53.

Table 51: Relative influence of each year on the average nitrate concentration in on-farm water

	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002
Sand	0.161	0.163	0.169	0.158	0.145	0.112	0.131	0.125	0.116	0.113
Clay					0.316	0.344	0.200	0.280	0.198	0.163

The importance of the less intensive dairy farms in the sand region increases from 2.1 to 3.7 in the 1992-2002 period, while the importance of other types of dairy farms decreases from 3.2 to 1.5 in the same period. The other farm types in the sand regions and those in the clay regions only show slight changes.

Table 52: Relative influence of each farm type in the sand regions per year on the average nitrate concentration in on-farm water

Farm type [a]	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002
1	2.1	2.3	2.4	2.5	2.8	2.9	3.1	3.4	3.4	3.7
2	1.5	1.4	1.4	1.4	1.1	1.0	0.9	0.8	0.9	0.6
3	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.7	0.6	0.6
4	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3
5	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.	0.3
7	0.4	0.4	0.5	0.5	0.5	0.6	0.5	0.6	0.5	0.6

[a] 1 = dairy farms, less intensive; 2 = dairy farms, intensive; 3 = dairy farms with intensive livestock farming, less intensive; 4 = dairy farms with intensive livestock farming, intensive; 5 = arable farms; 6= factory farms; 7 = mixed farms.

[b] sum of figures per year should equal 4; this may be slightly different due to rounding off.

Table 53: Relative influence [a] of each farm type in the clay regions per year on the average nitrate concentration in on-farm water

Farm type [a]	1997	1998	1999	2000	2001	2002
Arable farms	2.2	2.2	2.1	2.1	2.1	2.1
Dairy farms, river-clay regions	0.5	0.5	0.5	0.5	0.4	0.4
Dairy farms, marine-clay region	1.1	1.1	1.1	1.1	1.1	1.1
Other farm types	0.2	0.2	0.3	0.3	0.3	0.3

[a] Sum of figures per year should equal 4; due to rounding off this may be slightly different.

The re-calculated estimated annual average nitrate concentration in on-farm-waters (see Equation 3) in the sand and clay regions are given in Table 54.

Table 54: Recalculated annual average nitrate concentration in on-farm water in sand and clay regions

	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002
Sand	134	136	140	130	118	91	105	99	92	88
Clay					66	72	41	58	41	34

Comparison of
Table 50 and Table 54 shows the effect of weighing.
Table 55: Difference between recalculated (Table 54) and estimated (

Table 50) annual average nitrate concentration in on-farm water in sand and clay regions

	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002
Sand	10	10	12	11	12	10	13	13	12	13
Clay					12	11	4	7	5	4

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Annex 2.A: Acreage per farm type per year per soil-type region

Sand regions	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Arable farms	94598	93730	89114	88344	87573	86551	84546	84127	82596	82418	77785	77675
Dairy less intensive	188493	201868	215571	221815	228058	234484	251333	264170	284296	294227	290445	317937
Dairy intensive	157256	143870	130835	129958	129081	115124	98789	87987	84231	68742	77410	55675
Mixed dairy less intensive	88195	90672	93491	88903	84315	82121	80346	78695	67748	56816	52397	53273
Mixed dairy intensive	68702	69193	69630	64280	58930	54000	53096	46897	39811	32916	28458	23971
Factory farms	17839	19318	20820	20796	20772	21048	23192	22858	24767	26140	27087	27014
Mixed farms	42082	40712	41868	42160	42452	43836	48444	49763	48784	50703	45422	49984
Non-LMM farm types	272512	265535	263095	263377	263658	270415	272180	280965	273002	294982	288614	290508

Clay regions	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Arable farms	329733	324686	316704	313502	310370	307856	307404	301433	297588	297895	292996	288284
Dairy farms	217732	222562	223926	223098	223346	222004	225280	224078	224593	218702	217869	221211
Other farms	32689	31946	34077	32842	34351	35764	34697	38965	39646	42265	40754	43863
Non-LMM farm types	173356	174966	179314	178925	175367	172856	175134	177652	183673	178961	182354	187330

Annex 3: Discerning a decrease in the exceedance of EU target value

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May, 2004

Version 1.0

INTRODUCTION

Nitrate concentration in shallow groundwater on farms has been monitored in the framework of the National Monitoring Programme for the effectiveness of the Minerals Policy for more than ten years. The average measured nitrate concentration in the main soil-type regions (sand, clay, and peat) varies with the year. The cause of this variation can be attributed to climate, soil type, farm type and the Minerals Policy. A statistical approach has therefore been used to discern the effects of the Minerals Policy (see Annex 2).

In view of the fact that the above-mentioned approach can not be used directly to estimate a trend in the exceedance of the EU target value (50 mg/l) for nitrate in groundwater, the statistical approach described below has been applied to estimate the trends in exceedance of the EU target value.

Method

The number of farms (per year and farm-type) exceeding the EU target value was related to the average of the farm mean nitrate concentration using a generalised linear regression model with a binomial distribution and a logit link function ($P < 0.001$). Influences of the data on the relationship were investigated using the modified Cook's statistic (Payne R., 2000). In the case of sand regions, influences were equalised by transforming the mean concentrations. Besides the mean, year of measurement and farm type were not of significant influence ($P > 0.05$). The following relationships were derived.

$$L[\text{exceedance, sand}] = -7.58 + 1.98 * (NO_3 + 0.1)^{1/3}.$$

$$L[\text{exceedance, clay}] = -3.17 + 0.0549 * NO_3$$

Subsequently, these derived equations were used to estimate exceedance (re-calculated exceedance) for the re-calculated estimated mean concentrations in Table 54 in Annex 2

Results

Re-calculated estimated means and exceedances are given in Table 56.

Table 56: Recalculated estimated annual mean nitrate concentration in on-farm water and exceedance in sand and clay regions

	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002
Sand										
mg/l	134	136	140	130	118	91	105	99	92	88
%	93	93	94	92	90	79	85	83	79	77
Clay										
mg/l					66	72	41	58	41	34
%					61	68	29	50	29	21

Annex 4 Fact sheet 'Nitrate in groundwater at depths of 5-15 and 15-30 m'

1	**Data presented**	Nitrate concentration in groundwater at depths of 5-15 and 15-30 m in the Netherlands in the 1984-2002 period
2	**Filled in by / date**	H.F. Prins, 30-5-2004
3	**Source**	Making of database by: H.F. Prins Making of indicators by B. Fraters
4	**Description**	The data are collected in the framework of the National Groundwater Monitoring Network (LMG) established between 1978 and 1984. The LMG comprises about 360 locations (1 per 100 km^2) divided over the whole country. Special attention is paid to areas that are of importance for drinking-water production. The main criteria for site selection were: 1) type of soil 2) land use 3) hydrogeological conditions For most important combinations enough monitoring points were selected to insure the availability of applicable mean values of most parameters and the possibility of trend analyses. Secondary criteria for site selection were: 1) geological conditions. 2) absence of groundwater pumping stations in vicinity 3) accessibility of the site 4) no influence of local pollution sources. Well screens were placed at a depth of about 10 m (well-screen no. 1) and 25 m (well-screen no. 3) below the soil surface. A fallback well screen was placed at 15 m (well-screen no. 2). The sampling frequency was once per year in the 1984–1996. Since 1997 the sampling frequency has been once a year for groundwater in the sand regions at a depth of 10 m and once every two year in the other regions. Groundwater at a depth of 25 m is once every four years. This sampling frequency has also been used for well screens that had a chloride concentration of more than 1000 mg/l in the period before 1997. Locations with riverbank infiltration are excluded. The number of well screens at a depth of 10 m within the selection varies between 220 and 342 in the 1984–1998 period. The total number of well screens used for this analysis is 346. The number of well-screens at

		a depth of 25 m varies between 84 and 350 The total number of well-screens used for this analyses is 335.
5	**Calculation**	The indicators comprise the trend of (1) the average nitrate concentration and (2) the number of well-screens (expressed as percentage) with a nitrate concentration higher than the EU target value of 50 mg/l. For the period considered (1984-2002) the trend is depicted for well screens at an average depth of about 10 m –mv (screen number 1) and for those at about 25 (screen number 3). In those cases for which screen number 3 is absent, the results for screen number 2 are used. Results are used of well screens that haven been sampled each year in the 1984–2002 period. The results for well-screens that are not sampled each year are only used in case: (1) they are sampled at least once in the 1996-2002 period (2) they are sampled at least once in the 1984-1991 period For the selected well-screen, concentrations for missing values were estimated as follows: (a) in case data are missing for one or more consecutive years within a series the mean value of the preceding year with a concentration and the next year with a concentration is used as an estimate for all years without data. (b) For well-screens that haven not been sampled after a certain year within the 1996-2002 period, the concentration of the last year of sampling is used as an estimate for all years with missing data. (c) For well-screens that haven not been sampled before a certain year in the 1984-1991 period the concentration of the first year of sampling is used as an estimate for all years with missing data. Soil type and land use are derived for each well from the soil map and the topographical map in combination with field observations, respectively. For this report soil type and land use have been clustered as follows:: Soil type — Land use Sand: Za, Zr, Zo, Le — Agriculture: Lan, Gra, GBo, Ivh, Bou, Tui Clay: Ze, Ri, Kv, — Nature: Bos, Dui, Peat: Ho, La — Other: Onb, Boo, Beb, Irr, Nsp Other: On, Ov, Ha
6	**Uncertainty**	The indicators are based on simple and straitforward calculations

		(see point 4, 5 en 8). The standard error of the annual mean nitrate concentration (s.e.m.) in groundwater at a depth of 5-15 m varies between years. For agriculture the s.e.m. is 4-6 mg/l, for nature 2-3 mg/l and for other land use 3-5 mg/l. for agriculture on sandy soils the s.e.m. varies between 7-11 mg/l, for clay soils from 0,5-5 mg/l and for peat soils 0.1-2 mg/l.
7	**Input**	The data concern nitrate concentration analysed by RIVM/LAC (certified laboratory). There are no indications of systematic errors. The data were checked. For this study the 'labelled' database is used.
8	**Remarks**	The reason for selection of well-screens that are sampled most of the years and filling of the gaps is to avoid the presentation of apparent trends.
9	**References**	Van Drecht, G., Reijnders, H.F.R., Boumans, L.J.M., van Duijvenbooden, W. (1996). De kwaliteit van het grondwater op een diepte tussen 5 en 30 meter in Nederland in het jaar 1992 en de verandering daarvan in de periode 1984-1993 [Quality of groundwater at a depth of 5-30 m in the Netherlands in 1992, and the trend in the 194-1993 period]. Bilthoven, the Netherlands, RIVM-rapport 714801005: Van Duijvenbooden, W. (1987). Groundwater quality monitoring network: design and results. In: Van Duijvenbooden, W. and Van Wageningh, H.G. (eds.), Vulnerability of soil and groundwater to pollutants. Proceedings International Conference, Noordwijk aan Zee, the Netherlands, March 30 April 3, 1987, The Hague, the Netherlands, pp. 179-191.

Annex 5: Fact sheet 'Nitrate and chlorophyll-a in fresh waters'

1	**Data**	The nitrate concentration and the concentration of chlorophyll-*a* in the surface water of fresh waters: national waters, agricultural influence regional waters and other regional waters.
2	**Filled in by / date**	A.P.A. Mol, 12-3-2004
3	**Source**	Calculated by: Hein Barreveld (RIZA, IMI)
4	**Description**	National waters: The national waters data are being collected in the national chemical and biological monitoring network, the so-called 'Monitoring Waterstaatkundige Toestand des Lands' (Monitoring Water Status of the Country MWTL). It includes 27 locations. Regional water: The locations of the regional Water Boards are collected in a survey by RIZA on behalf of the CIW (Commission for Integrated Water management) for the yearly report Water in Beeld. Extra information is collected about location that are primarily agricultural influenced. Some locations appear in both databases. Those locations are classified as other regional waters The sum of nitrate and nitrite is used for the nitrate concentration, or just nitrate if the sum isn't available. Compared to the nitrate concentration is nitrite very low.
5	**Calculation**	The original nitrate data were provided as N, for presentation purposes these are multiplied by 64/14 to get NO_3. For each location a winter-average nitrate (1 October- 31 march) is calculated and a winter maximum concentration per year. The programme Bever was used and the calculation module Notove. The winter average was via the Toets-editor defined. For chlorophyll-*a* the summer average was calculated (1 April – 30 September) For the trend diagrams the three categories of waters are depicted

		separately. Surface waters used for drinking water production are also in this graph. These data are supplied by the RIVM. There is variation between the locations from the Water Boards every year. A supplemented database was made to tackle the problem of changing number of surface water sampling stations in the 1985-2002 period. This database was made in two steps; first minor gaps were bridged. If for a specific station in a certain year no data were available, then the average of the available values in the period "year –2" up to and including "year + 2" was used as estimate. If no data were available in that period, it was marked as 'no data'. Secondly, all stations were removed from the database that still contained missing data after the first step. So only stations remained was data (measured or estimated) for all years The figures with winter and summer averages and maximum in the 1984 – 2002 period are based on the supplemented database. The winter and summer-average and maximum are calculated respectively as the average of the winter and summer averages and the average of the winter and summer maximum of all surface water stations.
6	**Uncertanity**	
7	**Input**	Data from the national watermonitoring database DONAR-for the national waters and a seperate database for the regional data (CIW-database and agricultural influence regional waters in Access). .
8	**remarks**	
9	**references**	

Annex 6 Fact sheet 'Nitrate and chlorophyll-a in coastal and marine waters' (in Dutch)

1	**Data**	De nitraatconcentratie in het oppervlaktewater van de zoute rijkswateren.
2	**Filled in by / date**	V. T. Langenberg, 1-5-2004
3	**Source**	Calculated by: R. Bovelander in co-operation with Basisinfodesk RIKZ
4	**Description**	De gegevens worden verzameld in het chemische en biologische meetnet van de Monitoring Waterstaatkundige Toestand des Lands (MWTL). Het meetnet omvat 35 bemonsteringspunten verspreid over de zoute wateren. De belangrijkste criteria voor de keuze van de locaties waren: 1) verdeeld over de elf watersystemen 2) Historische tijdreeksen beschikbaar 3) Hydrologische omstandigheden De meetfrequentie op een locatie is over het algemeen eenmaal per maand in de winter en tweewekelijks in de zomer. Bemonsterd is op ca. 1,5 m onder de waterspiegel, op de Noordzee ca 3,5 m door de meetdiensten van Rijkswaterstaat. Voor nitraat wordt het water gefilterd voor analyse. Voor chlorofyl wordt het residu op een filter geanalyseerd. Bemonstering en analyse gaan volgens de Rijkswaterstaatvoorschriften (RWSV's). Analyse is uitgevoerd door het RIKZ-laboratorium dat een Sterlab-accreditatie heeft.
5	**Calculation**	De mediaan waarde van een meetreeks wordt gebruikt als schatter voor het gemiddelde. Gezien de niet normale verdeling van de gegevens is de mediaan een betere schatter dan het rekenkundig gemiddelde. Per locatie wordt eerst de mediaan per maand berekend, vervolgens wordt de mediaan over de maanden berekend. Voor het maximum geldt dezelfde rekenwijze. Voor nitraat wordt de winterwaarde berekend (1 december t/m 28/29 februari) en voor chlorofyl de zomerwaarde (1 april t/m 30 september). Waarden kleiner dan de detectiegrens worden in de berekening als de halve waarde meegenomen. Als het berekeningsresultaat kleiner is dan de kleinste detectiegrens (DG) wordt de waarde <DG gerapporteerd. De jaarmedianen en -maxima over de gepresenteerde periodes worden gemiddeld.

		De verschillen tussen 00-02, 96/97-92/93 worden bepaald. De waarden worden vermenigvuldigd met 62/14 om de concentratie in NO_3 uit te drukken. Als het absolute verschil groter is dan 1 mg/l (NO_3) of 5 µg/l (chlorofyl) wordt een toename of afname gerapporteerd.
6	**Uncertainty**	In de rapportage worden in de tabellen enkel percentages van aantallen meetlocaties gepresenteerd. Deze zijn gebaseerd op de volgens het rekenschema berekende gegevens. De gepresenteerde figuren zijn resultaat van samenvoeging van veel locaties en berekening volgens dezelfde methodiek. Er is geen betrouwbaarheid bij berekend. Verder zijn de gepresenteerde nutriënt waarden niet gecorrigeerd voor verschillen in zoutgehalten (zie Paragraaf 7.1) en is voor de uiteindelijke berekeningen gebruik gemaakt van een voorselectie en controle slag aan de hand van een zogenaamde plausibiliteit instrument (Meer informatie bij Basisinfodesk van het RIKZ in productcatalogus Basisinformatie Nat, 2003).
7	**Input…output**	Invoer: DONAR-bestanden Berekeningsmethode: DONBAT, Excel Resultaat: Twee tekstbestanden voor mediaan en maximum van NO3 en Chlorofyl met acht kolommen: locatienaam, omschrijving, waarde 92/93, 96/97 en 2000/2002, verandering (de laatste 3 eerst voor Average daarna voor maximum)
8	**Remarks**	
9	**References**	- Achtergrondnota Toekomst voor Water. Rijkswaterstaat. Rapport RIKZ-96.030, ISBN 90 369 50341. - Beleidsanalyse watersysteemverkenningen, Eutrofiëring zoute wateren, methodiek en resultaten van de thema-analyse. M.W.M. van der Tol. Werkdocument RIKZ/OS-97.149X. - Productcatalogus Basisinformatie Nat. 168 pp, Augustus 2003, ISBN 90 369 34478 - Report OSPAR Intersessional Working Group on the Common Procedure, 13-14 April 2000.