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

Water quality in the Netherlands; *status (2012-2015) and trend (1992-2015)*

Addendum to report 2016-0019

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Synopsis

Water quality in the Netherlands; status (2012-2015) and trend (1992-2015)
Addendum to report 2017-0019

Nitrogen and phosphorus are essential substances in manure used at farms to improve production. Nevertheless, too much nitrogen or phosphorus is harmful because the surplus can leach as a result of which the quality of ground and surface waters deteriorates. Too high concentrations in surface waters may cause, for example, algal blooms. The concentrations of nitrogen and phosphorus in ground and surface waters in 2015 are comparable with those in 2012-2014.

This overview is a supplement to the overview published in 2016. In 2016, the concentrations in 2012-2014 and the trend in the period 1992-2014 were considered. The conclusions drawn in 2016 do not change when adding the 2015 data.

The research is carried out by RIVM in co-operation with Rijkswaterstaat Water, Traffic and Environment (RWS/WVL) and the knowledge institute Deltares. This addendum has been pledged to the European Union. This addendum will also be used for the negotiations about the sixth Nitrate Directive Action Programme and the prolongation of the derogation for the period 2018-2021.

Keywords: nitrates directive, water quality, nitrate, eutrophication

Publiekssamenvatting

Waterkwaliteit in Nederland; toestand (2012-2015) en trend (1992-2015)
Addendum bij rapport 2016-0019

Stikstof en fosfaat zijn essentiële stoffen in mest die landbouwbedrijven gebruiken om de productie van gewassen te bevorderen. Te veel stikstof en fosfaat is echter schadelijk omdat het teveel kan uitspoelen waardoor de kwaliteit van het grond- en oppervlaktewater slechter wordt. Te hoge concentraties in het oppervlaktewater kunnen bijvoorbeeld algenbloei veroorzaken. De concentraties van stikstof en fosfaat in het grond- en oppervlaktewater in 2015 zijn vergelijkbaar met die in de jaren 2012-2014. Dit blijkt uit een inventarisatie van de grond- en oppervlaktewaterkwaliteit in 2015.

De inventarisatie is een aanvulling op de inventarisatie die in 2016 is gerapporteerd. In 2016 is gekeken naar de concentraties in 2012-2014 en de ontwikkeling in de periode 1992-2014. Door de cijfers over 2015 toe te voegen, ontstaan geen andere conclusies.

De aanvullende inventarisatie is uitgevoerd door het RIVM met Rijkswaterstaat Water, Verkeer en Leefomgeving (RWS/WVL) en Deltares. Deze aanvulling op het eerdere rapport is toegezegd aan de Europese Commissie. Dit addendum dient mede voor de onderhandelingen over het zesde Nederlandse Nitraatrichtlijnactieprogramma en een derogatie voor de periode 2018-2021.

Kernwoorden: nitraatrichtlijn, waterkwaliteit, nitraat, eutrofiëring

Contents

Summary

Introduction
This report is an addendum to the report about the status and trend in agricultural practise and water quality in the Netherlands (also known as the nitrate report) published in 2016. The later report was part of the Netherlands Member State reporting under Article 10 of the Nitrates Directive which reported water quality data up to and including 2014. The current report (addendum) is limited to ground and surface water quality. Data for 2015 for these waters are added in order to report about the water quality status for the 2012-2015 period and the trend in the 1992-2015 period. This addendum has been pledged to the European Commission in the framework of an inquiry the Commission has started as a consequence of the exceedance of the phosphorus ceiling laid down in the current derogation decision. The addendum will also be used for the negotiations about the sixth Nitrate Directive action programme and the prolongation of derogation for the period 2018-2021.

Groundwater
Nitrate concentrations in groundwater at all depths were practically the same in 2015 and in 2014. The nitrate concentrations in groundwater under agricultural land in the Sand region are clearly higher than under other forms of land use in this region, especially in the case of shallow groundwater (5-15 m below surface level). The effect of agriculture on concentrations in groundwater deeper than 5 m below surface level in the Clay and Peat regions is small, because the largest part of the precipitation surplus, with nutrients, is drained to regional surface water by surface drains, subsurface drains and ditches.

The nitrate concentration in shallow groundwater under agricultural land in the Sand region reached its highest level in 1996 (46 mg/L), about ten year after the peak value of the nitrogen surplus in 1985. Thereafter, the nitrate concentration decreased to 32 mg/l in 2015. In groundwater at a depth of 15-30 m below surface level the nitrate concentration is lower than in shallow groundwater. This is due to mixing and decomposition of nitrate (denitrification) during downward transport. Nitrate concentrations are higher in groundwater under agricultural land than under nature areas. Concentration in deeper groundwater under agricultural land in the Sand region decreased between 2002 and 2015 from 10 mg/L to 7 mg/L.

Fresh surface waters
Winter average nitrate concentrations in fresh surface waters were practically the same in 2015 and in 2014. There were small differences in concentrations between types of fresh waters. In 2015, the nitrate concentrations in agriculture-specific waters as well as in WFD waters – regional and national waters designated for the Water Framework Directive – were below 15 mg/l in winter, i.e. the leaching season. This is a decrease compared with the winter average nitrate concentrations in fresh surface waters in the early nineties when concentrations; then concentrations were about 30 mg/L for agriculture-specific waters and about 20 mg/L for WFD waters. This decrease occurs in agriculture-

specific waters as well as WFD waters. Nitrate concentrations in fresh waters are below the EU standard of 50 mg/L, but this standard aims to protect drinking water resources and is not normative for the status of good water quality as defined by the WFD or to prevent waters to become eutrophic. Sixty percent of the fresh water is eutrophic and over 25 percent of the water is not eutrophic.

Since the ninety nineties the concentrations of the parameters indicative for eutrophication in fresh waters in summer, such as total nitrogen, total phosphorus and chlorophyll a, decreased. However, the summer average nitrogen, phosphorus and chlorophyll concentrations did not change or hardly changed between the 2008-2011 and the 2012-2015 period.

Marine waters
The winter average nitrate concentrations in marine water were practically the same in 2015 as in previous years. The nitrate concentrations in coastal waters and open sea are stable and concentrations are 2.3 mg/L in coastal waters and 1.2 mg/L in open sea. The nitrate concentration in transitional waters showed a similar trend as fresh waters and decreased from about 13 mg/L in the early ninety nineties to 8.3 mg/L in 2015.

The summer average chlorophyll concentrations in transitional waters further decreased to 5.6 µg/L in 2015. In coastal waters and open sea, concentrations are more or less stable compared with previous years and are 8.6 and 3.6 µg/L, respectively, in 2015.

The trend in the chlorophyll concentrations in marine waters is similar to the trend in fresh waters, i.e. a clear decrease between the 1992-1995 period and the 2008-2011 period and almost no change between the 2008-2011 period and the 2012-2015 period.

Conclusions
Nutrient concentration in ground and surface waters in 2015 hardly differed from those in the 2012-2014 period. Therefore, the conclusions published in the 2016 nitrate report based on the 2012-2014 period are also valid for the 2012-2015 period.

Nitrogen and phosphate surpluses in Dutch agriculture increased in the period 1950 to 1987. Since 1987, the Netherlands has been successfully reducing them. The nitrate concentration in on farm groundwater and surface waters has decreased, and the quality of the surface waters in the Netherlands has improved. This is a result of measures taken in Dutch agriculture on account of the EU Nitrates Directive, such as using less manure and for a shorter time each year.

The nitrate concentrations in the water that leaches from the root zone of land on farms in the Sand and Clay Regions were lower in the period 2012-2014 than in the previous period, 2008-2011. The nitrate concentrations in the groundwater have been stable since 1992 (Clay and Peat Regions) or falling (Sand Region). Despite improvements in water quality, nitrate concentrations higher than 50 mg/l are still occurring in 2012-2015, mainly in the Sand and Loess Regions.

Moreover, 60 percent of the fresh surface waters are eutrophic, which means that the biology of the water is not at the desired level. Slightly more than a quarter of fresh water is non-eutrophic, and a small portion is potentially eutrophic because its biological status is good but the nutrient concentrations do not meet the WFD water quality standards for the various waters. Slightly more than 10 percent of marine waters are eutrophic. Nutrient concentrations (dissolved nitrogen) are too high in over 80 percent of marine waters, as a result of which these waters can be classified as potentially eutrophic.

The expectation is that water quality will improve in the first five years following full implementation of the Fifth Action Programme (2014-2017), owing to the measures that have been and are being taken during this Action Programme, and those taken in previous programmes. It will probably take a few more decades before policies will be fully reflected by the nitrate concentration in deep groundwater. Concerning eutrophication, the quality of fresh and marine water is expected to stabilise or improve slightly in the near future.

Samenvatting

Inleiding
Dit rapport is een addendum bij het in 2016 gepubliceerde rapport over de toestand en trend van de landbouwpraktijk en waterkwaliteit in Nederland (ook bekend als de nitraatrapportage). Dat rapport was onderdeel van de Nederlandse landenrapportage in het kader van artikel 10 van de Nitraatrichtlijn, waarin de waterkwaliteitscijfers tot en met 2014 zijn gerapporteerd. Het voorliggende rapport (addendum) beperkt zich tot de kwaliteit van grond- en oppervlaktewater. Voor deze wateren zijn de cijfers van 2015 verwerkt, zodat nu de toestand voor de periode 2012-2015 is geschetst en de trend voor de periode 1992-2015. Deze aanvulling op het eerdere rapport is toegezegd aan de Europese Commissie in het kader van het onderzoek dat de Commissie is gestart naar aanleiding van het overschrijden van het fosfaatplafond zoals vastgelegd in de huidige derogatiebeschikking. Het addendum dient mede ten behoeve van de onderhandelingen over het zesde Nederlandse Nitraatrichtlijnactieprogramma en een derogatie voor de periode 2018-2021.

Grondwater
De nitraatconcentraties in het grondwater waren in 2015 nagenoeg gelijk aan die in 2014 voor alle meetdiepten. De nitraatconcentraties in het grondwater onder landbouwgronden in de Zandregio zijn duidelijk hoger dan onder andere vormen van landgebruik in deze regio, vooral bij het ondiepe grondwater (5-15 meter beneden maaiveld). De invloed van de landbouw op de concentratie in het grondwater dieper dan 5 m beneden maaiveld in de Klei- en Veenregio is klein omdat de meeste neerslag, met nutriënten daarin opgenomen, via drainagebuizen, greppels en sloten wordt afgevoerd naar het regionale oppervlaktewater.

De nitraatconcentratie in het ondiepe grondwater onder landbouwgronden in de Zandregio bereikte de hoogste concentratie in 1996 (46 mg/l), ongeveer tien jaar na de piek in het stikstofoverschot (1985). Sindsdien is de gemiddelde nitraatconcentratie in het grondwater op deze diepte gedaald tot 32 mg/l in 2015. In het grondwater op een diepte van 15-30 meter is de nitraatconcentratie lager dan in het ondiepe grondwater. Dit is een gevolg van mengen en afbraak tijdens het neerwaartse transport. De nitraatconcentratie onder landbouwgronden is hoger dan onder natuurgebieden. De nitraatconcentratie in het grondwater op 15-30 m onder landbouwgronden in de Zandregio is vanaf 2002 gedaald van 10 mg/l tot 7 mg/l in 2015.

Zoet oppervlaktewater
De wintergemiddelde nitraatconcentraties in het zoete oppervlaktewater waren in 2015 nagenoeg gelijk aan die in 2014. Er waren kleine verschillen tussen de verschillende typen wateren. De nitraatconcentraties lagen in 2015 voor zowel de landbouwspecifieke oppervlaktewateren als de KRW-wateren (regionale en rijkswateren aangewezen voor de Kaderrichtlijn Water) in de winter, dit is het uitspoelingsseizoen, gemiddeld lager dan 15 mg/l. Dit is een daling ten

opzichte van de wintergemiddelde nitraatconcentraties begin jaren negentig voor de zoete oppervlaktewateren; te weten rond de 30 mg/l voor de landbouwspecifieke wateren en rond de 20 mg/l voor de KRW-wateren. De nitraatconcentraties liggen weliswaar onder de EU-norm van 50 mg/l, maar die norm is bedoeld voor de bescherming van het drinkwater en is niet maatgevend voor de na te streven goede waterkwaliteit binnen de KRW en het voorkomen van eutrofiëring van wateren. Van de zoete wateren is 60% eutroof en iets meer dan een kwart van de wateren is niet-eutroof.

Ook de concentraties van andere eutrofiëringsparameters in de zoete wateren, zoals totaal-fosfor, totaal-stikstof en chlorofyl-a, zijn sinds de jaren negentig gedaald. Echter, in de laatste rapportageperiode (2012-2015) zijn de zomergemiddelde stikstof-, fosfor- en chlorofyl-concentraties niet of nauwelijks veranderd ten opzichte van de periode daarvoor (2008-2011).

Zout oppervlaktewater
De wintergemiddelde nitraatconcentraties in het zoute oppervlaktewater waren in 2015 nagenoeg gelijk aan die in voorgaande jaren. De nitraatconcentraties in de kustwateren en open zee zijn stabiel en bedragen respectievelijk 2,3 mg/l in de kustwateren en 1,2 mg/l in de open zee. De nitraatconcentraties in de overgangswateren volgen de daling in de zoete wateren. De nitraatconcentratie daalde van circa 13 mg/l begin jaren negentig tot 8,3 mg/l in 2015.

De zomergemiddelde chlorofylconcentraties zijn in de overgangswateren in 2015 ten opzichte van 2014 verder gedaald tot 5,6 µg/l. Voor de kustwateren (8,5 µg/l) en open zee (3,3 µg/l) zijn de concentraties min of meer stabiel ten opzichte van voorgaande jaren.

De trends in de chlorofylconcentraties voor de kustwateren en open zee zijn hetzelfde als voor de zoete wateren; een duidelijke afname tussen 1992-1995 en 2008-2011 en een nagenoeg onveranderde situatie in 2012-2015 vergeleken met 2008-2011. Daarentegen is voor de overgangswateren een vergaande daling in de chlorofylconcentraties zichtbaar in de laatste periode.

Conclusies
De nutriëntenconcentraties in het grond- en oppervlaktewater in 2015 verschillen niet of nauwelijks van die in de andere jaren van de periode 2012-2015. Daarom zijn de conclusies uit de nitraatrapportage verschenen in 2016, gebaseerd op de 2012-2014 periode ook geldig voor de periode 2012-2015.

Sinds 1987 heeft Nederland de groei van het stikstof- en fosfaatoverschot in de Nederlandse landbouw die plaats heeft gevonden in de periode 1950-1987, weten om te zetten in een afname. De nitraatconcentraties in het water op landbouwbedrijven zijn gedaald en de kwaliteit van het oppervlaktewater is verbeterd. Dit is een gevolg van maatregelen die vanwege de Europese Nitraatrichtlijn in de Nederlandse landbouw zijn genomen, zoals een verminderd gebruik van mest en een inperking van de periode waarin mest mag worden toegepast.

De nitraatconcentraties in het water dat uitspoelt uit de wortelzone van percelen bij landbouwbedrijven in de Zand- en Kleiregio waren lager in de periode 2012-2015 dan in de voorgaande periode 2008-2011. De nitraatconcentraties in het grondwater zijn sinds 1992 stabiel (Klei- en Veenregio) of dalend (Zandregio). Ondanks de verbeteringen in de waterkwaliteit komen in 2012-2015 vooral de Zand- en de Lössregio nog nitraatconcentraties voor hoger dan 50 mg/l. Bovendien is 60% van de zoete oppervlaktewateren eutroof, dat wil zeggen dat de biologie van het water niet op het gewenste niveau is. Iets meer dan een kwart van de zoete wateren is niet-eutroof, en een klein deel is potentieel eutroof doordat de biologische toestand goed is, maar de nutriëntenconcentraties niet voldoen aan de KRW-waterkwaliteitsnormen voor de verschillende wateren. Van de zoute wateren is iets meer dan 10% eutroof. De nutriëntenconcentraties (opgelost stikstof) zijn in ruim 80% van de zoute wateren te hoog, waardoor deze wateren als potentieel eutroof kunnen worden aangemerkt.

De waterkwaliteit zal naar verwachting verbeteren in de eerste vijf jaar volgend op volledige uitvoering van het vijfde actieprogramma (2014-2017) dankzij de maatregelen die zijn en worden getroffen tijdens dit actieprogramma en die zijn getroffen gedurende eerdere programma's. Waarschijnlijk zal het nog enkele decennia duren voordat effecten op de nitraatconcentratie in het diepe grondwater volledig zichtbaar worden. Wat de eutrofiëring betreft, wordt een stabiele situatie tot een lichte verbetering van de waterkwaliteit van de zoete en zoute wateren in de nabije toekomst verwacht.

1 Introduction

This report is an addendum to the report published in 2016 about the status and trend in the agricultural practice and water quality in the Netherlands (Fraters et al., 2016). That report was part of the Dutch Member States report within the framework of Article 10 of the Nitrate Directive. It contained details on the status of the quality of the ground and surface water for the period 2012-2014 as well as the trend in the quality for the period 1992-2014. This current report (addendum) includes the figures for 2015, thereby outlining the status for the period 2012-2015 and the trend for the period 1992-2015. We have committed to submitting this supplement to the earlier report to the European Commission within the framework of the investigation that the Commission has started in response to the exceeding of the phosphate ceiling as laid down in the current Delegation Decision. The addendum is also intended to assist the negotiations about the sixth Dutch Nitrates Directive Action Programme and a derogation for the period 2018-2021.

The addendum is limited to the updating of the data for ground and surface water (sections 5, 6 and 7 in the 2016-report). Together with the 2016 report the addendum constitutes a single report. The data from the Minerals Policy Monitoring Programme [Landelijk Meetnet effecten Mestbeleid], used to report on the effects of the action programme on agricultural practice and the nitrate leaching (chapter 4 in the 2016 report), was already nearly complete in 2016. Only the figures for 2015 for the loess region were missing, but these were included in the report on the Evaluation of the Fertiliser Act [Meststoffenwet] 2016.

For background information regarding the reason and the purpose of the report, please refer to chapter 1 of the 2016 report (Fraters et al., 2016). The 2016 report describes the structure of the monitoring programmes in chapter 2, the developments in the regulation of fertilisers and the developments in agricultural practice are described in chapter 3, the effects of the action programme on the nitrate leaching in conjunction with agricultural practice are described in chapter 4 and the prognoses as regards the development of the water quality in the future are described in chapter 8.

Apart from the addition of the measurement results from 2015, a number of improvements have also been made (see Annex 1).

2 Groundwater quality

2.1 Introduction

This chapter is an update of chapter 5 of the report published in 2016 about the status and trend in agricultural practice and water quality in the Netherlands (Fraters et al., 2016).

The nitrate concentration in groundwater in the Netherlands shows a wide variation, both between different locations and in terms of depth. The variation between locations is partially accounted for by the variation in land use and differences in the nitrogen load of the soil. Other causes are the variations in the net precipitation, the soil type and the geohydrological characteristics of the aquifers (see also chapter 4 in Fraters et al., 2016).

In general the nitrate concentration is low in groundwater under peat and clay soils and relatively high under sandy soils (Van Vliet et al., 2010, Reijnders et al., 2004). Agriculture is a significant source of nitrogen in groundwater. As a consequence the nitrate concentration under agricultural land is higher than under soil used for other purposes. In general terms the nitrate concentration decreases proportionally to the depth at which the groundwater is sampled. This is caused by the reduction in the nitrate concentration during transport (reduction of nitrate due to denitrification), the mixing of water of different ages and the lateral transport of groundwater due to the presence of poorly draining layers which partially or completely inhibit downward movement.

The average nitrate concentrations per soil type region (abbreviated hereafter to region) and land use measured in 2015 are almost the same everywhere as those measured in 2014.

This chapter comprises three parts. Each part deals with one of the depths at which the Dutch groundwater is monitored: 5-15 m, 15-30 m and more than 30 m. In the case of the first two depth levels an assessment is made of all the groundwater, as per the Water Framework Directive (WFD), and specifically the groundwater under agricultural land. This is not possible for the deepest groundwater (> 30 m) because the information in question concerns drinking water extraction sites where the land use is mixed.

2.2 Nitrate in groundwater at a depth of 5-15 metres

In the period between 1984 and 1996 the nitrate concentration in groundwater for agricultural land in the Netherlands at a depth of 5-15 m below ground level increased from 24 to 28 mg/l in 1996 (Figure 2.1), approximately 10 years after the peak in the nitrogen surplus on the national nitrogen balance. After 1996 the nitrate concentration fell and the average concentration in 2014 (with the exception of 2008) is the lowest of the series at 19 mg/l. The nitrate concentration in 2015 is more or less the same as that in 2014 (Figure 2.1). With regard to other land use (for example orchards and urban areas) the concentration in 2015 had dropped to the level of before 2012. The high concentrations in other years were almost all caused by very high concentrations at a single monitoring site.

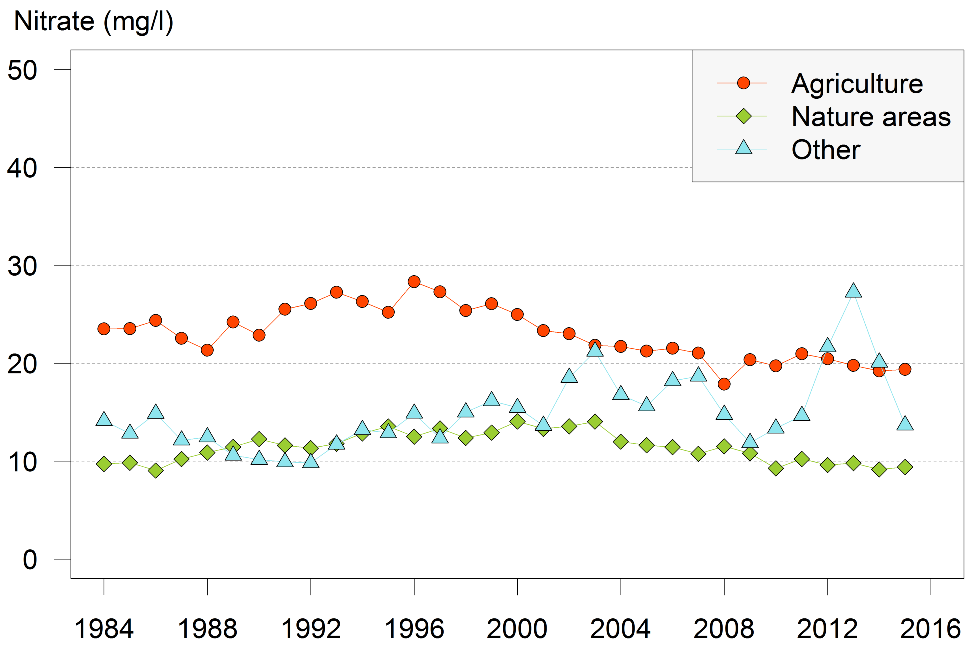


Figure 2.1 Average annual nitrate concentration (mg/l) in groundwater in the Netherlands at a depth of 5-15 m below ground level per type of land use

The nitrate concentration in groundwater originating from agriculture in the Sand Region (30 to 45 mg/l) was higher than in the clay (< 10 mg/l) and Peat Region (< 5 mg/l) (Figure 2.2). Before 1992 the concentrations in the agricultural areas were generally lower than 40 mg/l, while the concentrations in the period 1992-2000 fluctuated between 42 and 47 mg/l. Since 2001 the average nitrate concentration has remained lower than 40 mg/l and declined gradually to 32 mg/l in 2014.

The nitrate concentrations under agricultural land in 2015 scarcely differed per region from the concentrations in the previous year (Figure 2.2). The same applies for the nitrate concentrations per area in the Sand Region (Figure 2.5).

In the period 2012-2015, 13% of the monitoring sites under agricultural land recorded a nitrate concentration higher than the EU standard of 50 mg/l (Table 2.1). As was the case in 2016 this was reported for the period 2012-2014 as being 1% point more than in the previous period (2008-2011). The percentage in 2015 is slightly lower than in 2014 (Figure 2.3 and Figure 2.4). Consequently, the tendency for the percentage of monitoring sites to keep increasing above the EU standard under agriculture in the Sand Region since 2005 does not appear to be continuing.

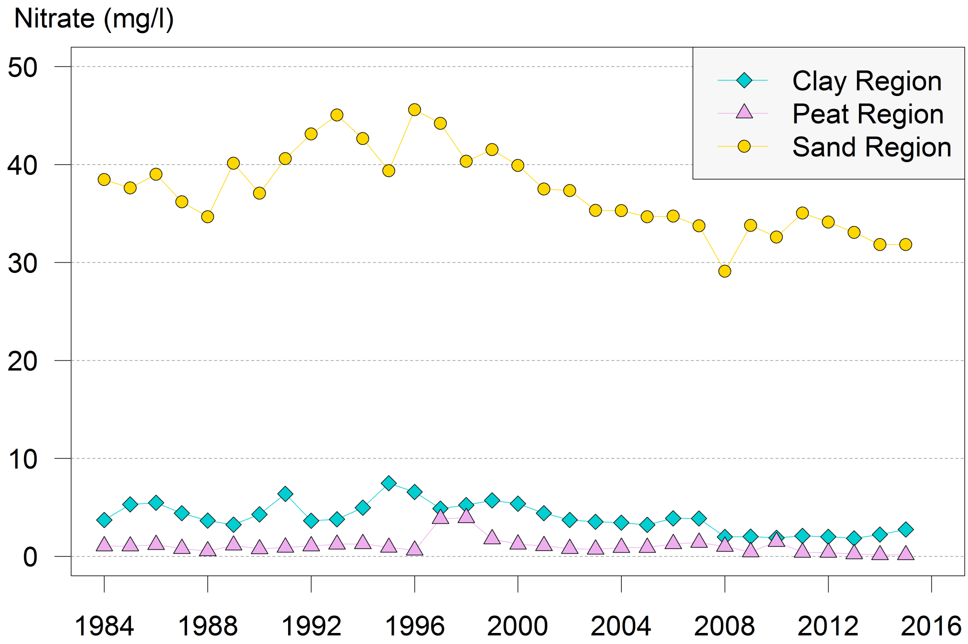


Figure 2.2 Average annual nitrate concentration (mg/l) in groundwater in agricultural areas at a depth of 5-15 m below ground level per region

Table 2.1 Percentage of monitoring sites in groundwater at a depth of 5-15 m per nitrate concentration class in the various reporting periods[1]

Nitrate class (NO_3 mg/l)	All monitoring sites			Monitoring sites in agricultural areas		
	'92-'95	'08-'11	'12-'15	'92-'95	'08-'11	'12-'15
0-15 mg/l	79	82	82	80	82	84
15-25 mg/l	4	3	3	2	3	0
25-40 mg/l	2	4	3	0	2	2
40-50 mg/l	3	0	2	2	0	1
> 50 mg/l	13	11	11	16	12	13
Number of monitoring sites	347	347	347	219	219	219

1 The total percentage may be higher or lower than 100 due to rounding off.

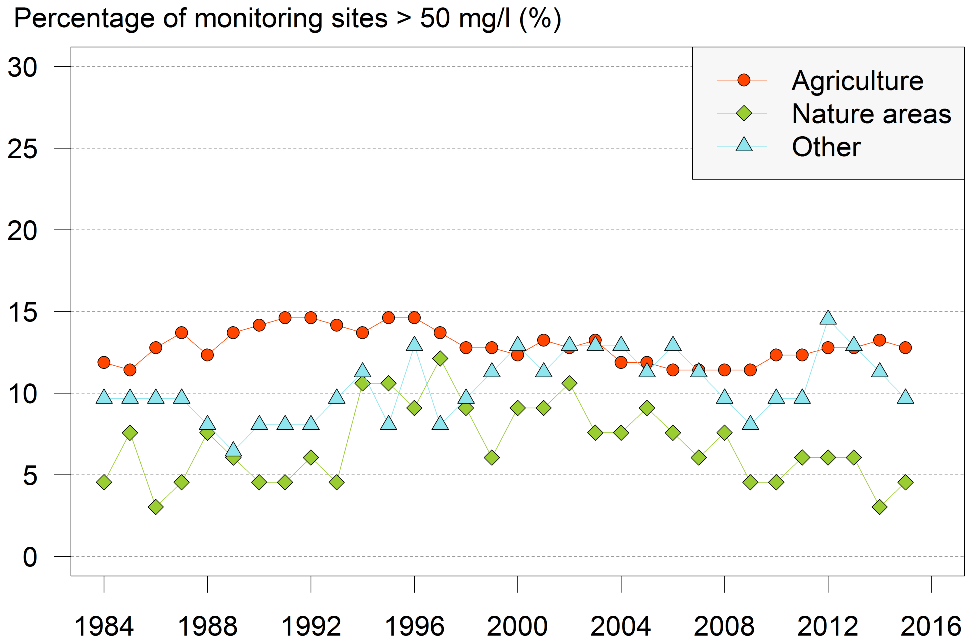


Figure 2.3 Exceedance of the EU standard of 50 mg/l for nitrate in groundwater at a depth of 5-15 m below ground level per type of land use

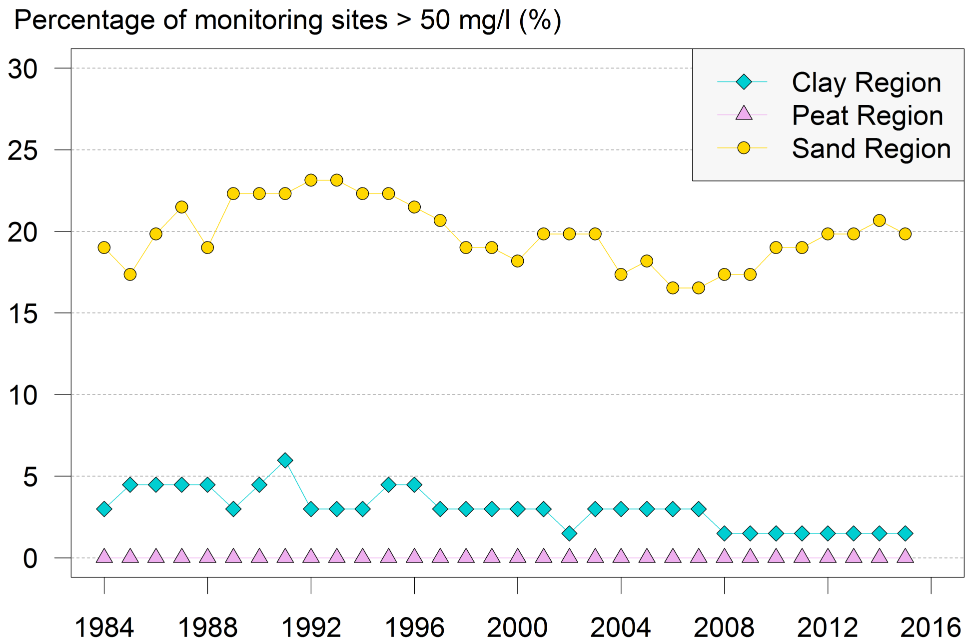


Figure 2.4 Exceedance of the EU standard of 50 mg/l for nitrate in groundwater in agricultural areas at a depth of 5-15 m below ground level per region

In the case of the majority of the sites under agricultural land, the nitrate concentrations between 2008 and 2015 are stable (75%; Table 2.2), 10% show a rising concentration and 14% a decreasing concentration. The figures do not differ from those reported in 2016 for the period 2008-2014.

Table 2.2 Percentage of monitoring sites in groundwater at a depth of 5-15 m with increasing or decreasing nitrate concentrations between various reporting periods[1]

Change (NO_3)	All monitoring sites		Monitoring sites in agricultural areas	
	‘92-‘95/ ‘08-‘11	‘08-‘11/ ‘12-‘15	‘92-‘95/ ‘08-‘11	‘08-‘11/ ‘12-‘15
Large increase (% > 5 mg/l)	7	9	5	9
Small increase (% 1-5 mg/l)	4	3	3	1
Stable (% ± 1 mg/l)	67	73	74	75
Small decrease (% 1-5 mg/l)	4	6	2	5
Large decrease (% > 5 mg/l)	18	9	16	9
Number of monitoring sites	347	347	219	219

1 The total percentage may be higher or lower than 100 due to rounding off.

Of the three sand areas (North, Central and South), the nitrate concentration is clearly highest in Sand South (around 75 mg/l) (Figure 2.5). The concentration is lower in Sand Central (approximately 17 mg/l) and is lowest in Sand North (approximately 12 mg/l). In Sand North and Sand Central the majority of the monitoring sites revealed little nitrate (Table 2.3). In these areas the concentration is determined by a small number of sites with increased nitrate concentrations. In Sand South there are approximately just as many monitoring sites with low concentrations as sites with nitrate concentrations higher than 15 mg/l. Other soil types are found in the sand areas because an area consists of subareas in which sandy soil is the most important soil type but is usually not the only soil type. If only the monitoring sites with sandy soils are selected, the nitrate concentrations are slightly higher. The area Sand South also has the largest number of monitoring sites where the EU standard is exceeded (Figure 2.6).

Table 2.3 Number of monitoring sites per nitrate concentration class for agriculture in the Sand Region per sand area at a depth of 5-15 m for the period 2012-2015

Nitrate class (NO_3 in mg/l)	Sand North	Sand Central	Sand South
< 1 mg/l	32	27	17
1 to 15 mg/l	3	3	5
15 to 25 mg/l	0	0	0
25 to 40 mg/l	1	1	1
40 to 50 mg/l	0	0	2
> 50 mg/l	6	6	13
Total number of monitoring sites	42	37	37

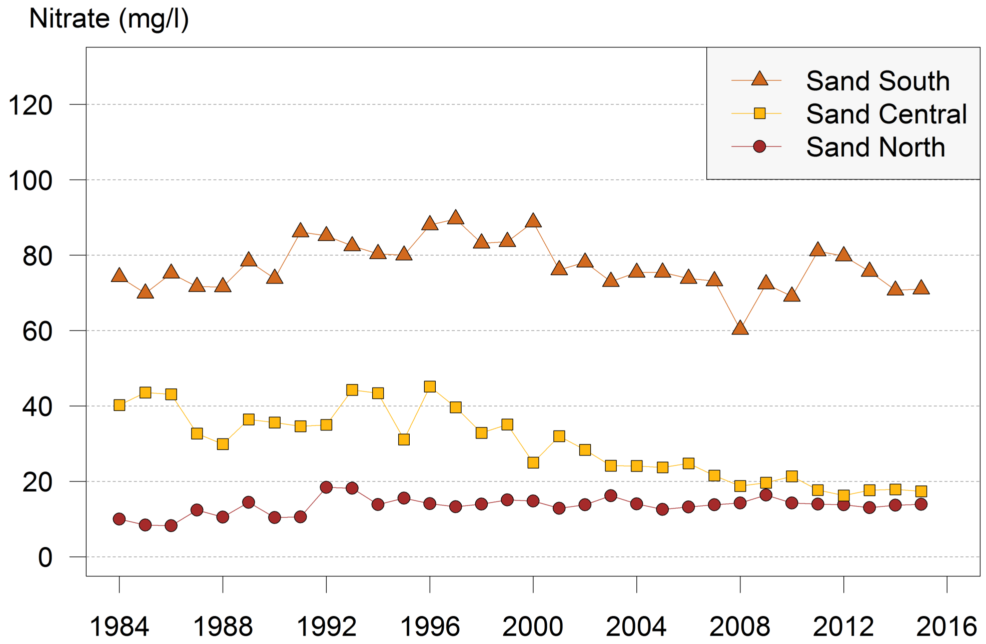


Figure 2.5 Nitrate in groundwater under agricultural land at a depth of 5-15 m below ground level per sand area

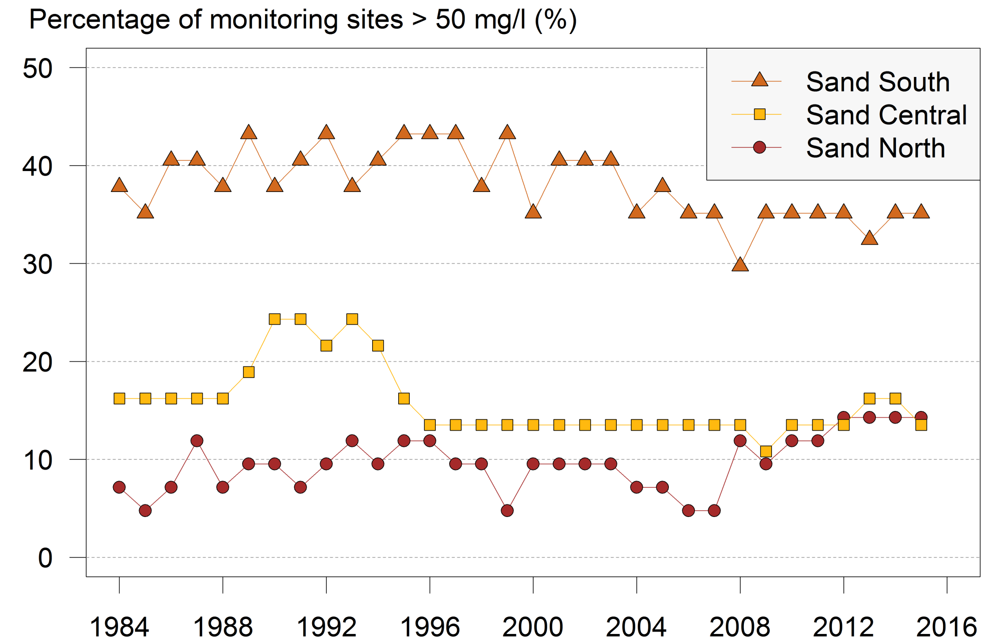
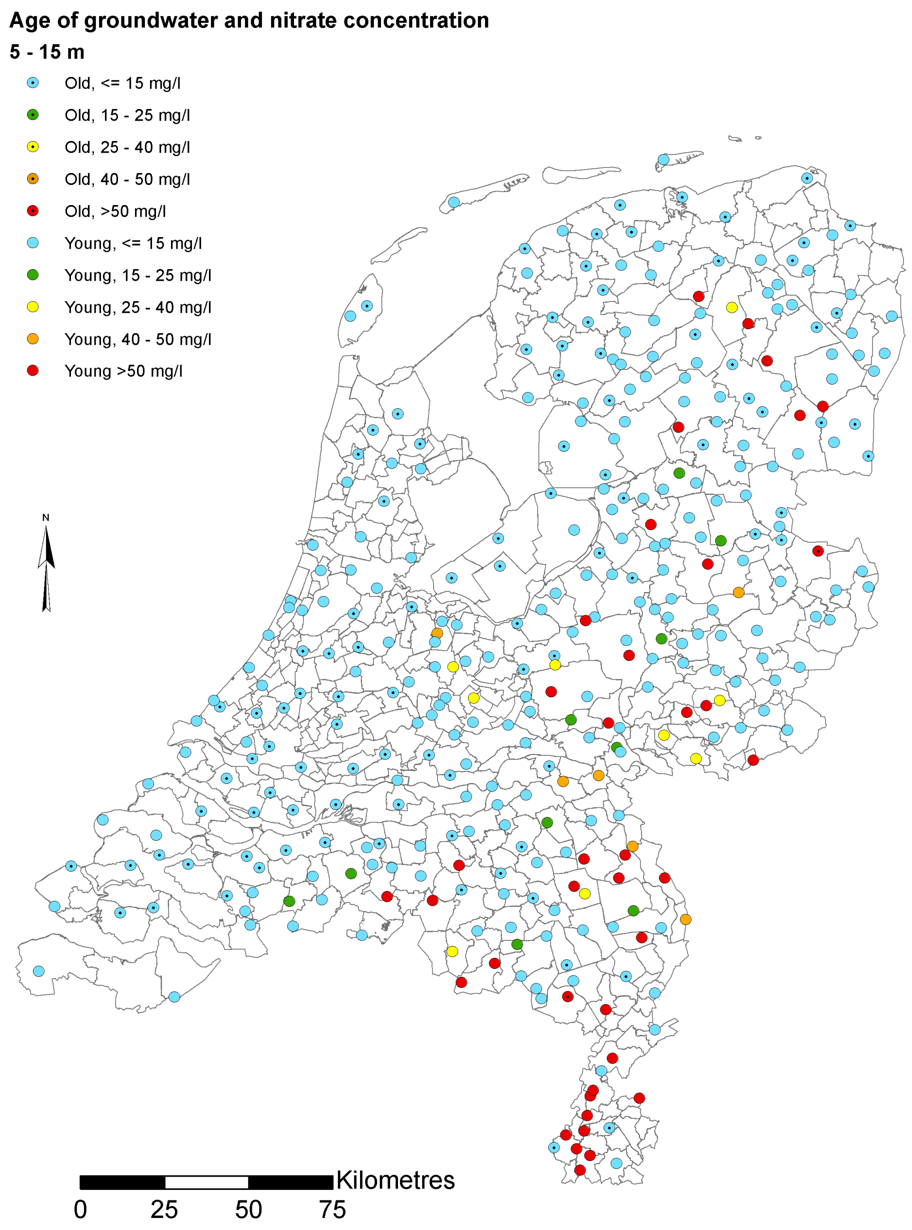


Figure 2.6 Exceedance of the EU standard of 50 mg/l for nitrate in groundwater under agricultural land at a depth of 5-15 m below ground level per sand area

The monitoring sites can be subdivided into those with wells with old (> 25 years) and young (< 25 years) groundwater (Map 2.1). In the wells with old groundwater there is generally water from artesian aquifers, as a result of which the nitrate concentrations are low (< 15 mg/l), while the wells with young groundwater contain water from phreatic layers which are affected by activities at ground level. High nitrate concentrations (> 50 mg/l) are found in young groundwater in the Sand and Loess Region (in the east and south of the Netherlands).

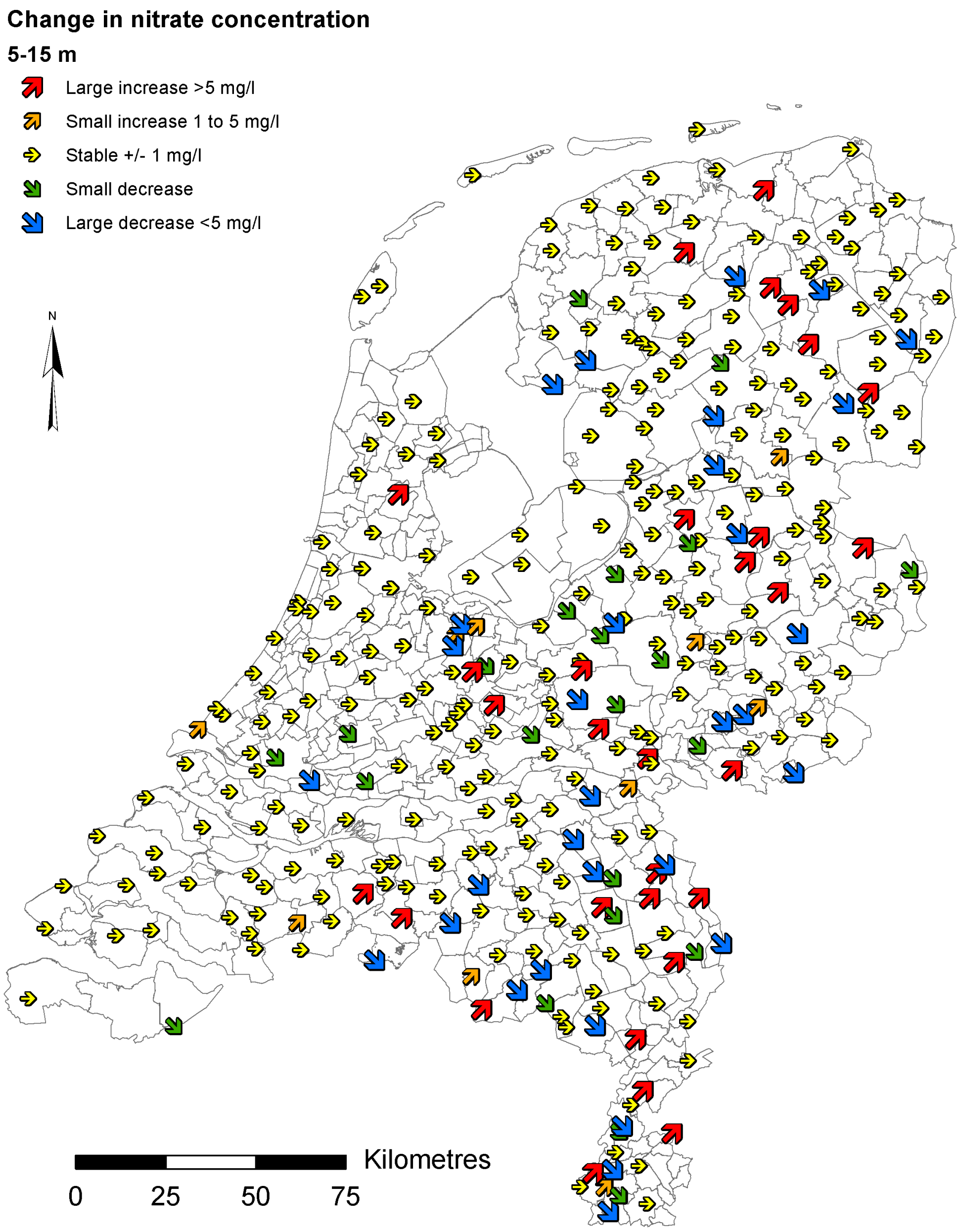
The majority of changes occur in the Sand and Loess Region (Map 2.2). Increases and decreases in the nitrate concentrations were both observed.

The map images are more or less the same as reported in 2016 for the period 2012-2104 instead of the current period 2012-2015.



Map 2.1 Average nitrate concentration in groundwater at a depth of 5-15 m for the period 2012-2015.

Young means groundwater which is no more than 25 years old. Old means older than 25 years.



Map 2.2 Change in the average nitrate concentration in groundwater at a depth of 5-15 m for the period 2008-2015.

Change is shown as the difference between the averages of the period 2008-2011 and the period 2012-2015.

2.3 Nitrate in groundwater at a depth of 15-30 metres

Nitrate concentration at the monitoring sites between 15 and 30 m below ground level the is lower than at the sites between 5 and 15 m. Up until 1998 the nitrate concentration was highest under agricultural land, followed by other land use and nature (Figure 2.7). Since 1998 the nitrate concentration in the case of other land use has been increasing significantly, meaning that it has been also increased more than in the agricultural areas. These higher values are caused by a low nitrate concentration having been found at a single monitoring site up to and including 1998 (varying from 0 to 6 mg/l), although 202 mg/l was measured in 1999. During the measurement period this concentration increased to 388 mg/l in 2014. The increase in the nitrate concentration in the other group is determined entirely by this one monitoring site. If this is ignored, the nitrate concentration is more or less stable at around 5 mg/l as was the case in the period before 1999.

The nitrate concentration in 2015 was more or less the same as in previous years (Figure 2.7). The same applies to the concentrations under agriculture per region (Figure 2.8).

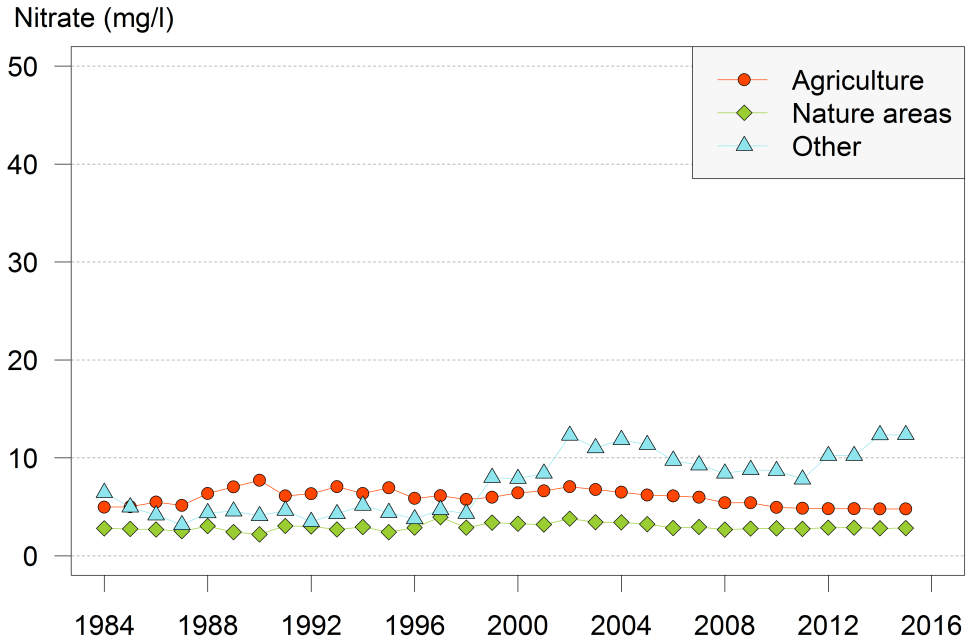


Figure 2.7 Average annual nitrate concentration (mg/l) in groundwater at a depth of 15-30 m below ground level per type of land use

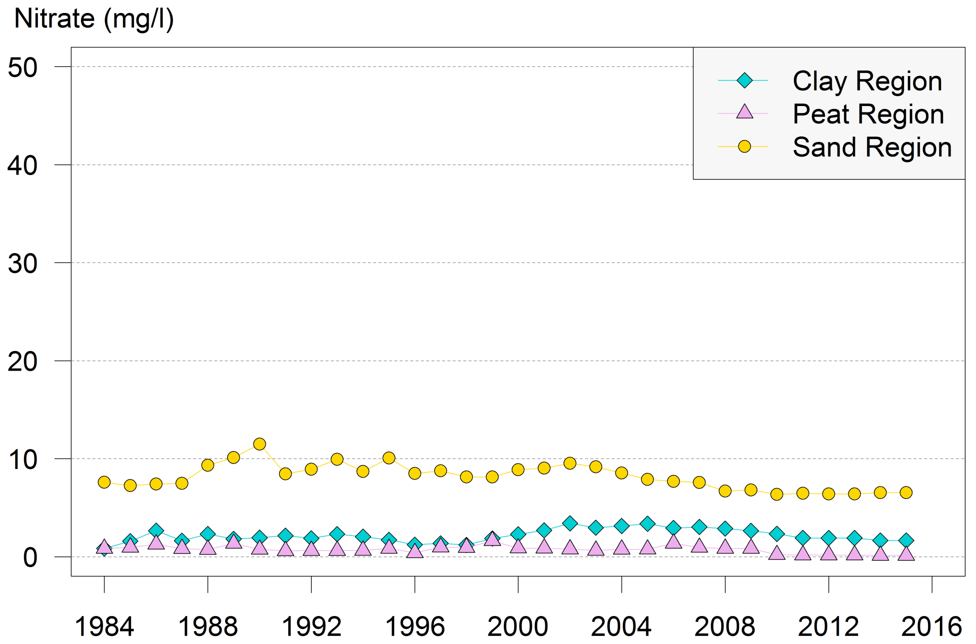


Figure 2.8 Average annual nitrate concentration (mg/l) in groundwater in agricultural areas at a depth of 15-30 m below ground level per region

The percentage of sites with a nitrate concentration higher than the EU standard was equal in 2015 to that of 2014 (Figure 2.9 and Figure 2.10) and was ≤ 5% in all situations.

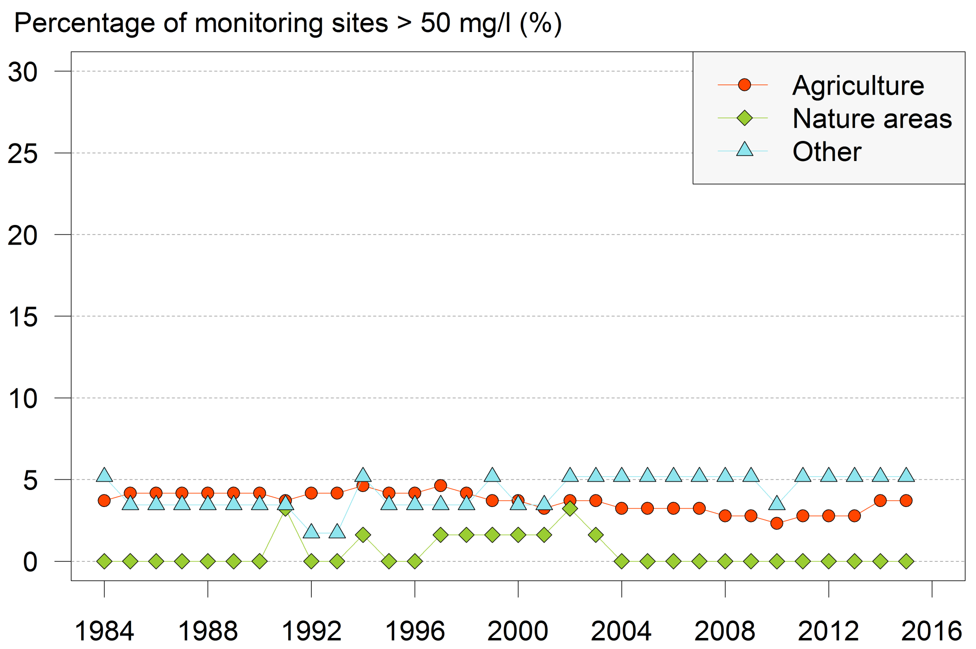


Figure 2.9 Exceedance of the EU standard of 50 mg/l for nitrate in the groundwater at a depth of 15-30 m below ground level per type of land use

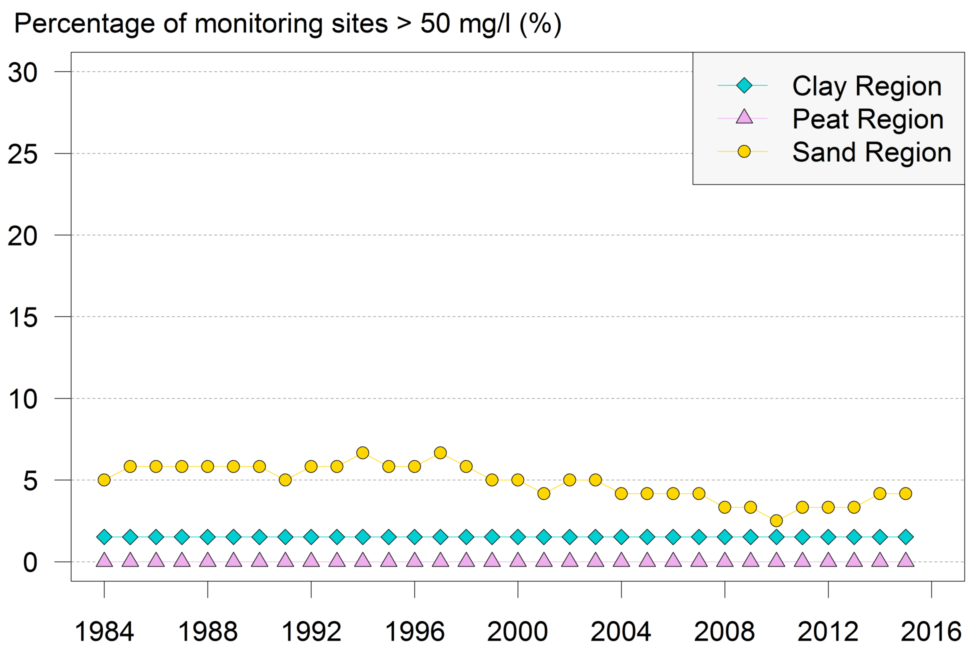


Figure 2.10 Exceedance of the EU standard of 50 mg/l for nitrate in the groundwater under agricultural areas at a depth of 15-30 m below ground level per region

The percentage of sites which exceed the nitrate standard under agricultural land amount to 3% in both the period 2008-2011 and in the period 2012-2015. For both periods this is (rounded off) 1% point higher than reported in 2016, because four sites with previously a different land use were classified as 'agriculture' after the whole 1984-2015 period had been checked.

Table 2.4 Percentage of monitoring sites in groundwater at a depth of 15-30 m per nitrate concentration class in the various reporting periods[1]

Nitrate class (NO_3 mg/l)	All monitoring sites			Monitoring sites in agricultural areas		
	'92-'95	'08-'11	'12-'15	'92-'95	'08-'11	'12-'15
0-15 mg/l	94	92	93	94	94	94
15-25 mg/l	1	2	1	0	1	1
25-40 mg/l	1	1	1	1	1	0
40-50 mg/l	1	2	2	0	1	1
> 50 mg/l	3	3	3	4	3	3
Number of monitoring sites	336	336	336	216	216	216

[1] The total percentage may be higher or lower than 100 due to rounding off.

The majority of monitoring sites (88%) did not display any change in the nitrate concentration between the two last reporting periods (2008-2011 and 2012-2014) (Table 2.5). The number of sites with a decrease between those two periods is slightly greater than the number of sites with an increase. This applies even more so to the agricultural areas: 2% of the monitoring sites exhibit an increase and 9% exhibit a decrease. Here too there are minor differences with the figures reported in 2016 due to reclassification of four monitoring sites.

Table 2.5 Percentage of monitoring sites in groundwater at a depth of 15-30 m with increasing or decreasing nitrate concentrations between various reporting periods[1]

Change (NO_3)	All monitoring sites		Monitoring sites in agricultural areas	
	'92-'95/ '08-'11	'08-'11/ '12-'15	'92-'95/ '08-'11	'08-'11/ '12-'15
Large increase (% > 5 mg/l)	7	3	5	2
Small increase (% 1-5 mg/l)	4	2	6	0
Stable (% ± 1 mg/l)	81	88	81	89
Small decrease (% 1-5 mg/l)	4	5	4	5
Large decrease (% > 5 mg/l)	4	3	4	4
Number of monitoring sites	336	336	216	216

1 The total percentage may be higher or lower than 100 due to rounding off.

Map 2.3 also shows that high nitrate concentrations were measured at more locations in Sand Central than in Sand North and Sand South. This map shows all the deep monitoring wells, therefore including the wells in the areas which are designated as nature and other land use, as well as the wells located on soil types other than sand.

In the sand areas, Sand North, Sand Central and Sand South, in contrast to the measurement results of the groundwater at 5-15 m-mv, the nitrate concentration in the deeper groundwater is highest in Sand Central (Figure 2.11). The average nitrate concentration at this depth in the sandy areas is determined entirely by a small number of monitoring wells where a high nitrate concentration was measured (Table 2.6), as a result of which chance (the choice of sites) may play a role. Nevertheless, there is a striking difference between the deep and shallow wells in Sand South, with almost half the shallow wells having a nitrate concentration in excess of 15 mg/l. In the deep wells in Sand South the same applies to just one monitoring site. The percentage of sites with a concentration in groundwater at 15-30 m above the EU standard of 50 mg/l is highest in Sand Central, at approximately 10% (Figure 2.12). This percentage is only slightly lower than in groundwater at 5-15 m (approximately 12%, see Figure 2.6). Things are different in Sand South where the standard is exceeded in approximately 35% of sites at 5-15 m and 3% at 15-30 m.

Van Vliet et al. (2010) also observed that the deeper groundwater in Sand South hardly exceeded the EU standard. What is more, the report by Van Loon and Fraters (2016) shows that the problems with nitrate due to fertiliser in drinking water sources primarily occur in Sand Central and not in Sand South. Map 2.7 shows that high maximum nitrate concentrations on sandy soil are primarily measured in Gelderland and Overijssel and less so in Noord-Brabant. According to Broers (2002) the oxidation of pyrite and the reduction of nitrate is the most likely explanation for low nitrate concentrations in the deeper groundwater of Noord-Brabant. Broers (2002) demonstrates that the substrate in Noord-Brabant contains more pyrite than in Drenthe. Presumably, the pyrite content in substrate of the Sand Central is also lower than in Sand South.

Table 2.6 Number of monitoring sites per nitrate concentration class for agriculture in the Sand Region per sand area at a depth of 15-30 m for the period 2012-2015

Nitrate class (NO_3 in mg/l)	Sand North	Sand Central	Sand South
< 1 mg/l	38	32	35
1 to 15 mg/l	1	1	0
15 to 25 mg/l	1	0	0
25 to 40 mg/l	0	0	1
40 to 50 mg/l	1	1	0
> 50 mg/l	1	3	0
Total number of monitoring sites	42	37	36

The monitoring sites at a depth of 15-30 m are subdivided into those with wells with old (> 25 years) and young (< 25 years) groundwater (Map 2.3). In the wells with old groundwater there is generally water from artesian aquifers, while the wells with young groundwater contain water from phreatic layers. High nitrate concentrations (> 50 mg/l) are found in young groundwater in sandy and loess soil (in the east and south of the Netherlands). Most changes in nitrate concentration between 2008-2011 and 2012-2015 occurred under sandy and loess soil (Map 2.4). Increases and decreases in the nitrate concentrations were both observed.

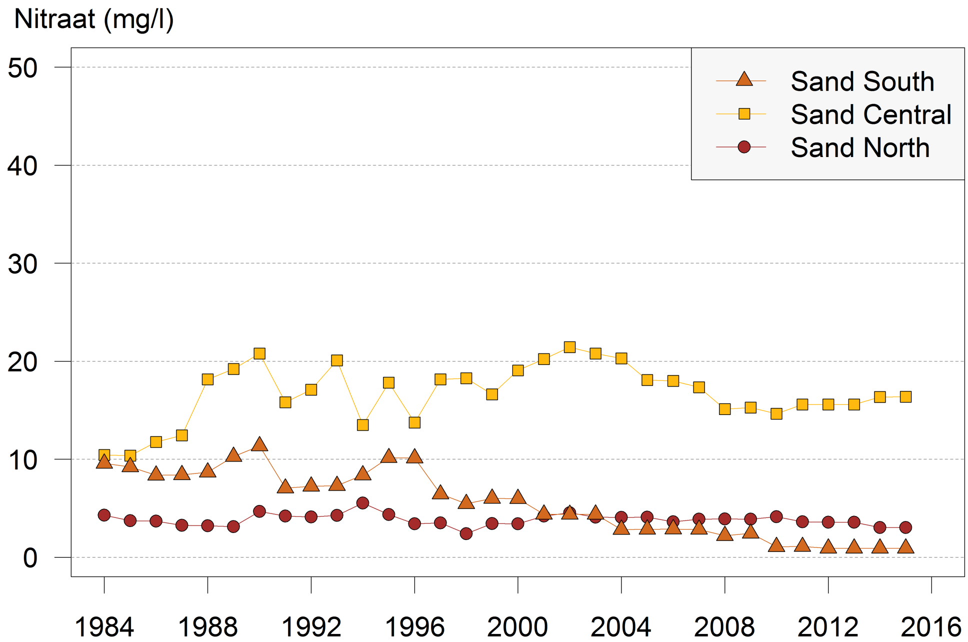


Figure 2.11 Nitrate in groundwater under agricultural land at a depth of 15-30 m below ground level per sand area

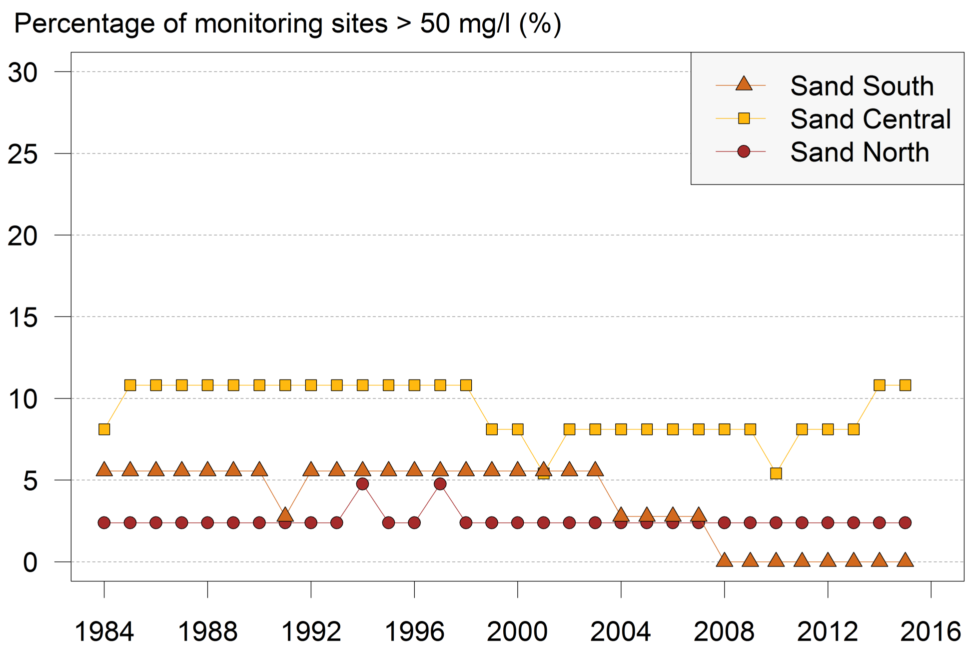
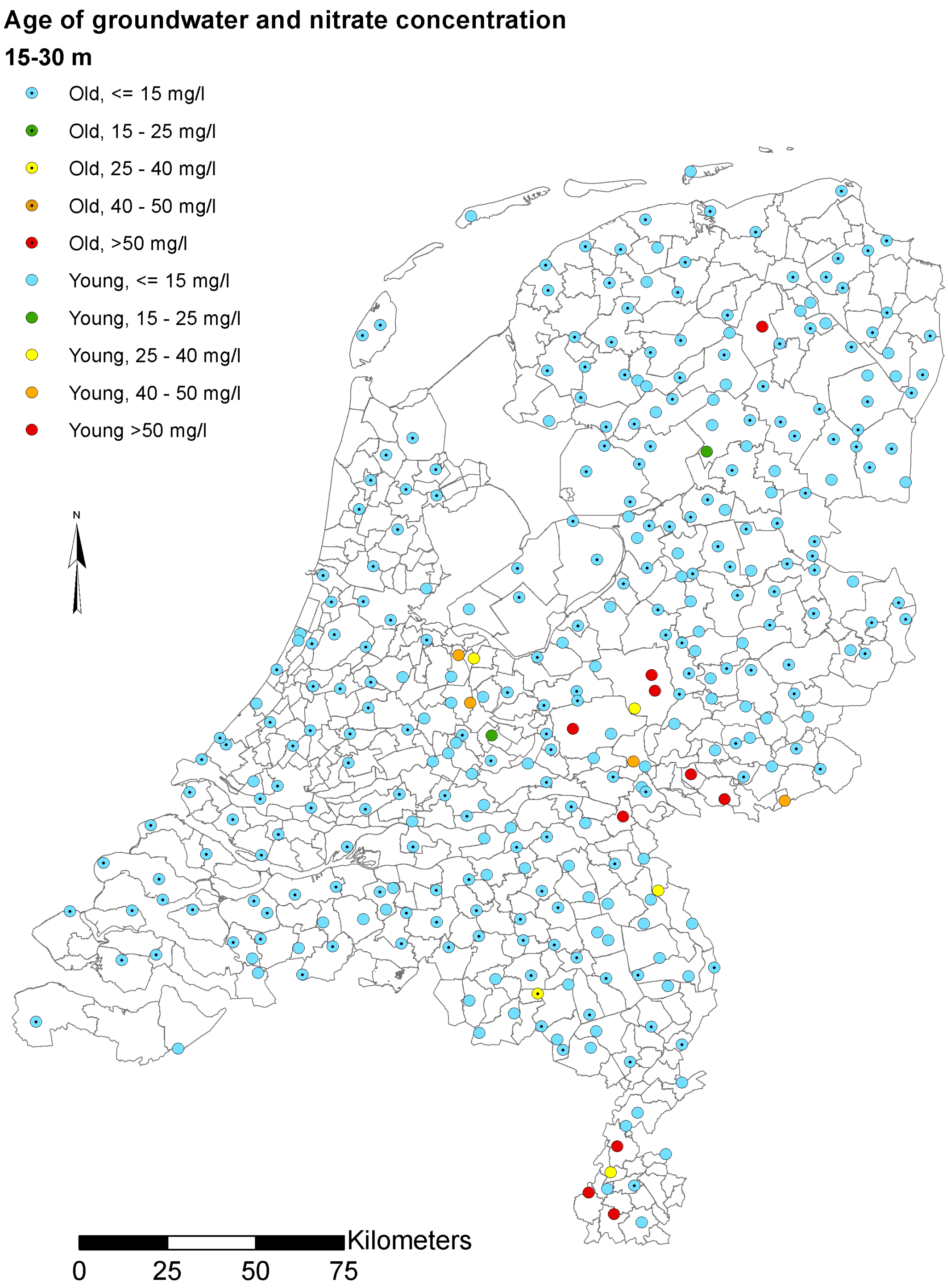
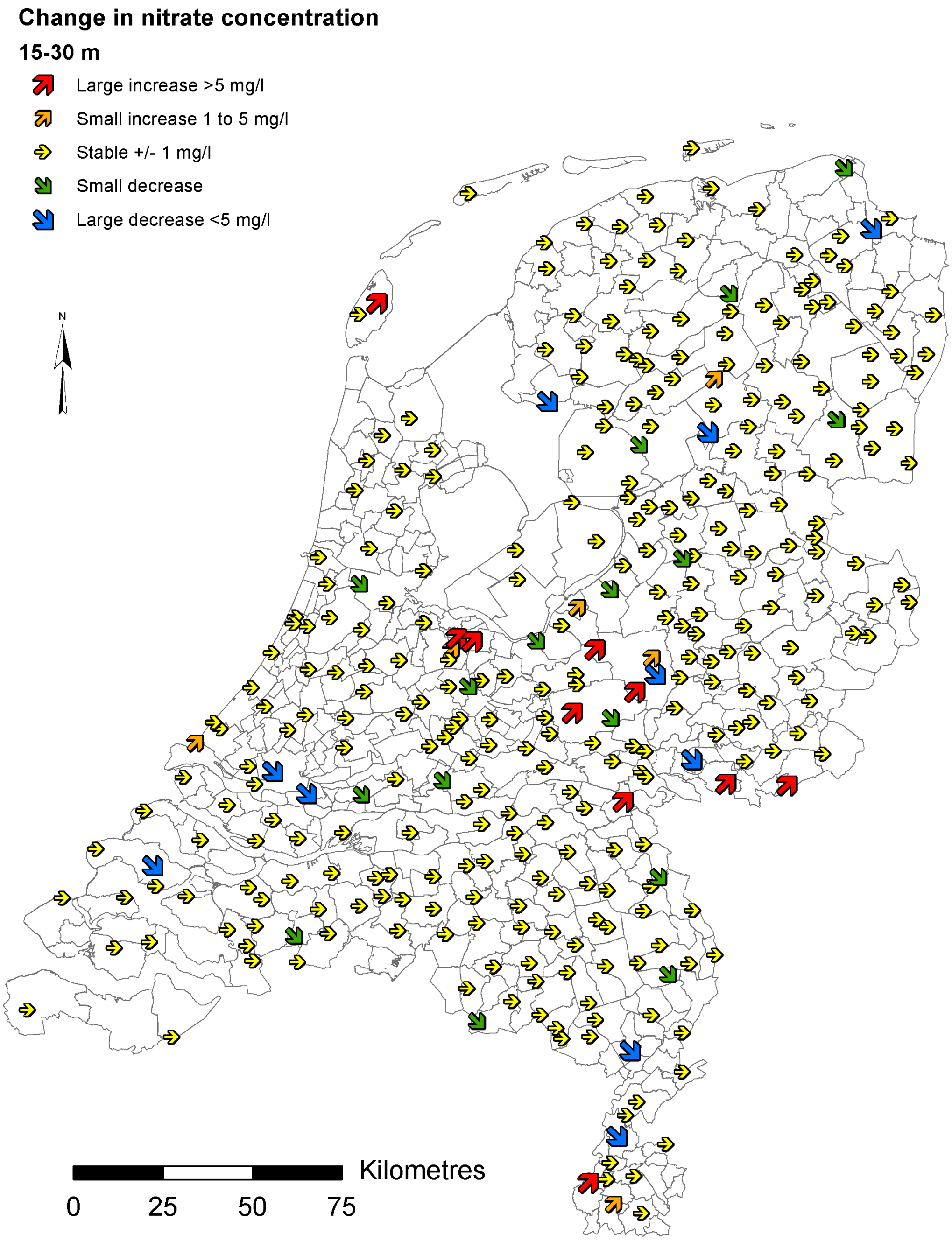


Figure 2.12 Exceedance of the EU standard of 50 mg/l for nitrate in groundwater under agricultural land at a depth of 15-30 m below ground level per sand area



Map 2.3 Average nitrate concentration in groundwater in the Netherlands at a depth of 15-30 m for the period 2012-2015.
Young means groundwater which is no more than 25 years old. Old means older than 25 years.



Map 2.4 Change in the average nitrate concentration in groundwater at a depth of 15-30 m for the period 2008-2015.

Change is shown as the difference between the averages of the period 2008-2011 and the period 2012-2015.

2.4 Nitrate in groundwater at a depth of more than 30 metres

In the period 2012-2015 the average nitrate concentration in groundwater used for the production of drinking water (raw water) is approximately 6.5 mg/l in phreatic aquifers and less than 1 mg/l in artesian aquifers. The nitrate concentration in 2015 is more or less the same as that in 2014.

The nitrate concentration in the raw water from phreatic groundwater increased slightly until 2003, followed by a decrease until 2006 (Figure 2.13). The nitrate concentration has been stable since 2006. As referred to in the 2016 report (Fraters et al., 2016), the nitrate concentration in the artesian groundwater increased by 1 mg/l between 2010 and 2011.

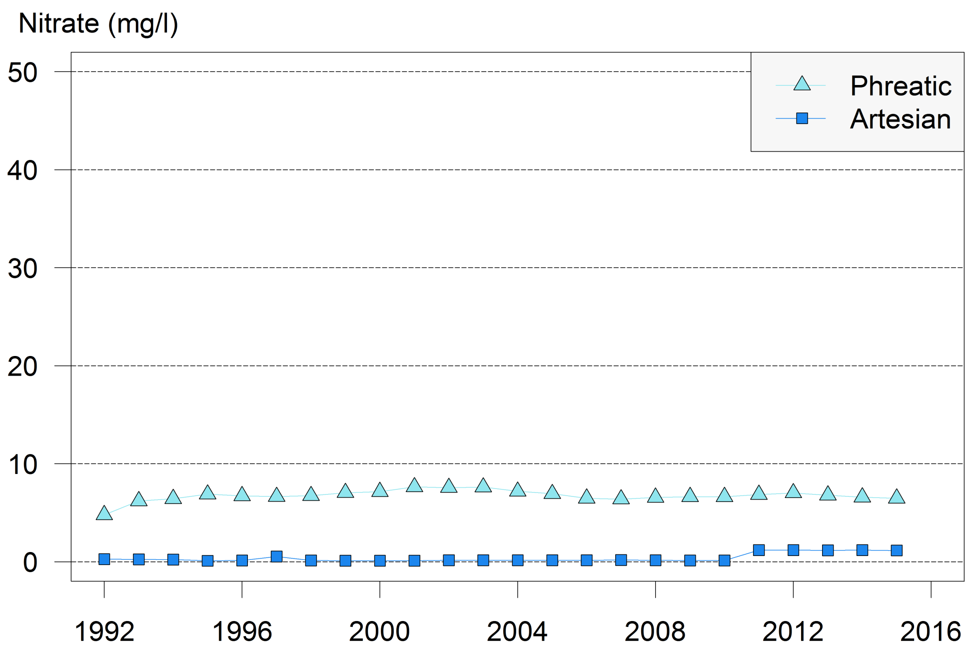


Figure 2.13 Average annual nitrate concentration (mg/l) in groundwater at drinking water production locations in phreatic and artesian aquifers

The percentage of monitoring sites at which the average nitrate concentration in the raw water was higher than 50 mg/l was smaller than 2% (Figure 2.14 and Table 2.7). The class of 40-50 mg/l is decreasing slightly and some lower classes are increasing as a result.

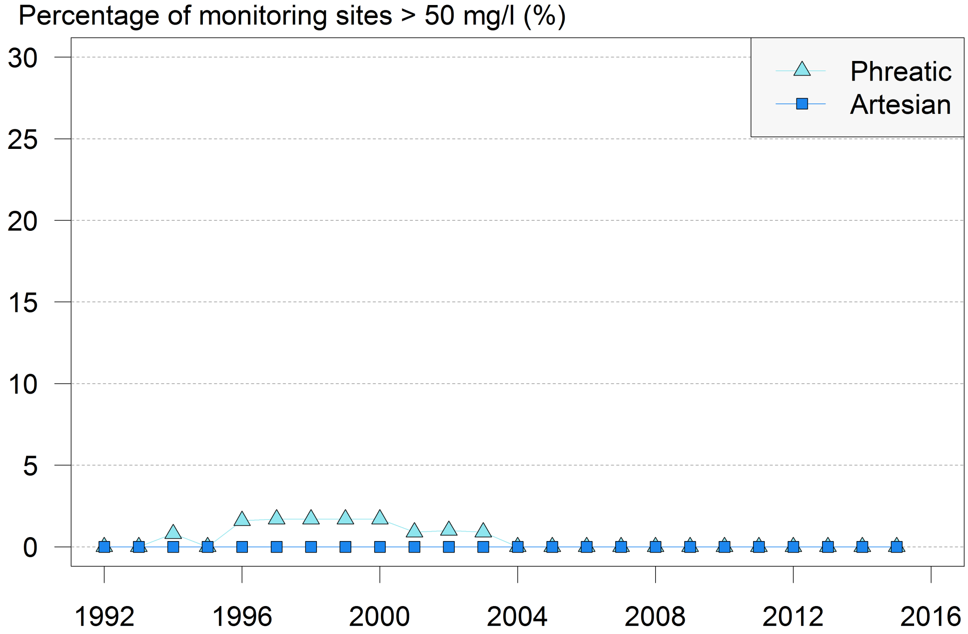


Figure 2.14 Exceedance of the EU standard of 50 mg/l for the average nitrate concentration in groundwater at drinking water production locations for phreatic groundwater and artesian groundwater. The degree to which the EU standard was exceeded is shown as the percentage of all production locations

Table 2.7 Percentage of monitoring sites in groundwater at a depth of more than 30 m per nitrate concentration class in the various reporting periods[1]

Nitrate class (NO_3 mg/l)	All production locations			Phreatic locations		
	'92-'95	'08-'11	'12-'15	'92-'95	'08-'11	'12-'15
0-15 mg/l	91	91	92	85	84	86
15-25 mg/l	5	5	6	9	9	11
25-40 mg/l	3	2	2	5	4	3
40-50 mg/l	0	2	0	1	3	0
> 50 mg/l	0	0	0	0	0	0
Number of locations	217	178	166	129	101	94

[1] The total percentage may be higher or lower than 100 in connection with the rounding off.

Between the two last periods there is a stable nitrate concentration at more than 70% of the monitoring sites and this applies to 67% of the phreatic monitoring sites (Table 2.8). What is striking is that there are more monitoring sites with an increase than with a decrease. This also has to do with the aforementioned slight but unexplained increase between 2010 and 2011 (Figure 2.13).

Table 2.8 Percentage of monitoring sites in groundwater at a depth of more than 30 m with increasing or decreasing nitrate concentrations between various reporting periods[1]

	All production locations		Phreatic locations	
Change (NO_3)	'92-'95/ '08-'11	'08-'11/ '12-'15	'92-'95/ '08-'11	'08-'11/ '12-'15
Large increase (% > 5 mg/l)	3	1	4	2
Small increase (% 1-5 mg/l)	11	20	18	19
Stable (% ± 1 mg/l)	77	72	62	67
Small decrease (% 1-5 mg/l)	7	5	13	8
Large decrease (% > 5 mg/l)	3	2	4	4
Number of locations	155	155	85	85

[1] The total percentage may be higher or lower than 100 in connection with the rounding off.

The EU standard of 50 mg/l was not exceeded in the drinking water supplied. In 2015 none of the 166 locations for drinking water production had a nitrate concentration of more than 50 mg/l. It should be noted that, if there is a risk of the 50 mg/l being exceeded at a certain location, boreholes are often sealed or mixed in such a way that the concentration is below 50 mg/l.

Maximum concentrations
In the period 2012-2015 the average nitrate concentration in groundwater used for the production of drinking water was approximately 9 mg/l in phreatic aquifers and less than 3 mg/l in artesian aquifers (Figure 2.15). The maximum nitrate concentration in the raw water from phreatic aquifers has remained constant during the last four years. The number of times that the EU standard was exceeded has decreased and in the period 2012-2015 there were no more maximum nitrate concentrations above the EU standard (Figure 2.16 and Table 2.9).

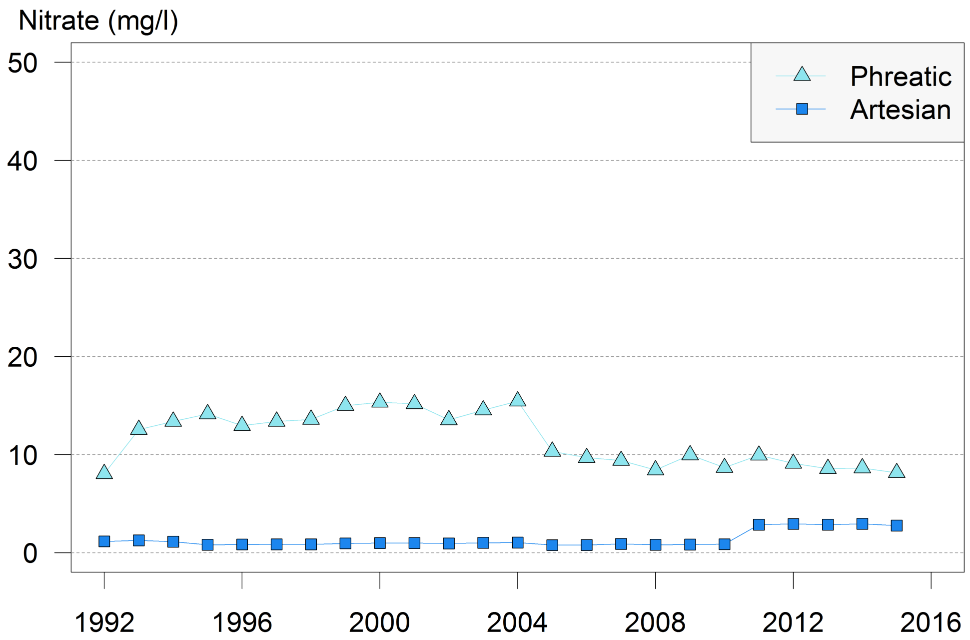


Figure 2.15 Maximum nitrate concentration (mg/l) in groundwater at drinking water production locations for phreatic groundwater and artesian groundwater

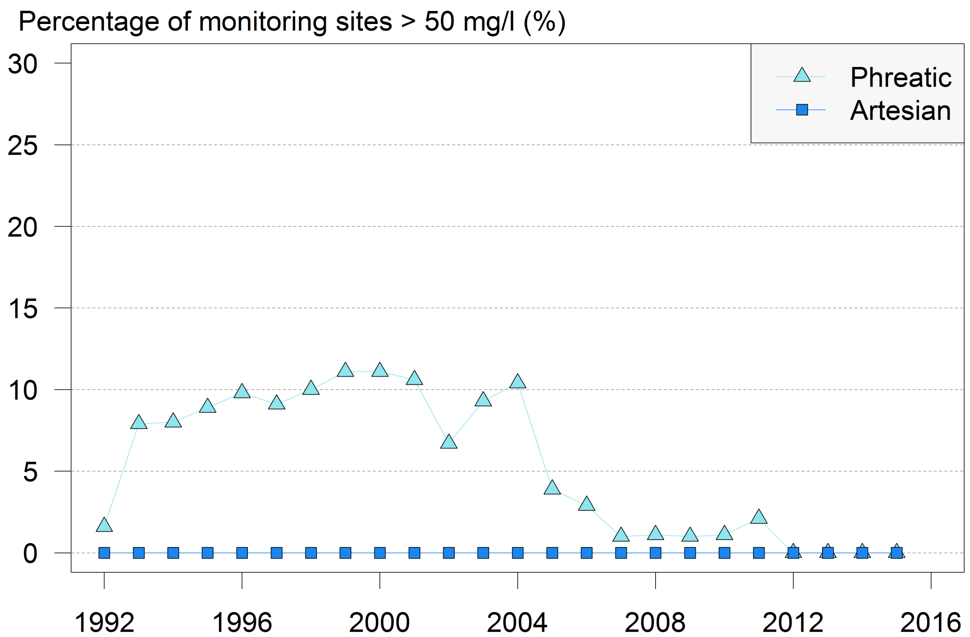


Figure 2.16 Exceedance of the EU standard of 50 mg/l for the maximum nitrate concentration in groundwater at drinking water production locations for phreatic groundwater and artesian groundwater. The degree to which the EU standard was exceeded is shown as the percentage of all production locations

Table 2.9 Percentage of monitoring sites in groundwater at a depth of more than 30 m per nitrate concentration class (maxima) in the various reporting periods1

Nitrate class (NO_3 mg/l)	All production locations			Phreatic locations		
	'92-'95	'08-'11	'12-'15	'92-'95	'08-'11	'12-'15
0-15 mg/l	84	85	87	75	74	77
15-25 mg/l	6	5	7	8	9	13
25-40 mg/l	5	5	4	9	9	6
40-50 mg/l	0	4	2	1	7	4
> 50 mg/l	5	1	0	8	1	0
Number of locations	217	178	166	129	101	94

1 The total percentage may be higher or lower than 100 in connection with the rounding off.

Between the two last periods there was a stable maximum nitrate concentration at approximately 50% of the monitoring sites (Table 2.10). 37% of the monitoring sites exhibited a small increase, while the number of sites with an increase is much bigger than the number of sites with a decrease. For phreatic monitoring sites the percentage of stable monitoring sites is 51%.

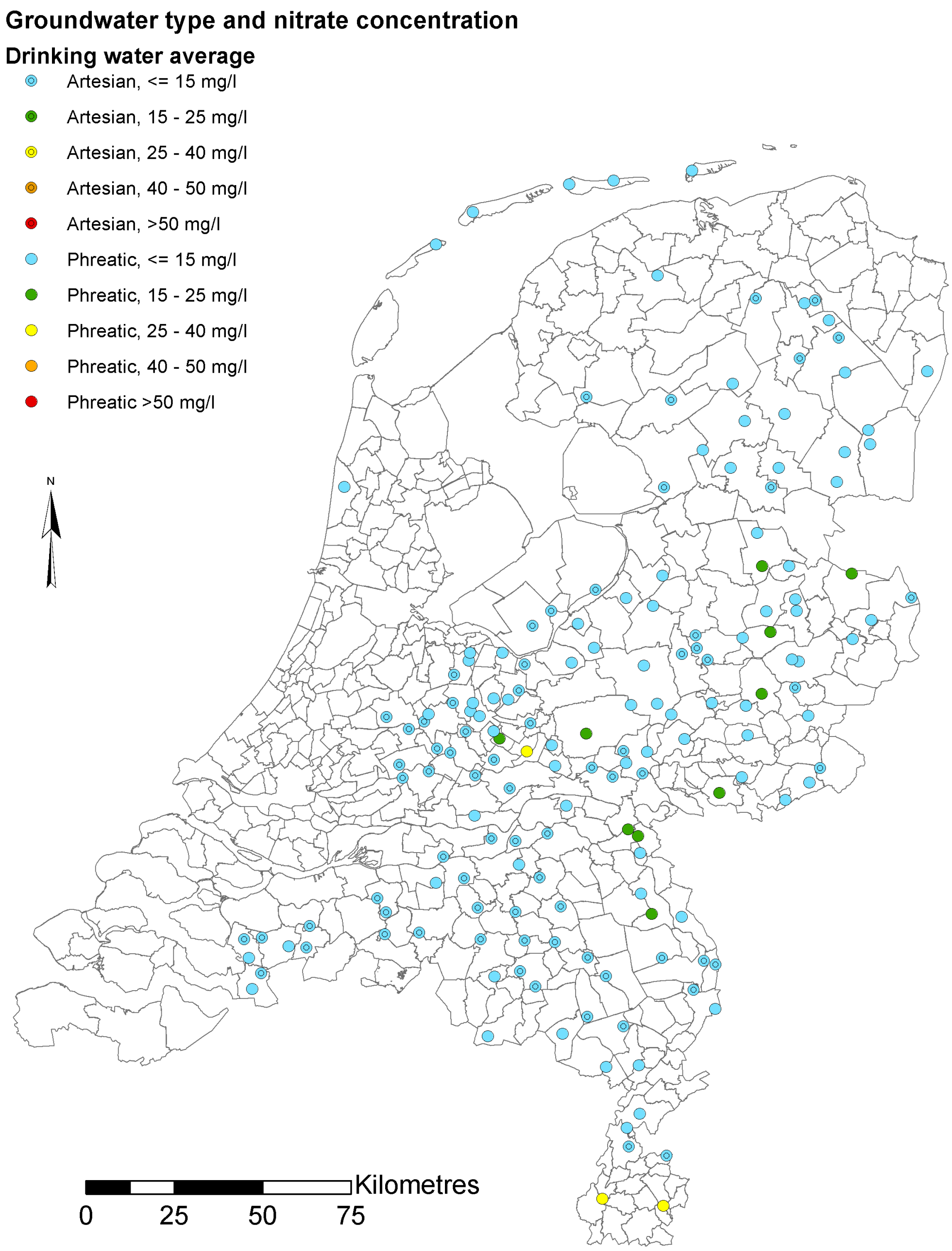
Table 2.10 Percentage of monitoring sites in groundwater at a depth of more than 30 m with increasing or decreasing maximum nitrate concentrations between various reporting periods[1]

	All production locations		Phreatic locations	
Change (NO_3 maximum)	'92-'95/ '08-'11	'08-'11/ '12-'15	'92-'95/ '08-'11	'08-'11/ '12-'15
Large increase (% > 5 mg/l)	4	6	7	7
Small increase (% 1-5 mg/l)	19	37	20	24
Stable (% ± 1 mg/l)	59	46	45	51
Small decrease (% 1-5 mg/l)	9	6	13	11
Large decrease (% > 5 mg/l)	9	5	15	8
Number of locations	155	155	85	85

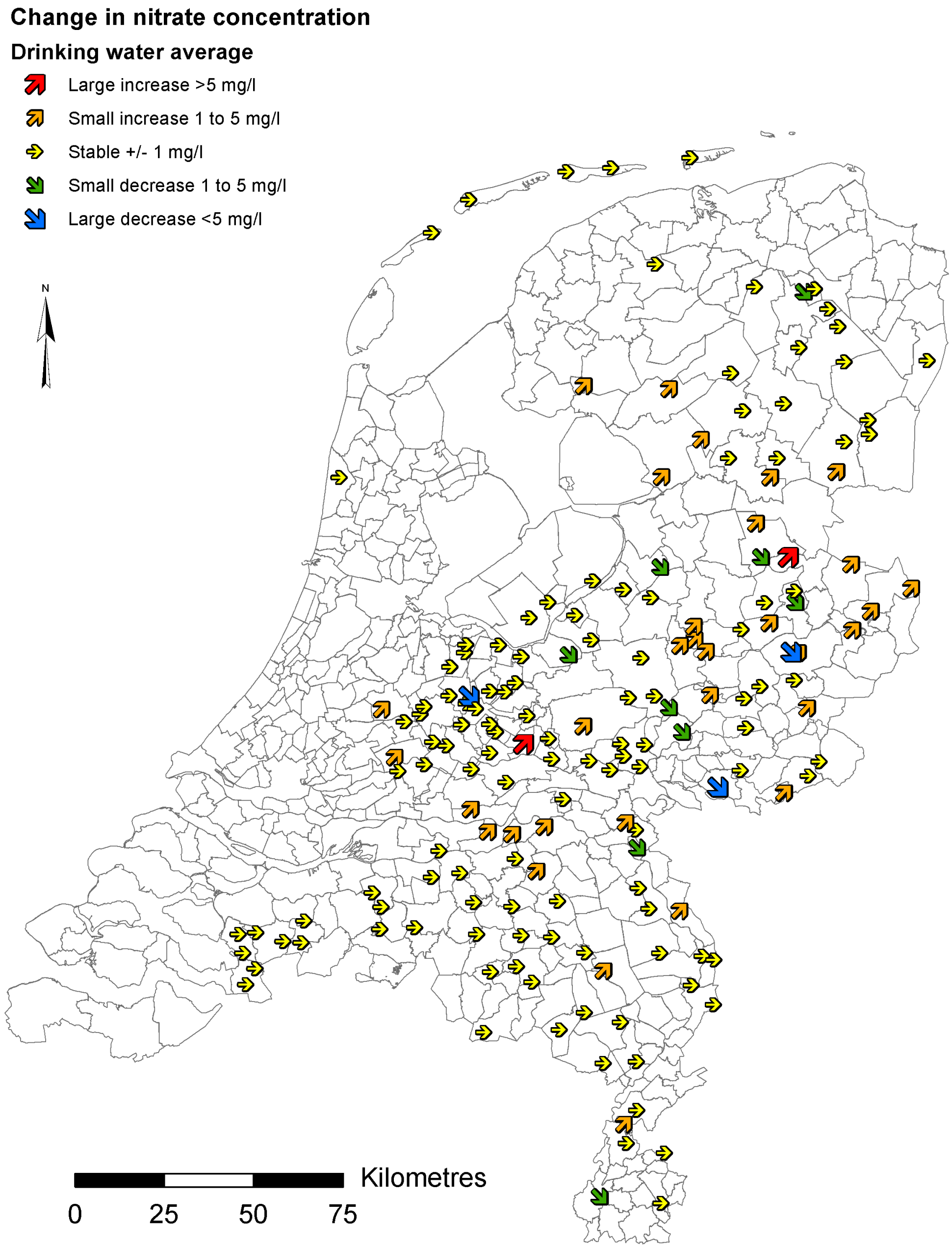
1 The total percentage may be higher or lower than 100 in connection with the rounding off.

The highest nitrate concentrations occur in the south (primarily in the Loess Region) (Map 2.5) and in the east of the Netherlands close to the German border (Sand region). These areas in particular display a decreasing trend (Map 2.6).

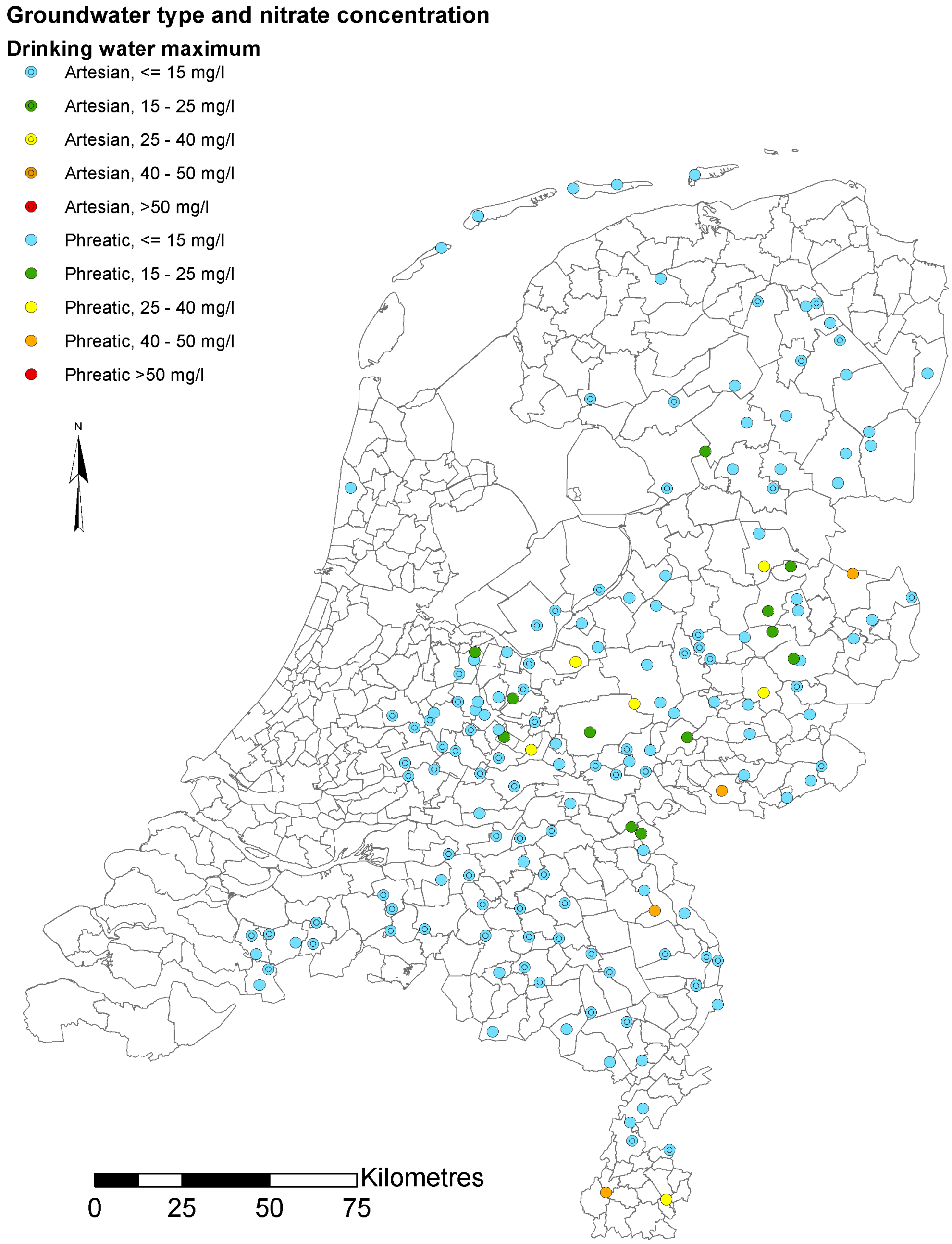
The highest maximum nitrate concentrations also occur in the south and the east of the Netherlands (Map 2.7). In Sand South there are many small increases in the nitrate concentration (Map 2.8).



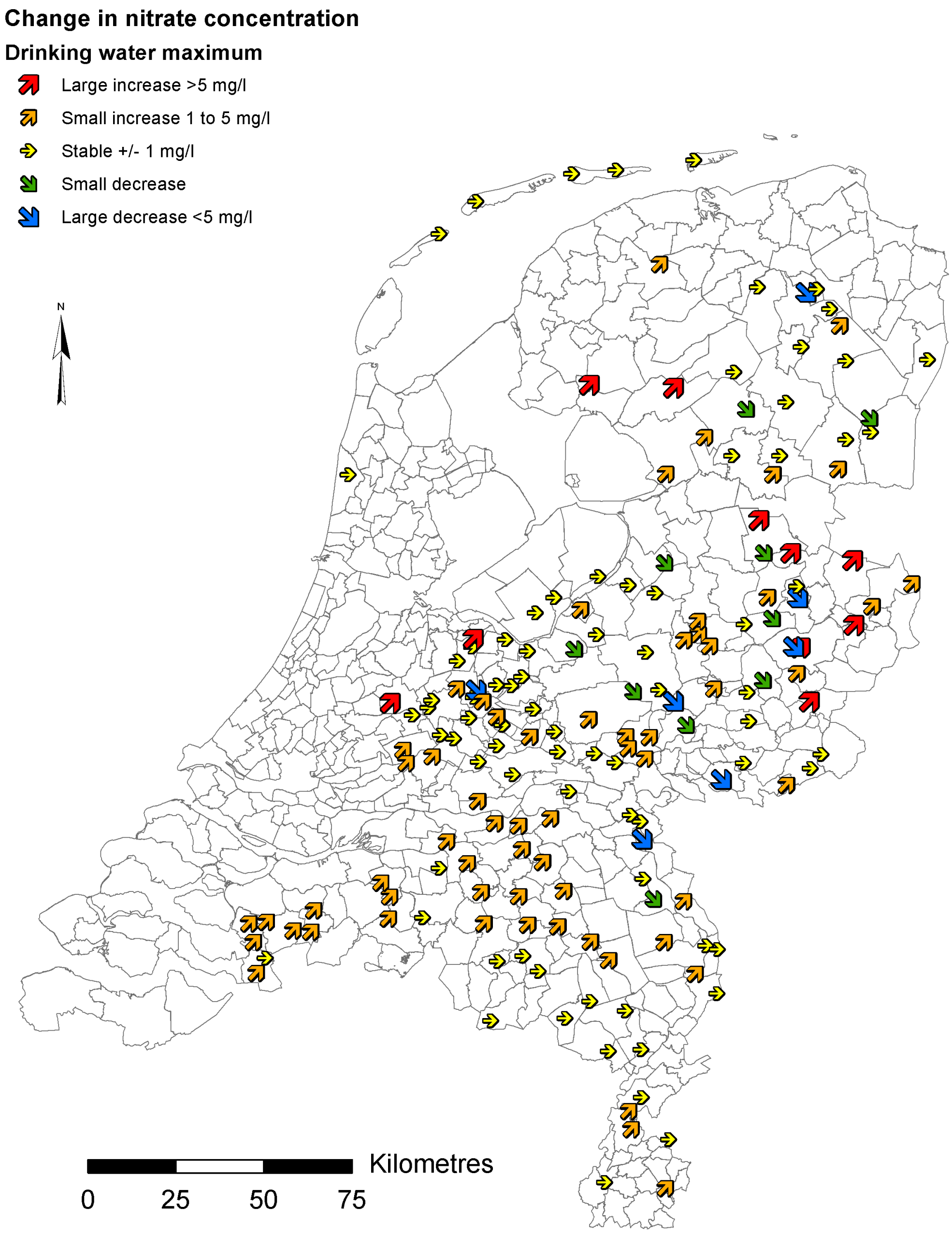
Map 2.5 Average nitrate concentration in groundwater used for the production of drinking water in the period 2012-2015



Map 2.6 Change in the average nitrate concentration in groundwater used for the production of drinking water in the period 2008-2014.
Change is shown as the difference between the averages of the period 2008-2011 and the period 2012-2015.



Map 2.7 Maximum nitrate concentration in groundwater used for the production of drinking water in the period 2012-2015



Map 2.8 Change in the maximum nitrate concentration in groundwater used for the production of drinking water in the period 2008-2015. Change is shown as the difference between the averages of the period 2008-2011 and the period 2012-2015.

2.5 Trend in agricultural practice and nitrate in groundwater

The nitrate concentration in the shallow and deeper groundwater is a reflection of the concentrations in the water that leaches from the root zone. The most significant source of nitrogen in the leaching water is agriculture. The nitrate concentrations in the shallow groundwater measured under agricultural areas are therefore higher than under nature reserves and other areas. What is more, the nitrate concentration is related to the soil's capacity to break down nitrate. Nitrate under sandy soil is broken down less than under clay and peat. The nitrate concentration in groundwater under sandy soil is therefore also highest.

The nitrate concentration under agriculture in the Sand Region in the shallow groundwater (5-15 metres below ground level) reached its highest concentration in 1996 (46 mg/l), approximately ten years after the peak in the soil surplus (1985). Since then the nitrate concentration in groundwater at this depth has decreased and was 32 mg/l in 2015. In groundwater at a depth of 15-30 metres the nitrate concentration is lower than in the shallow groundwater. This is a consequence of mixing and reduction during downward groundwater flow. The nitrate concentration under agricultural areas is higher than under nature reserves due to the agriculture-related effects. The nitrate concentration in the deeper groundwater under an agricultural area in the Sand Region has decreased since 2002 from 10 mg/l to 7 mg/l in 2015.

There are considerable regional differences in the way nitrate travels from shallow to deep groundwater. In the area Sand Central there has been a decrease of shallow to deep of, on average, 20 mg/l to 15 mg/l. In Sand South there has been a much greater decrease in the concentration in relation to depth, from 70 mg/l to 1 mg/l and in the Sand North from 15 mg/l to 3 mg/l. Presumably, a lot more nitrate reduction takes place in the subsoil of Sand South than in Sand Central.

In the case of the drinking water production locations the nitrate concentration is higher at the locations with phreatic groundwater than at locations with artesian groundwater. The confining layers above the aquifer offer protection against nitrate contamination in the case of artesian groundwater. In the phreatic aquifers, where these confining layers are absent, nitrate can penetrate to considerable depth. Although the EU standard is not exceeded at the production locations, there are a number of phreatic locations in Sand Central and in the Loess Region with a concentration of between 15 and 40 mg/l. In Sand South there are no increased nitrate concentrations. This ties in with the image of higher nitrate reduction in Sand South.

The nitrate concentration data for the drinking water production locations comes from the REWAB database (registration of data from drinking water companies). This database contains annual average information of the mixed pumped up groundwater per string of wells (a series of linked extraction wells) at the location (see Fraters et al., 2016), and not from individual extraction wells. As a result, high nitrate concentrations are averaged out, so that this data also provides an underestimation of the actual nutrient-related water quality problems at the production locations (Wuijts et al., 2010). The analysis by Van Loon and Fraters (2016) examined individual extraction wells. This shows, for example, that one or more raw water standards which indicate a negative effect of fertilisers were exceeded in individual extraction wells in the case of 89 groundwater extractions during the 2000-2015 period. This not only means nitrate but also other substances such as sulphate, heavy metals and hardness which are released during the reduction of nitrate due to denitrification. In most cases fertilising was a major reason for the standards being exceeded. Some cases were linked primarily to the groundwater level declining and to natural causes (Van Loon and Fraters, 2016). The fact that the standard was exceeded in individual wells is regarded as problematic because the drinking water companies have to mix various raw water flows in order to meet the quality standards. This increases the costs of monitoring and reduces flexibility.

3 Freshwater quality

3.1 Introduction

This chapter is an update of chapter 6 of the report published in 2016 about the status and trend in the agricultural practice and water quality in the Netherlands (Fraters et al., 2016).

This chapter begins with an overview of the nutrient load in water bodies in the Netherlands. Both nitrogen and phosphorus affect the degree of eutrophication. The status and the trend of the concentrations of nitrogen and phosphorus in the various fresh surface waters in the Netherlands are indicated. The various types of waters which can be identified are agriculture-specific waters and regional and national waters which have been designated as a WFD (European Water Framework Directive) body of water. The underlying emission sources for these waters are various and the direct effect from agriculture decreases in the following order: agriculture-specific waters, regional WFD waters and WFD national waters.

Besides information about nitrogen and phosphorus, the concentrations of chlorophyll-a were also provided. The eutrophication status of these fresh waters in the Netherlands based on an eutrophication characteristic, which has been brought into line with the system used within the WFD, has not been updated due to the lack of new data.

Within the framework of the EU reporting guideline (EC/DGXI, 2011), nitrate-nitrogen is regarded as the most significant variable when presenting the effects of agriculture on the quality of the surface water. In waters which are sensitive to eutrophication, some of the nitrate present disappears because the algae absorbs the nitrate during the summer period and this can give a distorted picture as regards the monitoring results for the summer. The greater the degree of eutrophication in a water body, the greater the reduction in the nitrate concentration in the summer. Another relevant factor in the Dutch situation is that, in the summer, upward seepage and inlet of water from other areas into polders can affect the measured water quality. The winter average (October to March) therefore provides a more representative picture than the summer or annual average. For that reason the maximum winter concentrations and the winter and annual averages for nitrate are presented in this chapter.

3.2 Nutrient load of the fresh surface water

The greater part of the total quantity of phosphorus and nitrogen in the Dutch fresh water system originates from outside the country. Around 53% of the total quantity of phosphorus and 75% of the total quantity of nitrogen that flows into fresh water in the Netherlands (2011-2012) originates from abroad (PBL, 2016). This is partly because a large part of the river basins of the major rivers that flow through the Netherlands are located abroad. The majority of these phosphorus and nitrogen loads soon leaves the Netherlands again and flows into the North Sea via the rivers Meuse and Rhine. The other portion of the nutrients in the Dutch water system is from various domestic sources (Table 3.1 and Table 3.2).

The leaching and run-off is the leading domestic source of both phosphorus (56%; Figure 3.1 on the left) and nitrogen (58%; Figure 3.1 on the right). The relative contribution by leaching and run-off increased for phosphorus over time from 15 to 56%, primarily because the contributions from other sources, including direct emissions from agriculture ('agriculture direct', such as fertiliser in the ditch, farmyard run-off, glasshouse horticulture), decreased even more (Table 3.2). In the case of nitrogen, the contribution from leaching and run-off has fluctuated between 50 and 61% since 1995.

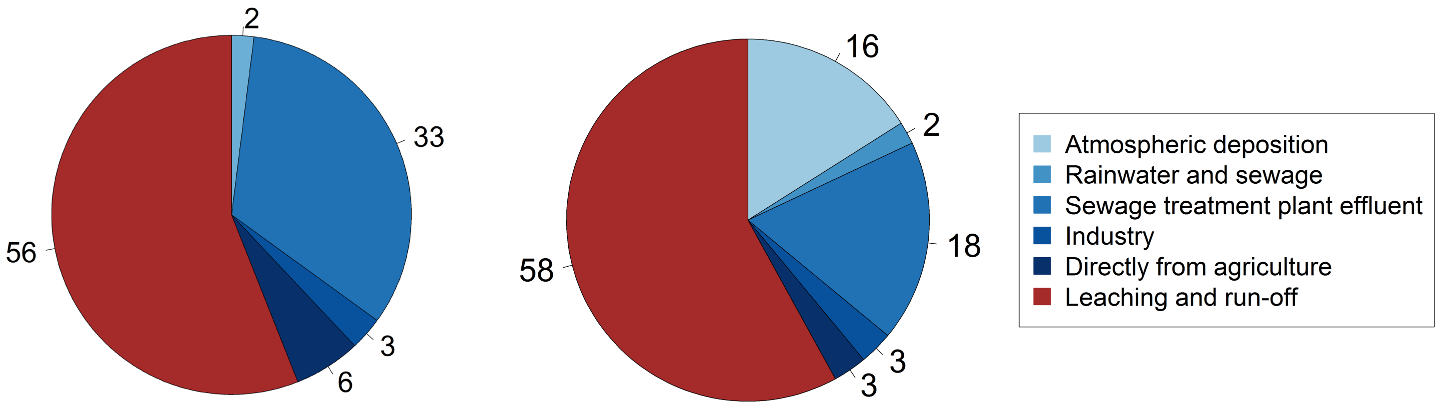


Figure 3.1 Percentages of different domestic sources (%) in the phosphorus load (on the left) and nitrogen load (on the right) of the surface water in the period 2012-2014

Source: Emissions registration 1990-2014, 2016

Table 3.1 Phosphorus load of surface water via domestic sources (millions of kilos per year)

Origin	1990	1995	2000	2005	2010	2013	2014
Leaching and run off rural area	3.4	4.3	5.1	3.4	3.8	3.6	3.6
Sewage treatment plant effluents	6.2	3.5	2.8	2.7	2.2	2.1	2.2
Rain and waste water not from sewage treatment plant[1]	0.6	0.4	0.2	0.1	0.1	0.1	0.1
Industry	11.0	3.6	1.9	0.4	0.2	0.2	0.2
Agriculture direct[2]	0.9	0.7	0.7	0.6	0.5	0.4	0.4
Other	0	0	0	0	0	0	0
Total	22.1	12.5	10.7	7.1	6.9	6.4	6.5

[1] Waste water not via sewage treatment plant = overflows, storm water sewers, discharges via individual treatment of waste water, non-purified sewers and unconnected households.

[2] Agriculture direct = glasshouse horticulture, farmyard run-off and unintended fertilisation of ditches.

Source: Emissions registration 1990-2014, 2016

Table 3.2 Nitrogen load of surface water via domestic sources (millions of kilos per year)

Origin	1990	1995	2000	2005	2010	2013	2014
Atmospheric deposition[1]	24	20	17	15	13	12	12
Leaching and run-off rural area	59	84	88	47	54	42	42
Sewage treatment plant effluents	39	36	29	22	17	15	14
Rain and waste water not from a sewage treatment plant[2]	5.0	3.4	2.3	1.7	1.2	1.2	1.2
Industry	12.7	6.5	4.6	3.9	2.4	2.4	2.4
Agriculture direct[3]	7.7	5.7	3.7	3.2	2.7	2.6	2.6
Other	0.4	0.4	0.2	0.3	0.2	0.2	0.2
Total	148	156	145	94	90	76	75

1 Atmospheric deposition onto fresh and salt surface water including one-mile coastal zone.

2 Waste water not via sewage treatment plant = overflows, storm water sewers, discharges via individual treatment of waste water, non-purified sewers and unconnected households.

3 Agriculture direct = glasshouse horticulture, farmyard run-off and unintended fertilisation of ditches.

Source: Emissions registration 1990-2014, 2016

As regards leaching and run-off in the rural area the emissions registration does not yet make a distinction between agricultural land and nature land. A study by Groenendijk et al. (2014) showed that the contribution from agricultural land to the phosphorus load of the surface water is 46% and 47% to the nitrogen load, whereby the portion affected by fertilising is 34% and 33% respectively. The share of the sources of leaching and run-off differs significantly between the various regions.

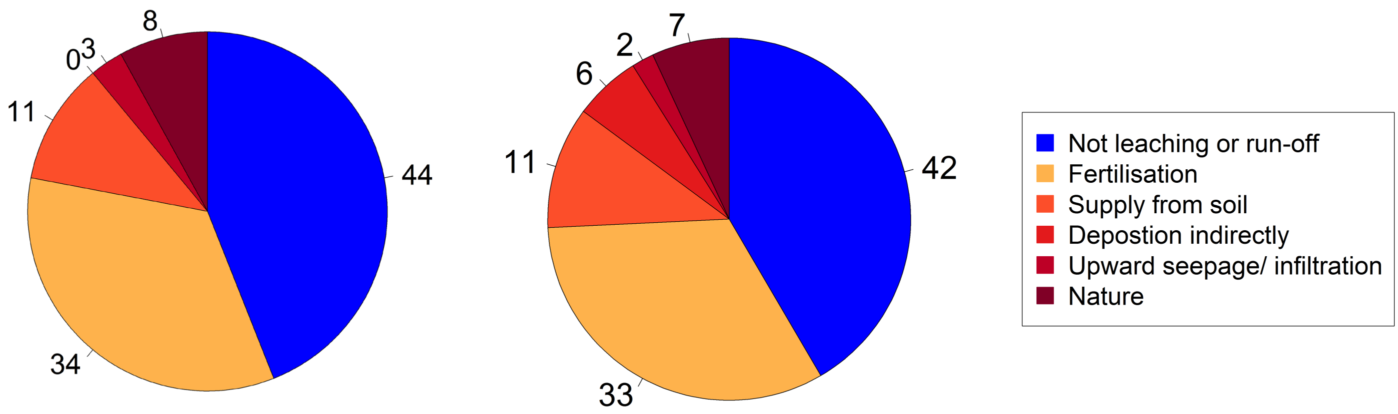


Figure 3.2 Percentages of different sources (%) in the phosphorus load (on the left) and the nitrogen load (on the right) of the surface water via leaching and run-off in the period 2012-2014
Source: Groenendijk et al., 2014

3.3 Nitrate concentrations in fresh water

3.3.1 Nitrate concentration – winter average

The nitrate concentrations, calculated as winter averages, at both the monitoring sites in the WFD water bodies and at the monitoring sites in the agriculture-specific waters have been measured since 1992 (Tables 3.3 and 3.4, Figure 3.3). In the WFD water bodies the average concentration decreased by around 20 mg/l to 10-12 mg/l. In the agriculture-specific waters the average nitrate concentration decreased from 25-30 mg/l to approximately 14 mg/l.

The EU standard of 50 mg/l, which is used in this report as the benchmark figure for nitrate, was exceeded during the last period of 2012-2014 in fewer than 2% of the monitoring sites in the agriculture-specific waters (Table 3.3). It should be noted that this EU standard of 50 mg/l of nitrate is much too high to achieve any sound eutrophication status and is not normative for the (ecological) water quality within the WFD.

The nitrate concentrations in the various waters presented in this addendum, including measurement data from 2015, does not differ from the 2016 report (Fraters et al., 2016).

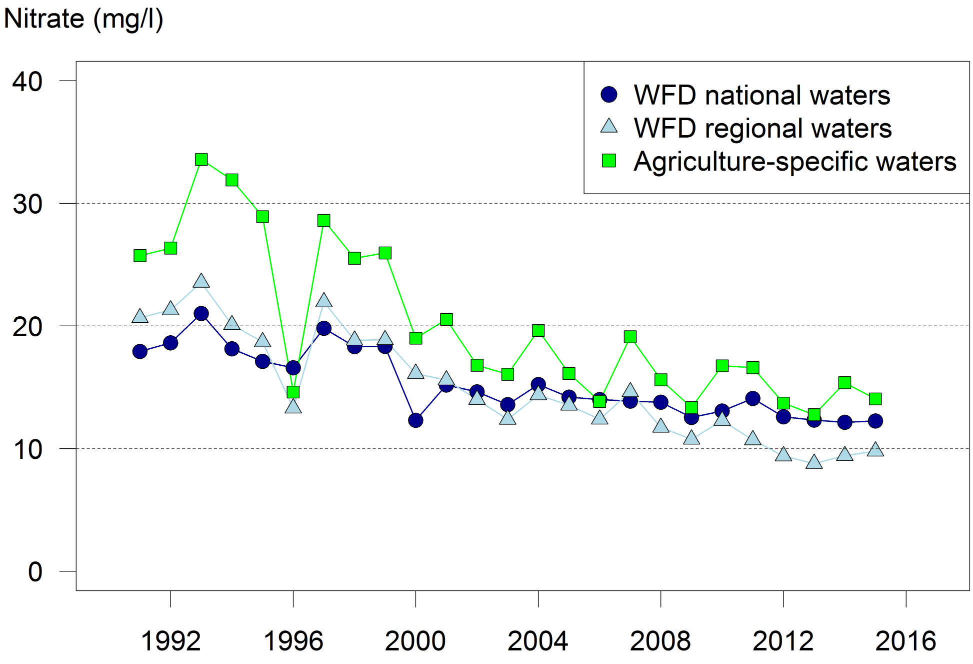


Figure 3.3 Nitrate concentration (winter average of NO_3 in mg/l) in fresh surface waters in the period 1990-2015

The decreasing trend in nitrate concentrations also continued in the last reporting period (2012-2015). The percentage of monitoring sites with declining nitrate concentrations is a factor of five higher than the percentage of monitoring sites that increases. This applies both to the WFD waters and the agriculture-specific waters (Table 3.4).

Table 3.3 Percentage of monitoring sites in WFD and agriculture-specific fresh waters per nitrate concentration class (as winter average) in various reporting periods[1]

Nitrate class (as NO_3)	WFD waters			Agriculture-specific waters		
	1992-1995	2008-2011	2012-2015	1992-1995	2008-2011	2012-2015
0-2 mg/l	9	11	13	6	7	7
2-10 mg/l	18	49	53	20	39	43
10-25 mg/l	45	32	28	24	32	34
25-40 mg/l	18	7	5	27	9	11
40-50 mg/l	5	1	1	7	4	3
> 50 mg/l	5	1	1	16	4	3
Number of locations	356	648	685	55	138	151

1 The total percentage may be higher or lower than 100 due to rounding off.

Table 3.4 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters with increasing or decreasing nitrate concentrations (as winter average) between various reporting periods[1]

Change (NO_3)	WFD waters		Agriculture-specific waters	
	1992/1995-2008/2011	2008/2011-2012/2015	1992/1995-2008/2011	2008/2011-2012/2015
Large increase (> 5 mg/l)	1	1	0	0
Small increase (1-5 mg/l)	2	8	2	11
Stable (+/- 1 mg/l)	14	48	9	34
Small decrease (1-5 mg/l)	23	36	23	38
Large decrease (> 5 mg/l)	60	7	66	17
Number of locations	351	619	47	125

1 The total percentage may be higher or lower than 100 due to rounding off.

3.3.2 *Nitrate concentration – winter maximum*

Similarly to the average concentrations, the winter maximum concentrations decreased in the period 1992-2014. In the case of 15% of the agriculture-specific waters the EU standard of 50 mg/l nitrate was exceeded by the winter maximum concentrations in the penultimate and last reporting period (Table 3.5). In the case of the WFD waters the standard was exceeded in 3-6% of the waters. A comparison between the last and penultimate period reveals increasing and decreasing winter maximum nitrate concentrations in both WFD and agriculture-specific waters (Table 3.6).

Table 3.5 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters per nitrate concentration class (as winter maximum) in the various reporting periods[1]

Nitrate class (NO_3 in mg/l)	WFD waters			Agriculture-specific waters		
	1992-1995	2008-2011	2012-2015	1992-1995	2008-2011	2012-2015
0-2 mg/l	3	5	4	2	0	1
2-10 mg/l	13	28	34	6	18	14
10-25 mg/l	27	39	38	20	36	37
25-40 mg/l	23	16	16	22	20	24
40-50 mg/l	10	6	5	9	11	9
> 50 mg/l	24	6	3	42	15	15
Number of locations	356	648	685	55	138	151

1 The total percentage may be higher or lower than 100 due to rounding off.

Table 3.6 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters with increasing or decreasing nitrate concentrations (as winter maximum) between various reporting periods[1]

Change (NO_3)	WFD waters		Agriculture-specific waters	
	1992/1995-2008/2011	2008/2011-2012/2015	1992/1995-2008/2011	2008/2011-2012/2015
Large increase (> 5 mg/l)	5	7	9	20
Small increase (1-5 mg/l)	2	15	4	13
Stable (+/- 1 mg/l)	7	28	9	20
Small decrease (1-5 mg/l)	15	27	2	23
Large decrease (> 5 mg/l)	70	23	77	24
Number of locations	351	619	47	125

1 The total percentage may be higher or lower than 100 due to rounding off.

3.3.3 *Nitrate concentration – annual average*

Annual average nitrate concentrations which are higher than the EU standard of 50 mg/l nitrate were only found sporadically in the last and penultimate reporting periods in the case of the agriculture-specific waters (1%) (Table 3.7). A comparison between the last and penultimate period revealed a slight improvement in the case of the WFD waters while, in the case of the agriculture-specific waters, the percentage of waters in a certain concentration class remained the same in both periods.

Table 3.7 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters per nitrate concentration class (as annual average) in the various reporting periods[1]

Nitrate class (NO_3 in mg/l)	WFD waters			Agriculture-specific waters		
	1992-1995	2008-2011	2012-2015	1992-1995	2008-2011	2012-2015
0-2 mg/l	12	20	22	3	17	17
2-10 mg/l	28	52	55	31	48	48
10-25 mg/l	44	24	19	39	26	25
25-40 mg/l	12	3	3	15	6	6
40-50 mg/l	2	0	1	6	3	2
50 µg/l.	3	1	0	7	1	1
Number of locations	389	695	729	83	160	172

[1] The total percentage may be higher or lower than 100 due to rounding off.

In the fresh surface water in the east and south of the Netherlands (sandy soils) the higher nitrate concentrations (> 25 mg/l) are found in the winter (Map 3.1). The majority of declines occur in this area (Map 3.2). The map with the maximum nitrate concentrations (Map 3.3) shows that numerous concentrations of more than 25 mg/l occur in this area, as well as nitrate concentrations of more than 50 mg/l. The presented changes in the maximum nitric concentrations in the winter is diffuse, with rising and declining maximum concentrations being spread across the Netherlands (Map 3.4).

3.4 The eutrophication of fresh water

3.4.1 General status

The EU standard of 50 mg/l (winter average) is not a good indicator for providing information about the ecological water quality for the WFD and the eutrophication of the surface water. This value of 50 mg/l is not intended to be used for this purpose and is much too high to achieve a sound eutrophication status. The 2016 report (Fraters et al., 2016) indicates which data is suitable. In accordance with the WFD system, various quality elements are used per water type to assess the status of the WFD waters. Consequently, not only were nutrients assessed, but also biological quality elements in the water bodies, such as phytoplankton and phytobenthos.

Of the WFD water bodies, 60% were assessed as eutrophic and 13% as potentially eutrophic for the period 2011-2013. More recent assessments are unavailable and, therefore, the figures have not been updated. 'Eutrophic' means that eutrophication effects can be observed in the biology. The biological quality elements then score less than 'good' irrespective of the score of the nutrients. 'Potentially eutrophic' means that no eutrophication effects can be observed, but that the nutrient concentrations are so high that they may well cause the effects. For the majority of the waters (94%) the assessment took place on the basis of biological characteristics. In the case of the remaining waters this information was missing and the assessment took place only on the basis of nutrients.

The above shows that, if a water body is eutrophic, this does not mean that the nutrients do not comply either. It is also apparent that for almost half the waters the nutrients comply with the derived nutrient standards for these waters, but that the right (eutrophication) status is only achieved in 27% of the waters.

3.4.2 *Chlorophyll-a*

Since the beginning of the 1990s the concentration of chlorophyll-a has been measured in both the WFD waters and in some of the agriculture-specific waters (Table 3.8). The chlorophyll-a concentration has decreased over time. Since 2004 the concentration of chlorophyll-a in the regional WFD waters and the agriculture-specific waters is comparable and fluctuates at around 38 µg/l. In the WFD national waters the chlorophyll a concentration in the summer is quite a bit lower at 12 µg/l (Figure 3.4).

By way of an illustration the summer average WFD standard for chlorophyll-a is for shallow (medium-sized) buffered lakes (WFD type M14; Bijkerk, 2014) 10.8 µg/l and 23 µg/l for weakly buffered (regional) ditches (WFD type M4; Bijkerk, 2014).

The percentage of locations with declining and increasing concentrations of chlorophyll-a between 2008 and 2015 is comparable for the WFD waters and the agriculture-specific waters (Table 3.9).

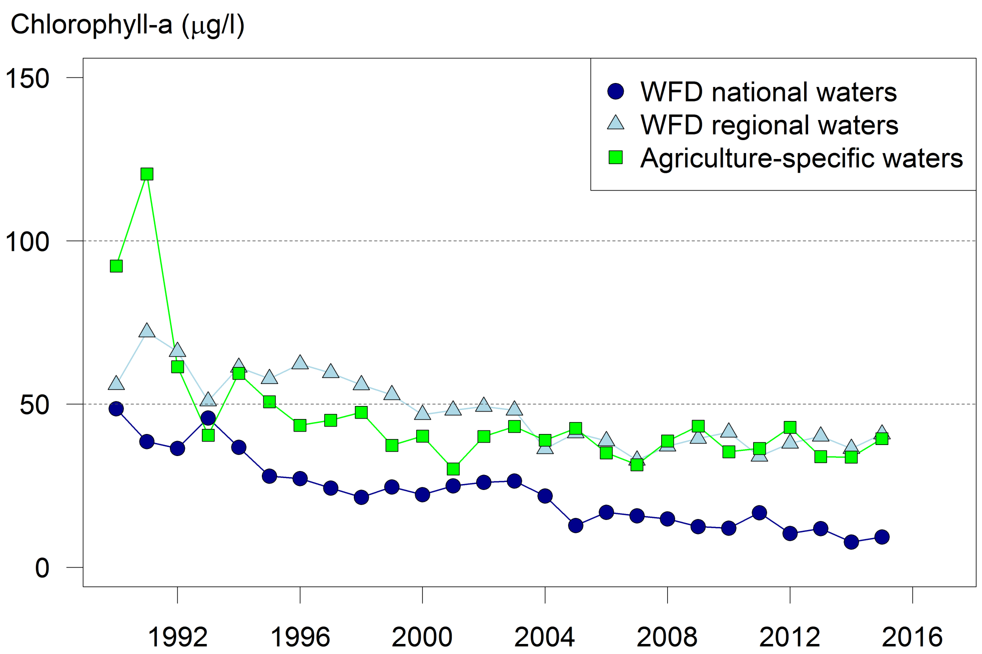


Figure 3.4 Chlorophyll-a (summer average concentration in µg/l) in fresh surface waters in the period 1990-2015

Table 3.8 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters per chlorophyll-a concentration class (as summer average) in the various reporting periods[1]

☐ Chlorophyll class	WFD waters 1992-1995	WFD waters 2008-2011	WFD waters 2012-2015	Agriculture-specific waters 1992-1995	Agriculture-specific waters 2008-2011	Agriculture-specific waters 2012-2015
0-2.5 µg/l	1	0	2	3	0	0
2.5-8 µg/l	6	13	15	11	12	15
8.0-25 µg/l	30	38	36	32	48	40
25-75 µg/l	37	37	36	27	29	31
> 75 µg/l	27	11	11	27	12	13
Number of locations	199	408	460	37	77	67

1 The total percentage may be higher or lower than 100 due to rounding off.

Table 3.9 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters with increasing or decreasing chlorophyll-a concentrations (as summer average) between various reporting periods[1]

Change (chlorophyll)	WFD waters 1992/1995-2008/2011	WFD waters 2008/2011-2012/2015	Agriculture-specific waters 1992/1995-2008/2011	Agriculture-specific waters 2008/2011-2012/2015
Large increase (> 10 µg/l)	10	15	14	22
Small increase (5-10 µg/l)	5	9	7	8
Stable (+/- 5 µg/l)	24	44	31	33
Small decrease (5-10 µg/l)	7	15	7	12
Large decrease (> 10 µg/l)	54	18	41	26
Number of locations	176	365	29	51

1 The total percentage may be higher or lower than 100 due to rounding off.

3.4.3 *Nitrogen and phosphorus*

Nitrogen

The summer average total nitrogen concentrations have declined since 1992 (Figure 3.6). The number of monitoring sites in the WFD waters in a high nitrogen class is declining and the number of monitoring sites in a low nitrogen class is increasing if the period 1992-1995 is compared to 2012-2015 (Table 3.10). This did not change significantly in the last and penultimate reporting period in the case of both the WFD waters and the agriculture-specific waters. In both waters there is still a higher percentage of waters where concentrations are decreasing rather than increasing (Table 3.11). The concentrations of total nitrogen for both WFD waters, regional and national, are comparable (2.9 mg/l) while those of the agriculture-specific waters are higher (3.5 mg/l).

By way of an illustration, the WFD standard for shallow (medium-sized) buffered lakes (type M14) is 1.3 mg/l (summer average) for total nitrogen. For weakly buffered (regional) ditches (type M4) the summer average standard for total nitrogen is 2.8 mg/l.

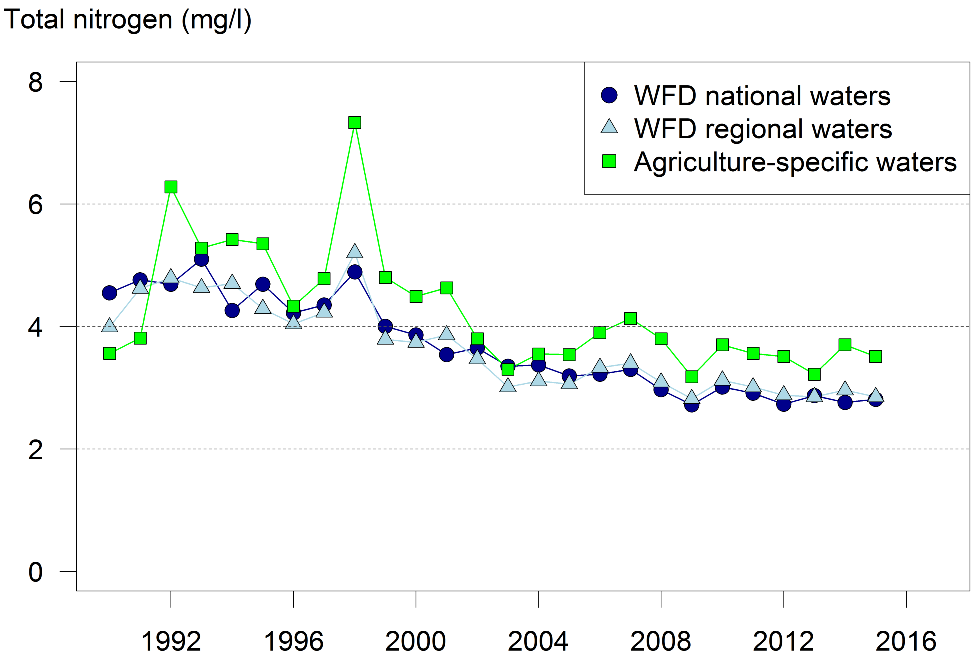


Figure 3.5 Total nitrogen concentration (summer average as N in mg/l) in fresh waters in the period 1990-2015

Table 3.10 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters per total nitrogen concentration class (as summer average) in the various reporting periods[1]

Nitrogen class (N)	WFD waters			Agriculture-specific waters		
	1992-1995	2008-2011	2012-2015	1992-1995	2008-2011	2012-2015
0-2 mg/l	11	29	32	6	21	19
2-5 mg/l	57	61	60	55	59	62
5-7 mg/l	16	6	6	18	11	12
>7 mg/l	16	3	3	21	9	7
Number of locations	386	722	759	85	164	174

1 The total percentage may be higher or lower than 100 due to rounding off

Table 3.11 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters with increasing or decreasing total-nitrogen concentrations (as summer average) between various reporting periods[1]

Change (N)	WFD waters		Agriculture-specific waters	
	1992/1995-2008/2011	2008/2011-2012/2015	1992/1995-2008/2011	2008/2011-2012/2015
Large increase (> 0.5 mg/l)	4	8	6	18
Small increase (0.25-0.50 mg/l)	2	10	4	9
Stable (+/- 0.25 mg/l)	12	49	6	43
Small decrease (0.25-0.50 mg/l)	5	16	5	12
Large decrease (> 0.5 mg/l)	78	17	80	18
Number of locations	385	716	83	164

1 The total percentage may be higher or lower than 100 due to rounding off.

Phosphorous
Since the beginning of the 1990s the summer average total phosphorous concentration has been gradually decreasing (Figure 3.6). In the WFD national waters the phosphorous concentration has reduced to 1/3 of the original concentrations. After 2010 a sharp drop occurred to 0.12 mg/l. In the case of the regional WFD waters the phosphorous concentration decreased sharply until 2005, but stabilised in the subsequent years to a phosphorous concentration of approximately 0.26 mg/l. In the agriculture-specific waters the phosphorous concentration first increased until the end of the 1990s and then decreased again to approximately 0.4 mg/l. The average phosphorous concentration can differ significantly each year as a consequence of outliers.

By way of an illustration, the WFD standard for shallow (medium-sized) buffered lakes (type M14) is 0.09 mg/l (summer average) for total phosphorus. For weakly buffered (regional) ditches (type M4) the summer average standard for total phosphorus is 0.15 mg/l.

The percentage of monitoring sites with a total phosphorous concentration that is higher than 0.2 mg/l decreased in the case of the WFD waters from 62% in 1992-1995 to 41% in 2008-2011 and thereafter to 37% in 2012-2015 (Table 3.12). In the case of the agriculture-specific waters a decrease also occurred between 1992 and 2008 (from 56% to 47%), after which it stopped decreasing. If a comparison is made between the last and the penultimate reporting periods (Table 3.13) it is clear that the total phosphorous concentrations in the WFD and the agriculture-specific waters are stable and that there is little decrease or increase in the concentration.

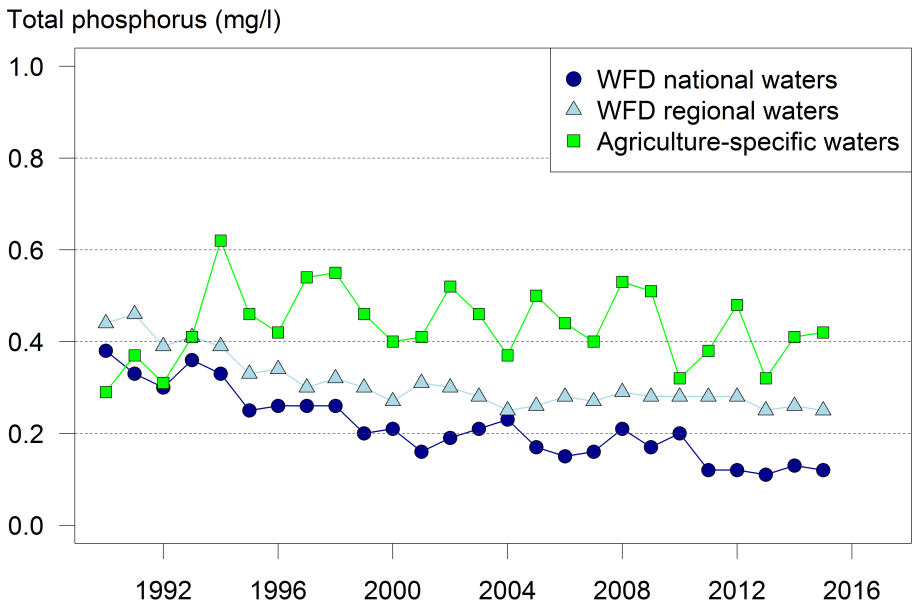


Figure 3.6 Total-phosphorous concentration (summer average as P in mg/l) in fresh waters in the period 1990-2015

Table 3.12 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters per total phosphorus concentration class (as summer average) in the various reporting periods[1]

Phosphorus class (P)	WFD waters			Agriculture-specific waters		
	1992-1995	2008-2011	2012-2015	1992-1995	2008-2011	2012-2015
< 0.05 mg/l	3	5	8	7	3	3
0.05-0.10 mg/l	11	22	23	18	27	22
0.10-0.20 mg/l	25	32	33	20	23	28
0.20-0.50 mg/l	41	26	24	21	16	16
> 0.50 mg/l	21	15	13	35	31	31
Number of locations	393	724	762	87	164	174

1 The total percentage may be higher or lower than 100 due to rounding off.

Table 3.13 Percentage of monitoring sites in WFD and agriculture-specific fresh surface waters with increasing or decreasing total phosphorus concentrations (as summer average P) between the various reporting periods[1]

Change (P)	WFD waters 1992/1995-2008/2011	WFD waters 2008/2011-2012/2015	Agriculture-specific waters 1992/1995-2008/2011	Agriculture-specific waters 2008/2011-2012/2015
Large increase (> 0.10 mg/l)	0	0	2	3
Small increase (0.05-0.10 mg/l)	2	1	4	2
Stable (+/- 0.05 mg/l)	83	95	78	86
Small decrease (0.05-0.10 mg/l)	9	2	12	5
Large decrease (> 0.10 mg/l)	6	1	5	4
Number of locations	393	721	85	164

1 The total percentage may be higher or lower than 100 due to rounding off.

3.5 Trend in agricultural practice and quality of fresh surface water

The previous paragraphs revealed a clear decline in the concentrations of nitrate, total nitrogen and total phosphorus since 1992 in both the regional agriculture-specific waters and in the regional and national WFD waters. This downward trend was also clarified by determining a trend line for each measuring point with LOWESS (LOcally WEighted Scatterplot Smoothing) and by then calculating aggregated trend lines using the same method (see Klein and Rozemeijer, 2015). A description of this calculation method can be found in paragraph 2.6.3 of the 2016 report (Fraters et al., 2016). Using aggregated trend lines (median, 25th and 75th percentile) an insight is obtained as to whether a trend steepens or flattens over time. The 25th-percentile represents the trends for the lower concentration range and the 75th percentile represents the trend for the higher concentration range. Together, the 25th and 75th percentiles reflect the bandwidth within which 50% of the concentration level measurements are located.

The calculation show a downward trend for the nitrate concentrations in the winter for the agriculture-specific waters, the regional waters and the national waters (Figure 3.7 to 3.9). In the case of the agriculture-specific waters the downward trend for nitrate concentrations has continued in recent years (Figure 3.7), while in the case of the WFD waters they flattened in the years 2003-2005 (Figure 3.8 and Figure 3.9).

If a comparison is made between the calculated trend lines for the nitrate concentrations in the winter (Figures 3.7 to 3.9) with the development of the winter average nitrate concentrations over time (Figure 3.3), it transpires that the calculated trend line for agriculture-specific waters is substantially lower than in the case of the line which indicates the development of the winter average concentration. One clarification for this is the greater knock-on effect of a number of outliers in the nitrate concentrations which have a larger influence on the calculated average values and less of an effect on the calculated trend lines. What is more, an outlier has a relatively greater effect in the case of agriculture-specific waters than in the case of the WFD waters because there are also fewer measuring locations. This is confirmed by the broader margin to the 75th percentile values.

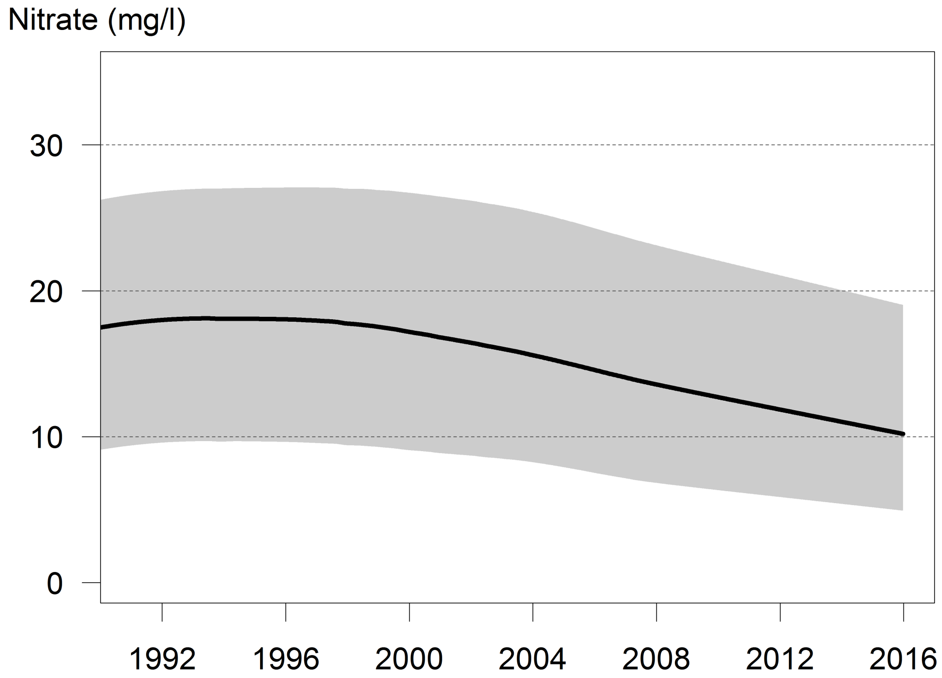


Figure 3.7 Calculated trend in the nitrate concentration (winter measurements; as NO_3 in mg/l) for agriculture-specific waters; median trend (continuous line) and the area between the 25th and 75th percentile trends (grey area)

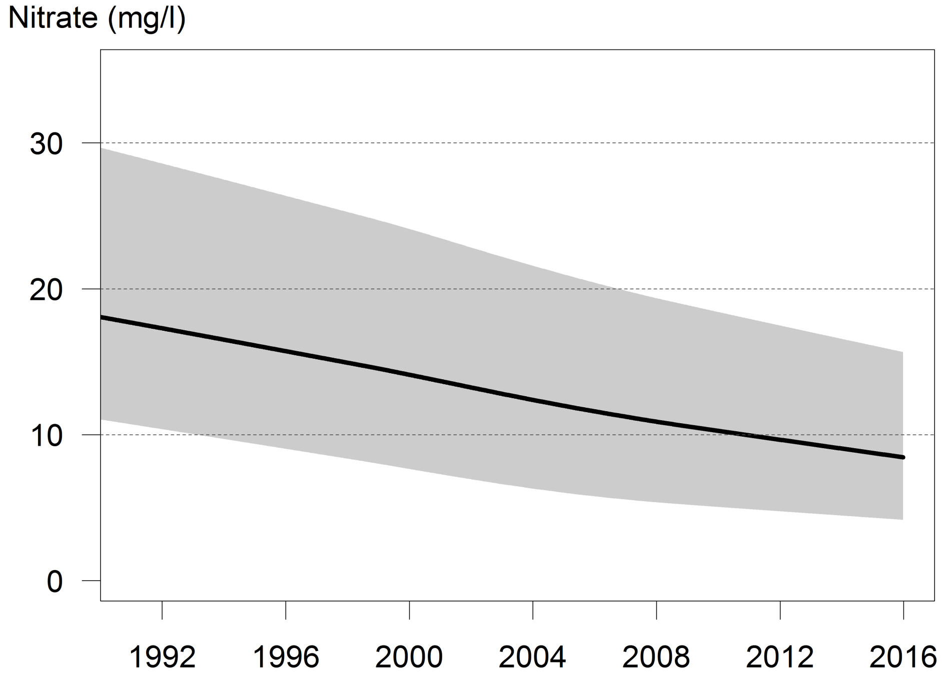


Figure 3.8 Calculated trend in the nitrate concentration (winter measurements; as NO_3 in mg/l) for regional WFD waters; median trend (continuous line) and the area between the 25th and 75th percentile trends (grey area)

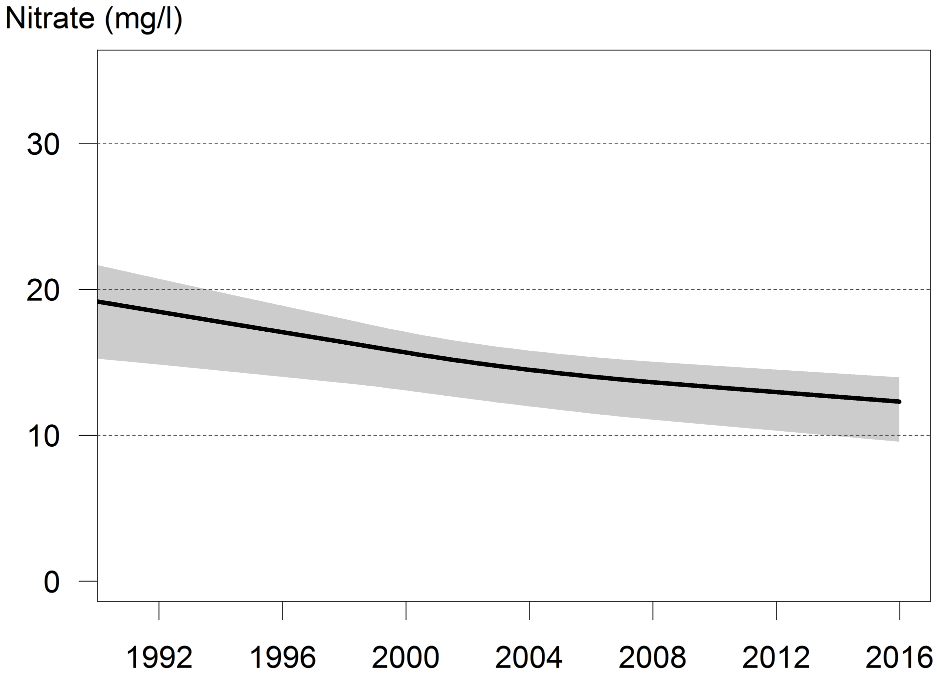
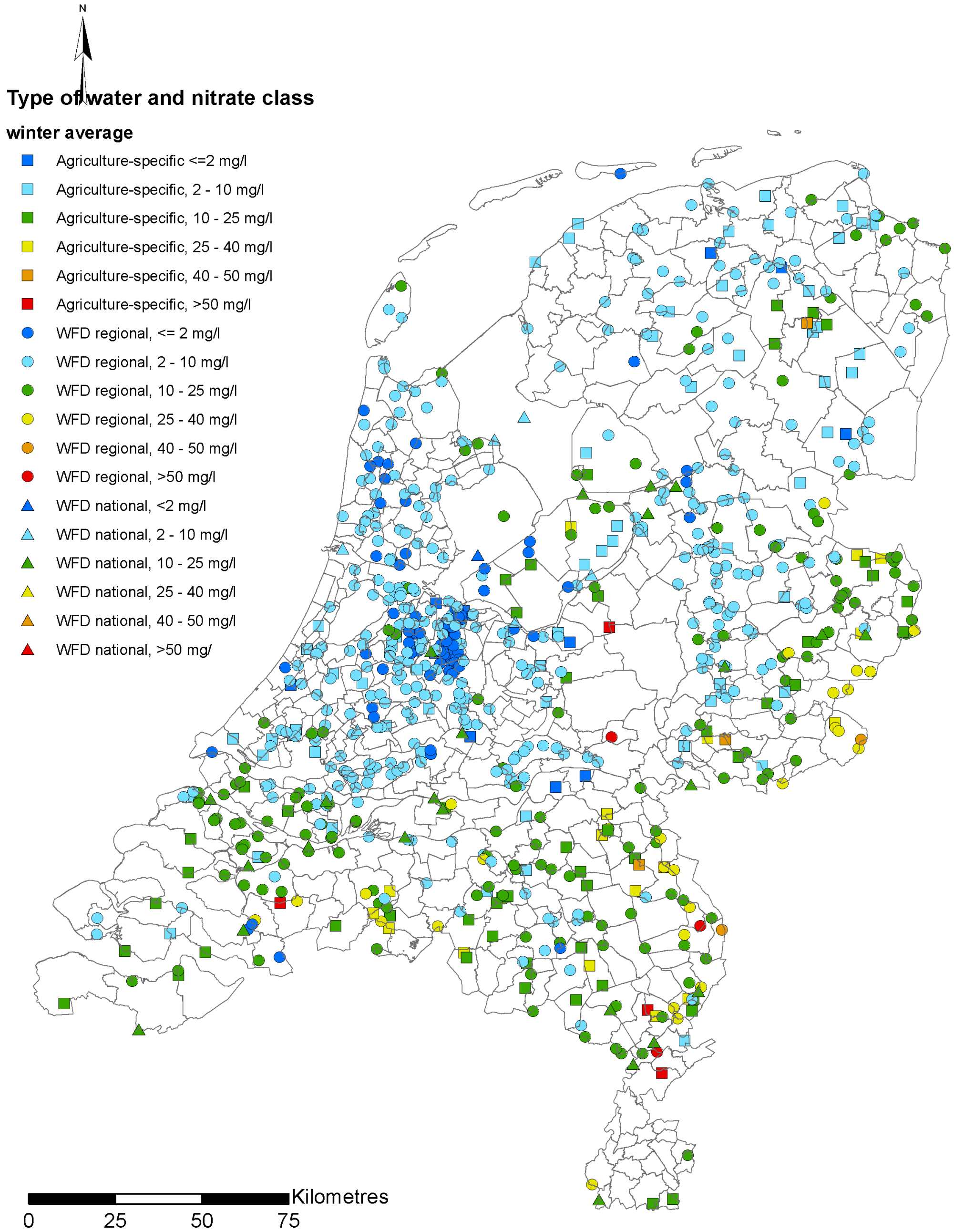
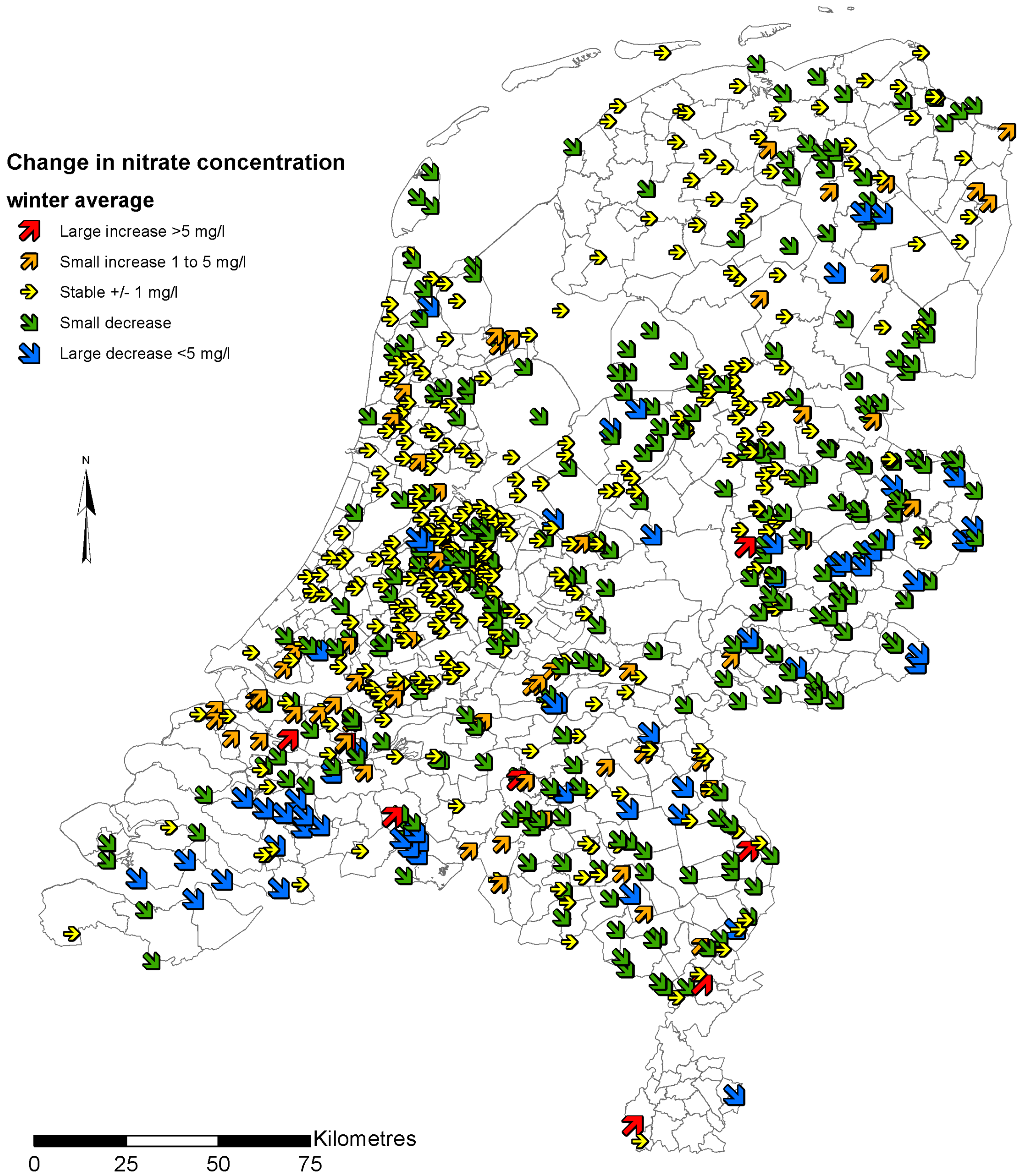


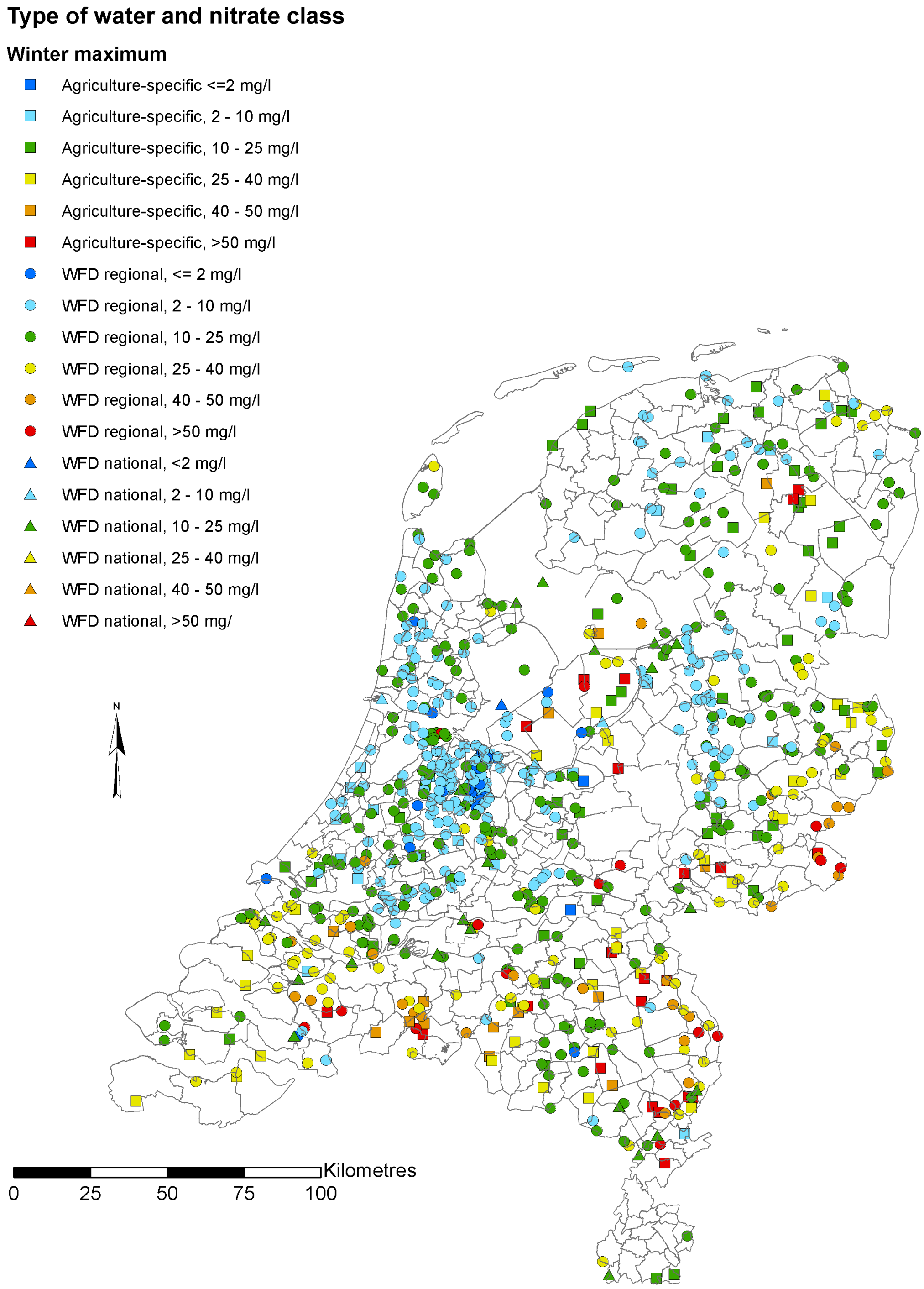
Figure 3.9 Calculated trend in the nitrate concentration (winter measurements; as NO_3 in mg/l) for WFD national waters; median trend (continuous line) and the area between the 25th and 75th percentile (grey area)



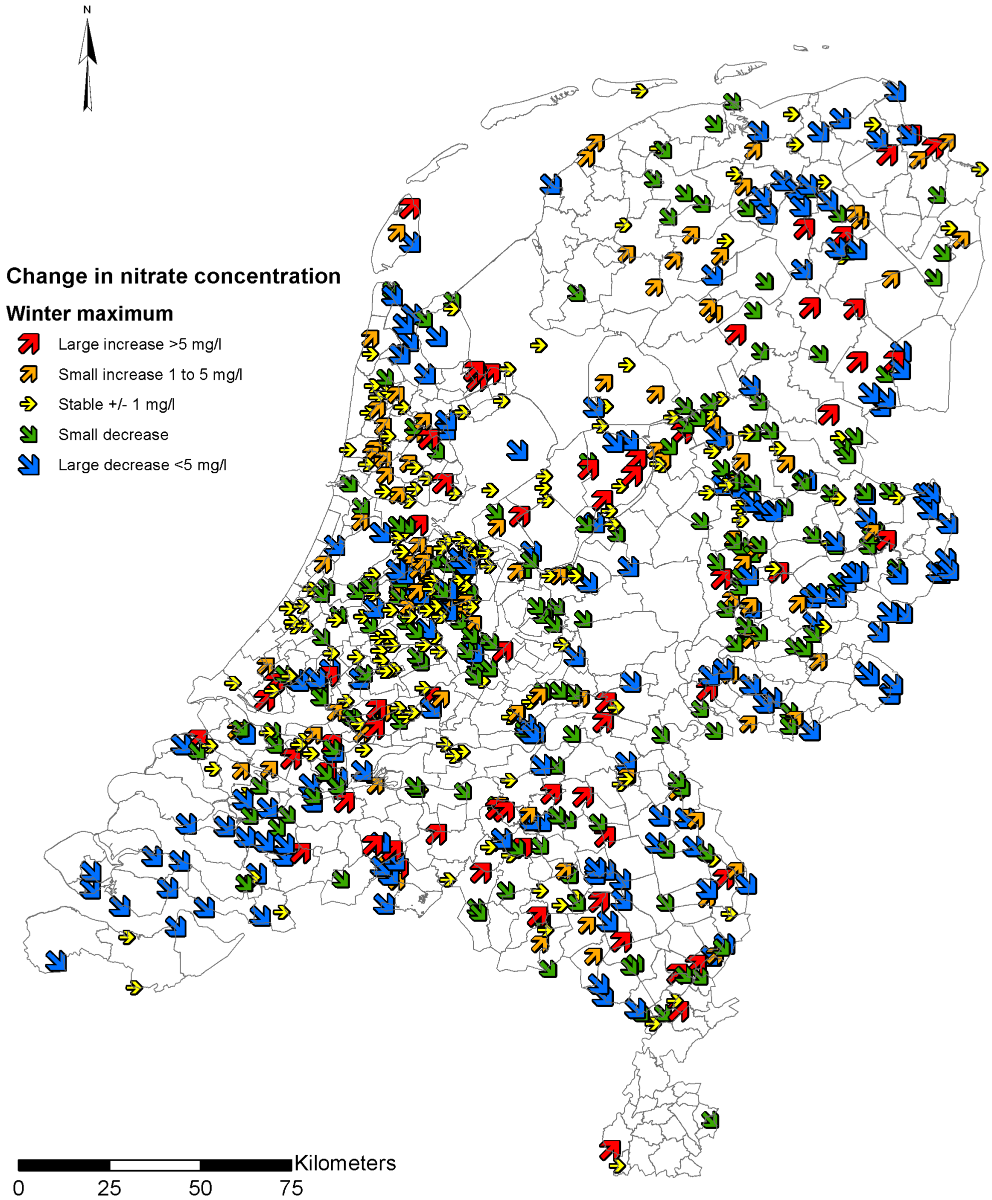
Map 3.1 Winter average nitrate concentration in Dutch fresh waters per measurement location in the period 2012-2015



Map 3.2 Change in the winter average nitrate concentration in Dutch fresh waters between 2008-2011 and 2012-2014 per measurement location
The change is shown as the difference between the averages of 2008-2011 and 2012-2015.



Map 3.3 Winter maximum nitrate concentration in Dutch fresh waters per measurement location in the period 2012-2015



Map 3.4 Change in the winter maximum nitrate concentration in Dutch fresh waters between 2008-2011 and 2012-2015 per measurement location
The change is shown as the difference between the averages of 2008-2011 and 2012-2015.

4 Marine water quality

4.1 Introduction

This chapter is an update of chapter 7 of the report published in 2016 about the status and trend in the agricultural practice and water quality in the Netherlands (Fraters et al., 2016). This chapter discusses the results of the monitoring of nitrogen and phosphorus concentrations in marine surface waters.

The current report does not include the paragraph about the nutrient load of the marine water, nor the table with the assessment of the eutrophication in paragraph 4.3, because no new information is available.

In accordance with the WFD the marine surface waters are classified as transitional waters and coastal waters. All other marine waters are defined as open sea and are therefore not part of the waters defined in the WFD.

The nitrogen concentrations presented are based on the average or maximum concentrations in the winter (December-February), given that the least amount of biological activity takes place during this period. Consequently, the nitrate concentrations measured in the winter are better indicator of changes in the status of the water quality than the nitrate concentrations measured in the summer.

4.2 Nitrate concentration in sea and coastal waters

The nitrate concentrations in the transitional waters have been declining since the beginning of the 1990s. The nitrate concentrations in the coastal waters and open sea are stable (Table 4.2) and have always been lower than 10 mg/l (Table 4.1). Since 2009 the average (winter) nitrate concentration of the transitional waters has also been under 10 mg/l and this is continuing to decline every year (Figure 4.1). Although the highest winter average nitrate concentrations are found in transitional waters (Map 4.1), the nitrate concentrations at the measuring locations in these waters are declining (Map 4.2).

Table 4.1 Percentage of monitoring sites in marine waters per nitrate concentration class (as winter average) in the various reporting periods[1]

Nitrate class (NO_3 in mg/l)	Transitional waters 1992-1995	Transitional waters 2008-2011	Transitional waters 2012-2015	Coastal waters 1992-1995	Coastal waters 2008-2011	Coastal waters 2012-2015	Open sea 1992-1995	Open sea 2008-2011	Open sea 2012-2015
0-10 mg/l	39	50	60	100	100	100	100	100	100
10-25 mg/l	62	50	40						
25-40 mg/l									
40-50 mg/l									
> 50 mg/l									
Number of locations	13	14	15	10	12	12	13	14	12

1 The total percentage may be higher or lower than 100 due to rounding off.

Table 4.2 Percentage of monitoring sites in marine waters with increasing or decreasing nitrate concentrations (as winter average) between various reporting periods[1]

Change	Transitional waters 1992/1995 - 2008/2011	Transitional waters 2008/2011 - 2012/2015	Coastal waters 1992/1995 - 2008/2011	Coastal waters 2008/2011 - 2012/2015
Large increase (> 5 mg/l)				
Small increase (1-5 mg/l)				
Stable (+/- 1 mg/l)	23	71	40	100
Small decrease (1-5 mg/l)	46	29	60	
Large decrease (> 5 mg/l)	31			
Number of locations	13	14	10	12

1 The total percentage may be higher or lower than 100 due to rounding off.

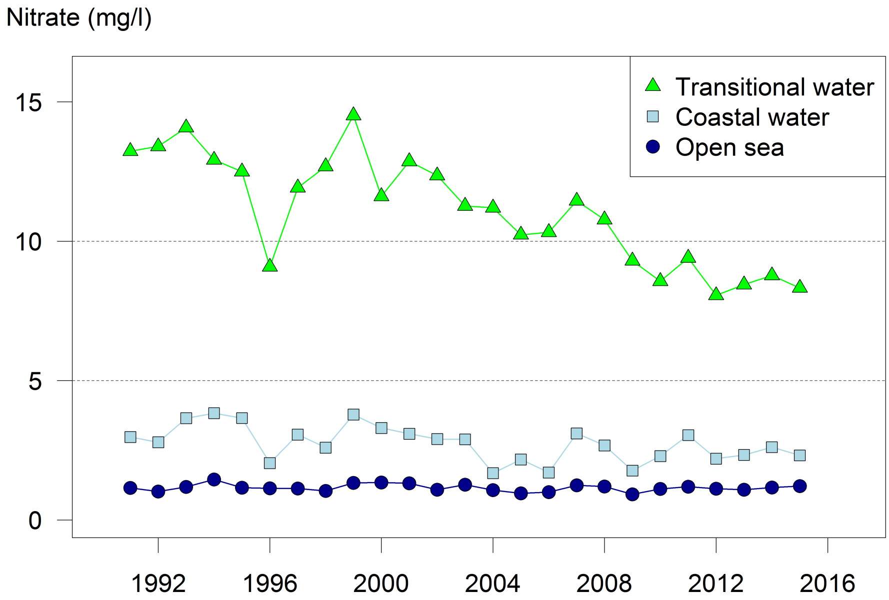


Figure 4.1 Average nitrate concentration in the winter (mg/l) in open sea and in Dutch transitional and coastal waters in the period 1991-2015

The maximum nitrate concentrations measured in the winter reveal the same picture as the winter average concentrations, with the highest concentrations in the transitional waters, where the concentration is, however, declining, and low and stable concentrations in the coastal waters and open sea (Figure 4.2 and Map 4.3). In the last reporting period (2012-2015) the maximum nitrate concentrations in the coastal waters and open sea were also under 10 mg/l (Table 4.3). In the case of the transitional waters the concentrations at approximately half of the measurement locations are under 10 mg/l, but these are still declining (Figure 4.2, Table 4.3, Map 4.4).

Table 4.3 Percentage of monitoring sites in marine waters per nitrate concentration class (as maximum in the winter) in the various reporting periods1

Concentration	Transitional waters			Coastal waters			Open sea		
	1992-1995	2008-2011	2012-2015	1992-1995	2008-2011	2012-2015	1992-1995	2008-2011	2012-2015
0-10 mg/l	15	43	47	90	92	100	100	100	100
10-25 mg/l	62	57	53	10	8				
25-40 mg/l	23								
40-50 mg/l									
> 50 mg/l									
Number of locations	13	14	15	10	12	12	13	14	12

[1] The total percentage may be higher or lower than 100 due to rounding off.

Table 4.4 Percentage of monitoring sites in marine waters with increasing or decreasing nitrate concentrations (as maximum in the winter) between the various reporting periods1

Change	Transitional waters		Coastal waters		Open sea	
	1992/1995-2008/2011	2008/2011-2012/2015	1992/1995-2008/2011	2008/2011-2012/2015	1992/1995-2008/2011	2008/2011-2012/2015
Large increase (> 5 mg/l)						
Small increase (1-5 mg/l)		7	10	17		15
Stable (+/- 1 mg/l)	23	50	30	67	92	69
Small decrease (1-5 mg/l)	15	43	60	8	8	15
Large decrease (> 5 mg/l)	62			8		
Number of locations	13	14	10	12	13	13

[1] The total percentage may be higher or lower than 100 due to rounding off.

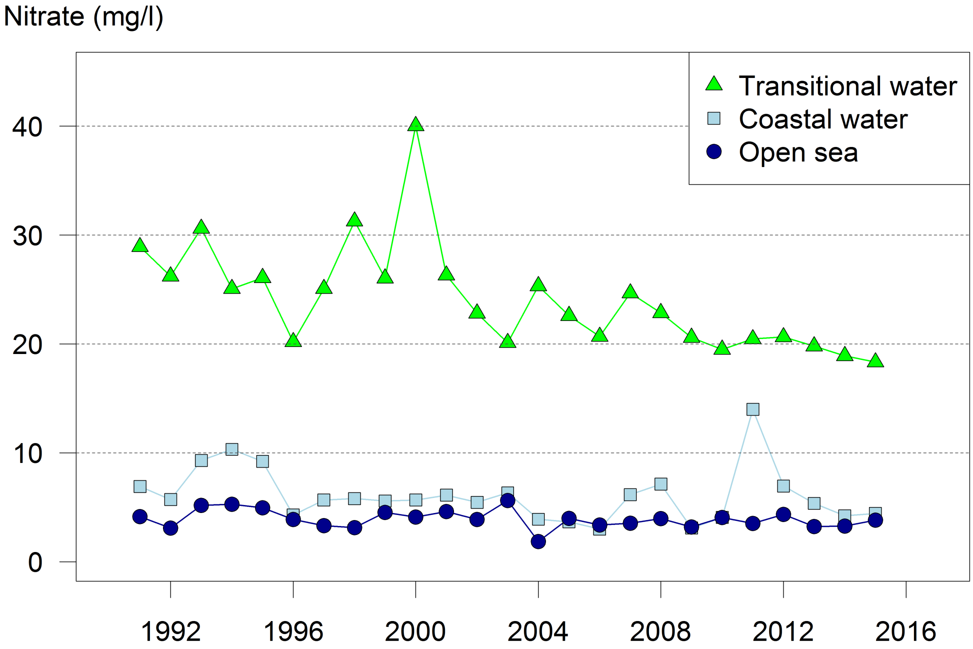


Figure 4.2 Maximum nitrate concentration (as NO_3 in mg/l) in open sea and in Dutch transitional and coastal waters in winter in the period 1991-2015

4.3 The eutrophication of sea and coastal waters

4.3.1 General status

With regard to the marine waters which have been designated as WFD water, 6% is assessed as 'not-eutrophic', 81% as 'potentially eutrophic' and 13% as 'eutrophic' in the period 2011-2013. More recent assessments are unavailable and, therefore, the figures have not been updated. Potentially eutrophic means that the biological status is good, but that the nutrient concentrations do not comply with the WFD water quality standards. A trend cannot be defined because this indicator is new. However, with regard to a number of parameters, which partly determine the eutrophication status, such as the concentration of inorganic nitrogen (DIN) and the chlorophyll-a concentration, the development of the concentration over time can be shown (Figure 4.3 and Figure 4.4).

When determining the eutrophication of fresh waters, including the coastal and transitional waters, an assessment was made of the status of the 'algae' biological quality element (composition of Phaeocystis growth and chlorophyll-a) and nutrients. This is in accordance with the WFD system. It is noticeable here that the biological quality element of phytoplankton was assessed almost everywhere as good (with the exception of the Wadden Sea). However, the eutrophia potential is still present in almost all coastal waters because DIN winter concentrations in coastal and transitional waters are assessed in the WFD assessment as 'poor' or 'moderate.

4.3.2 Inorganic nitrogen

The concentrations of inorganic nitrogen (DIN) in the winter (Figure 4.3), adjusted for the salt content, show the same trend as the nitrate concentrations (Figure 4.1 and Figure 4.2). By way of illustration, the standard for inorganic nitrogen (DIN) in conjunction with a standardised salinity (30 psu) for the winter average (expressed as N) is: 0.46 mg/l in coastal waters.

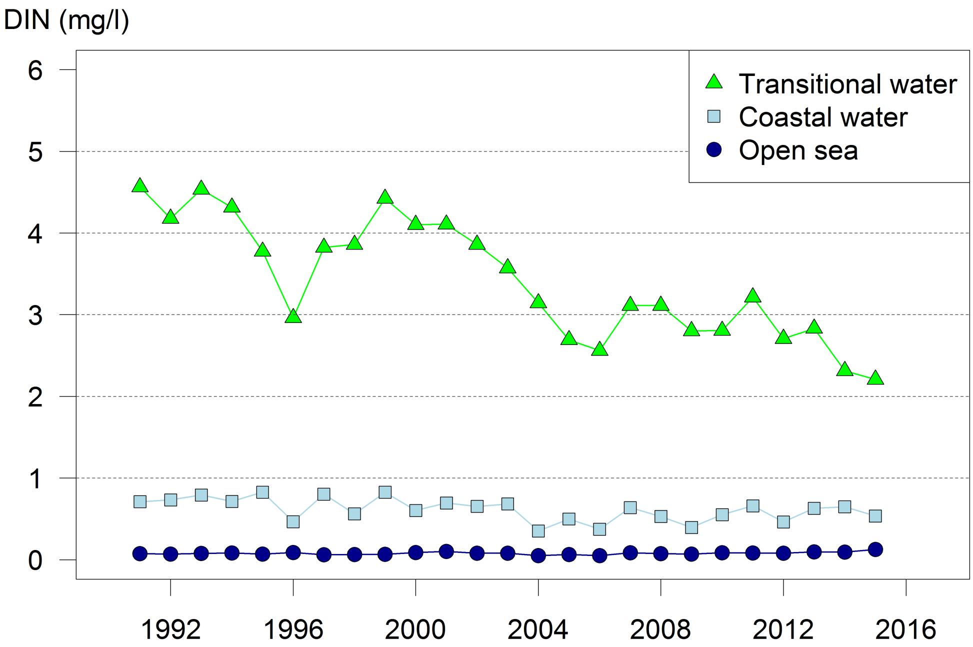


Figure 4.3 Average dissolved inorganic nitrogen concentrations in the winter (DIN, as N in mg/l) in Dutch transitional waters, coastal waters (WFD) and open sea in the period 1991-2015

4.3.3 *Chlorophyll-a*

The summer average (April to September) concentrations are presented for chlorophyll-a. The chlorophyll-a concentrations declined in all types of salt waters between 1992 and 2015 (Figure 4.4). Between 2008 and 2015 the concentrations of the monitoring sites in open sea were more or less stable and were under 5 µg/l (Table 4.5 and Table 4.6). For coastal waters and, to a greater degree, transitional waters a continuing decrease in the chlorophyll-a concentrations to under 10 µg/l occurred during the last two reporting periods.

Table 4.5 Percentage of monitoring sites in marine waters per chlorophyll-a concentration class (as summer average) in the various reporting periods[1]

Concentration	Transitional waters 1992-1995	Transitional waters 2008-2011	Transitional waters 2012-2015	Coastal waters 1992-1995	Coastal waters 2008-2011	Coastal waters 2012-2015	Open sea 1992-1995	Open sea 2008-2011	Open sea 2012-2015
0-2.5 µg/l							38	53	57
2.5-8.0 µg/l	17	54	79	20	42	58	25	33	36
8.0-25 µg/l	83	39	21	80	50	33	38	13	7
25-75 µg/l		8	0		8	8			
> 75 µg/l									
Number of locations	12	13	14	10	12	12	16	15	14

[1] The total percentage may be higher or lower than 100 due to rounding off.

Table 4.6 Percentage of monitoring sites in marine waters with increasing or decreasing chlorophyll-a concentrations (as summer average) between the various reporting periods[1]

Change	Transitional waters 1992/1995-2008/2011	Transitional waters 2008/2011-2012/2015	Coastal waters 1992/1995-2008/2011	Coastal waters 2008/2011-2012/2015	Open sea 1992/1995-2008/2011	Open sea 2008/2011-2012/2015
Large increase (> 5 µg/l)	8					
Small increase (1-5 µg/l)						
Stable (+/- 1 µg/l)	42	92	60	100	73	100
Small decrease (1-5 µg/l)	50	8	40		27	
Large decrease (>5 µg/l)						
Number of locations	12	13	10	12	15	13

[1] The total percentage may be higher or lower than 100 due to rounding off.

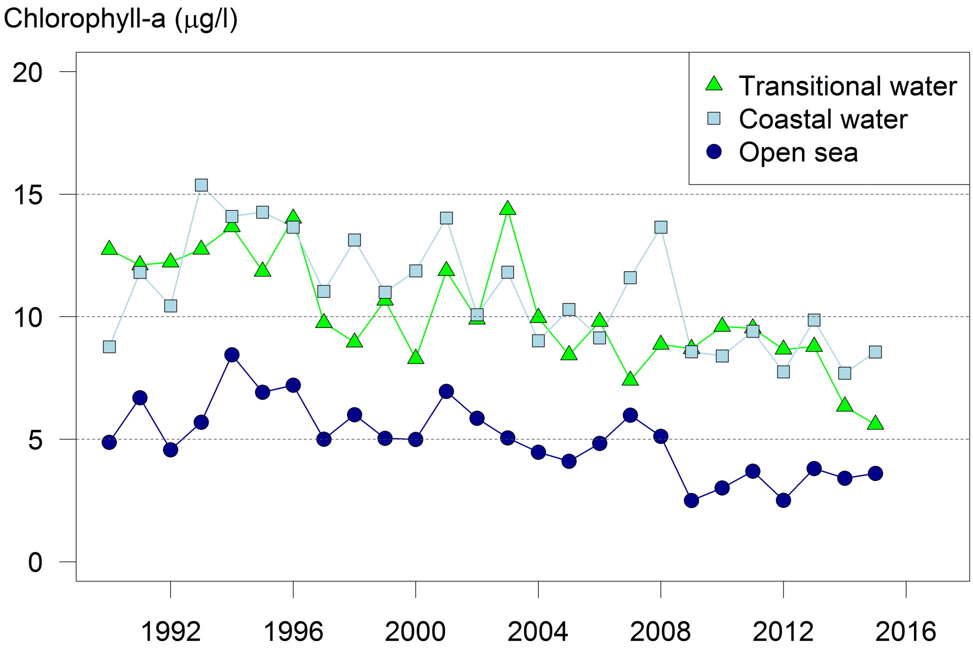


Figure 4.4 Average chlorophyll-a concentration (µg/l) in the summer in open sea and in Dutch transitional and coastal waters in the period 1990-2015

4.4 Trend in agricultural practice and quality of salt surface water

Concentrations of nitrate, as winter average and maximum, and of inorganic nitrogen (DIN) are decreasing continually. The decrease is strongest in transitional waters and to a lesser extent in coastal waters and in open sea. This downward trend has also been revealed by calculating aggregated trend lines (using the LOWESS method; see Klein and Rozemeijer, 2015) for the three different types of salt surface waters: transitional waters, coastal waters and open sea (Figures 4.5 to 4.7). A description of the calculation method can be found in paragraph 2.6.3 of the 2016 report (Fraters et al., 2016), whereby individual measurements are used. Using an aggregated trend line an insight is obtained as to whether a trend steepens or flattens over time. The bandwidth between the 25 and 75 percentile LOWESS indicates the concentration level within which 50% of the measurements can be found. The decrease in nitrate concentration (winter measurements) is strongest in the case of transitional waters.

Although a comparison of the trend lines for the nitrate concentrations in the winter for transitional waters (Figure 4.5) and the changes to the winter average nitrate concentration (Figure 4.1) reveals the same picture, the concentrations differ and are higher in conjunction with the trend line (medians) than in conjunction with the average values in the concentration changes. As regards the coastal waters and open sea the concentrations of Figures 4.1 and 4.5 are comparable.

In the case of marine waters as well, the nitrate concentrations are too high almost everywhere in the WFD marine waters, despite the downward trend. Eutrophication effects are visible in the biology in the case of 13% of the waters, while in the case of 81% of the waters, the biology is acceptable despite the excessively high dissolved nitrogen concentrations. This probably means that other factors, such as limited light or grazing by plankton, or nutrients other than nitrogen, are ensuring that the biomass of algae does not indicate eutrophic circumstances.

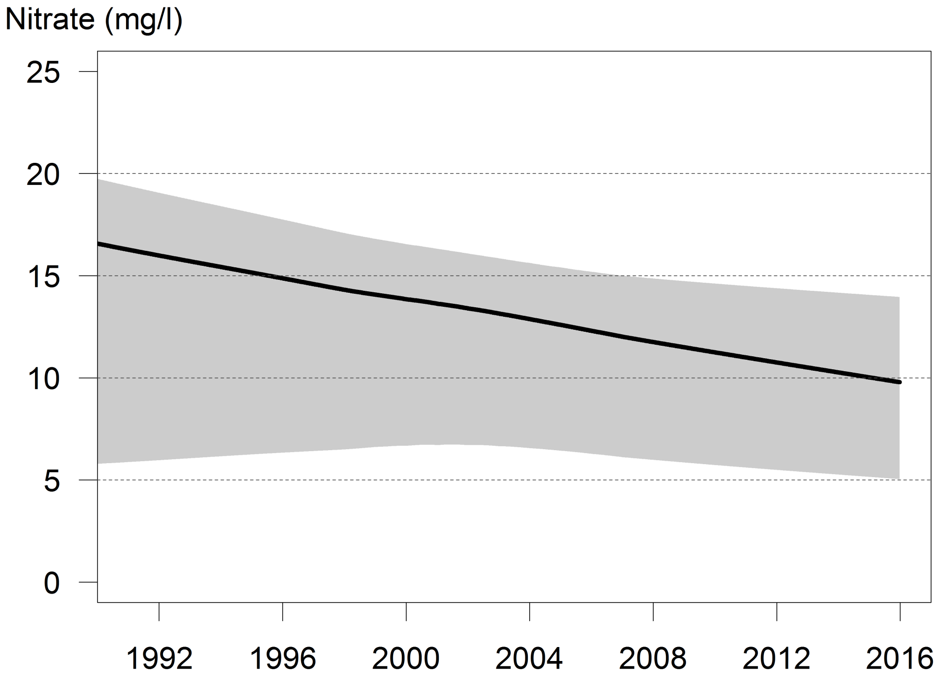


Figure 4.5 Calculated trend for the nitrate concentration (winter measurements; as NO_3 in mg/l) for WFD transitional waters; median trend (continuous line) and the area between the 25th and 75th percentile trends (grey area)

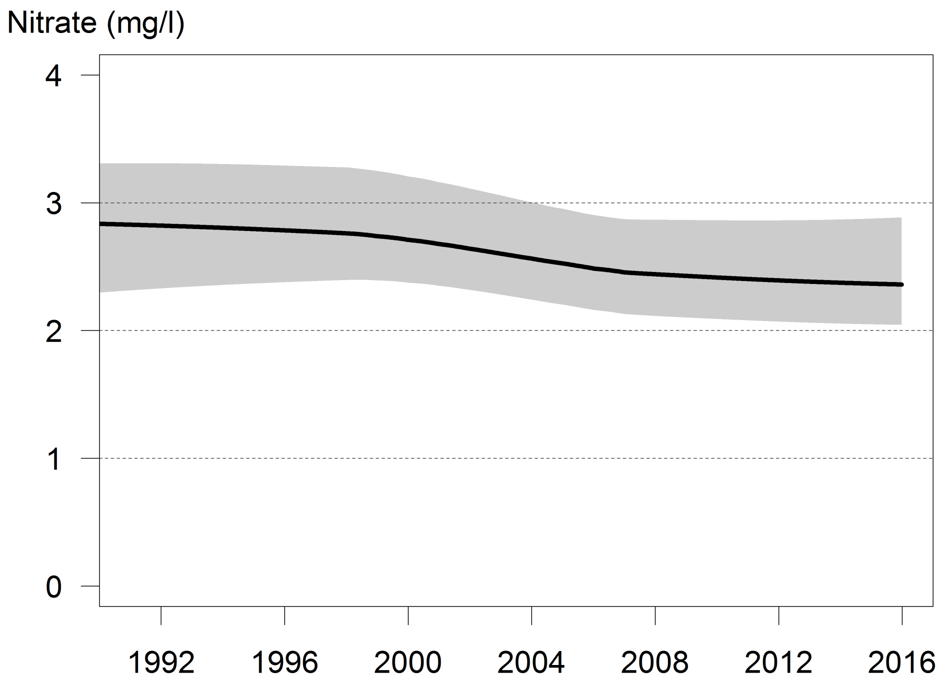


Figure 4.6 Calculated trend for nitrate concentration (winter measurements; as NO_3 in mg/l) for coastal waters; median trend (continuous line) and the area between the 25th and 75th percentile trends (grey area)

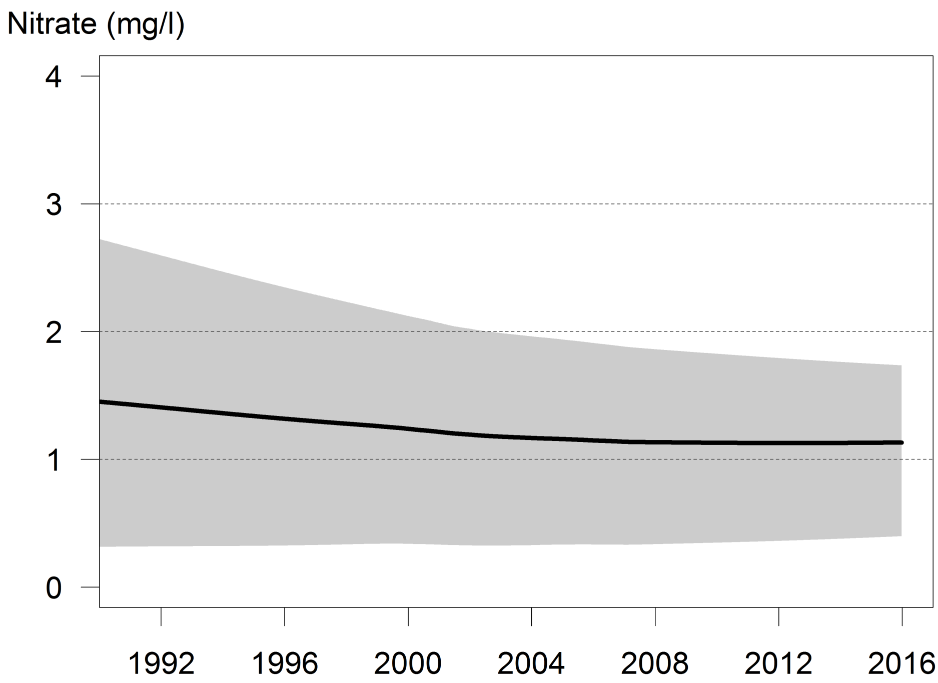
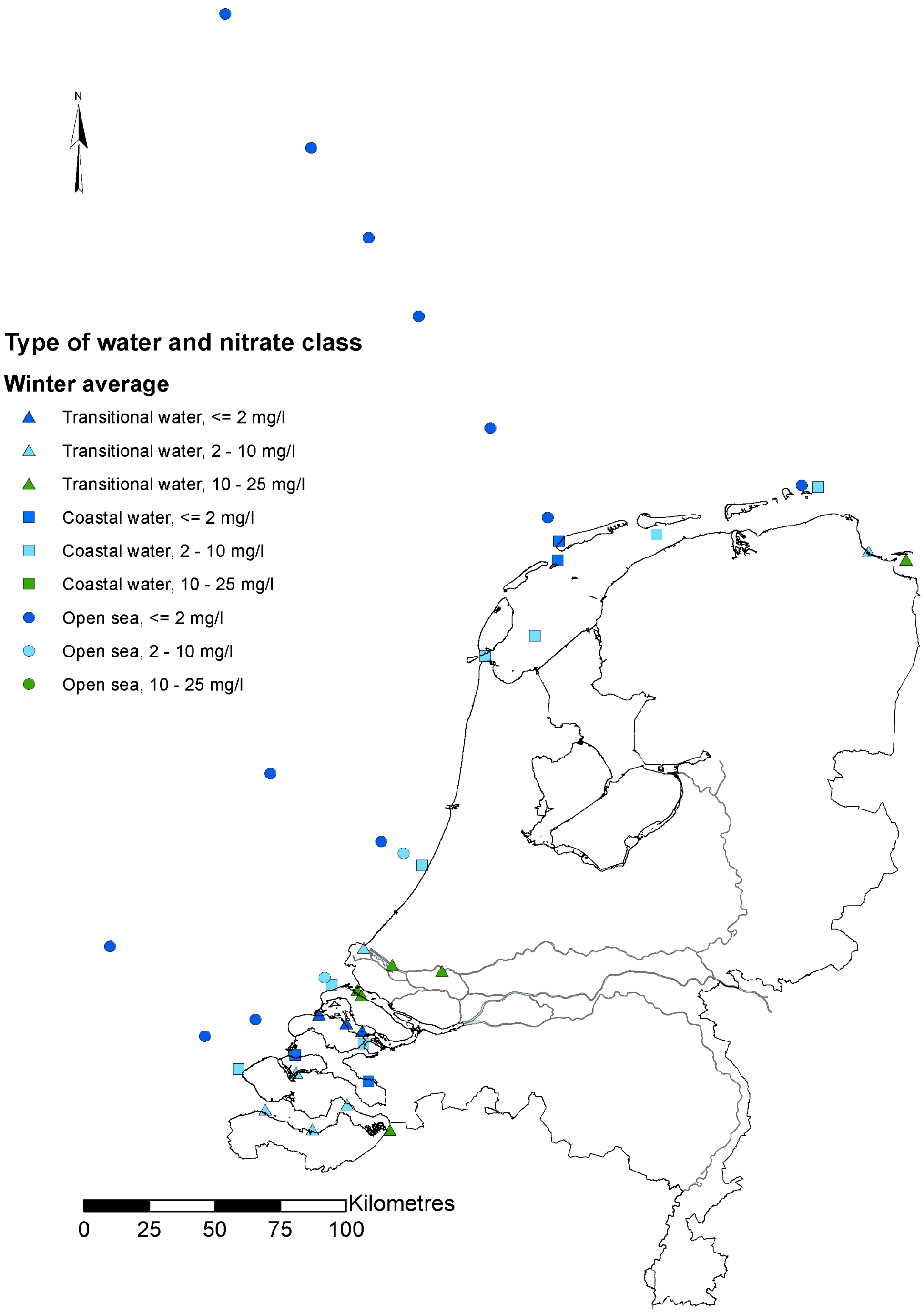
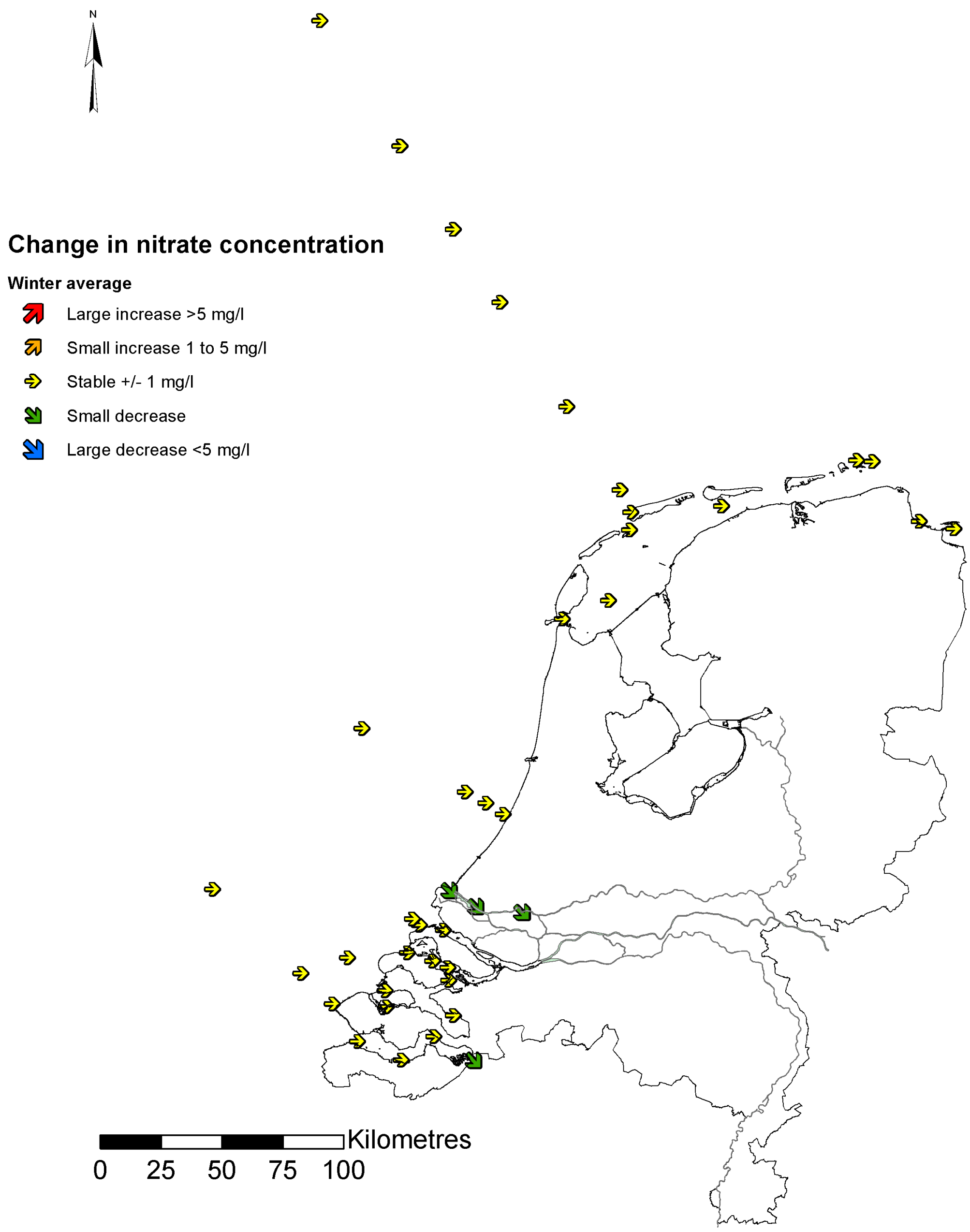


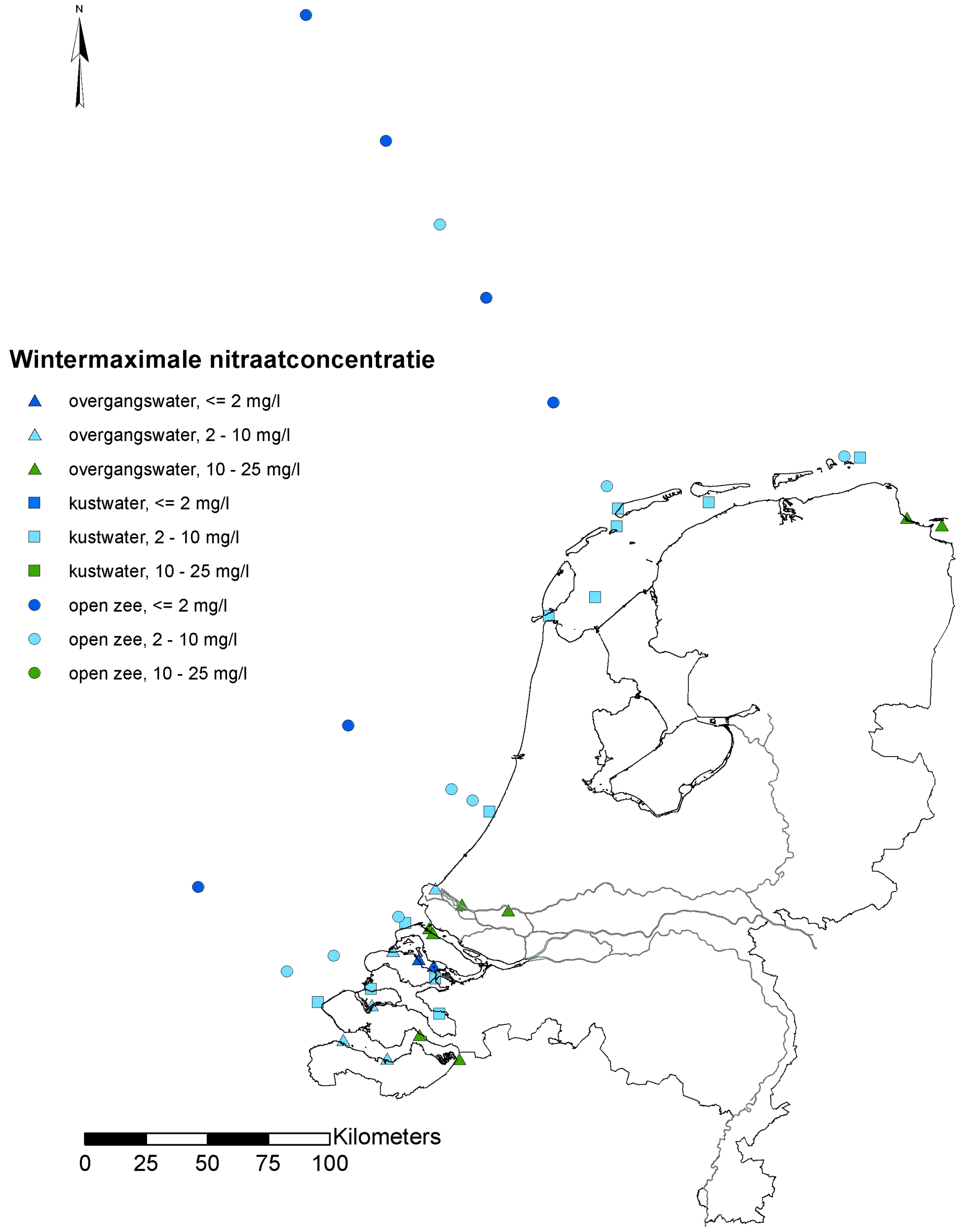
Figure 4.7 Calculated trend for nitrate concentration (winter measurements; as NO3 in mg/l) for open sea locations; median trend (continuous line) and the area between the 25th and 75th percentile (grey area)



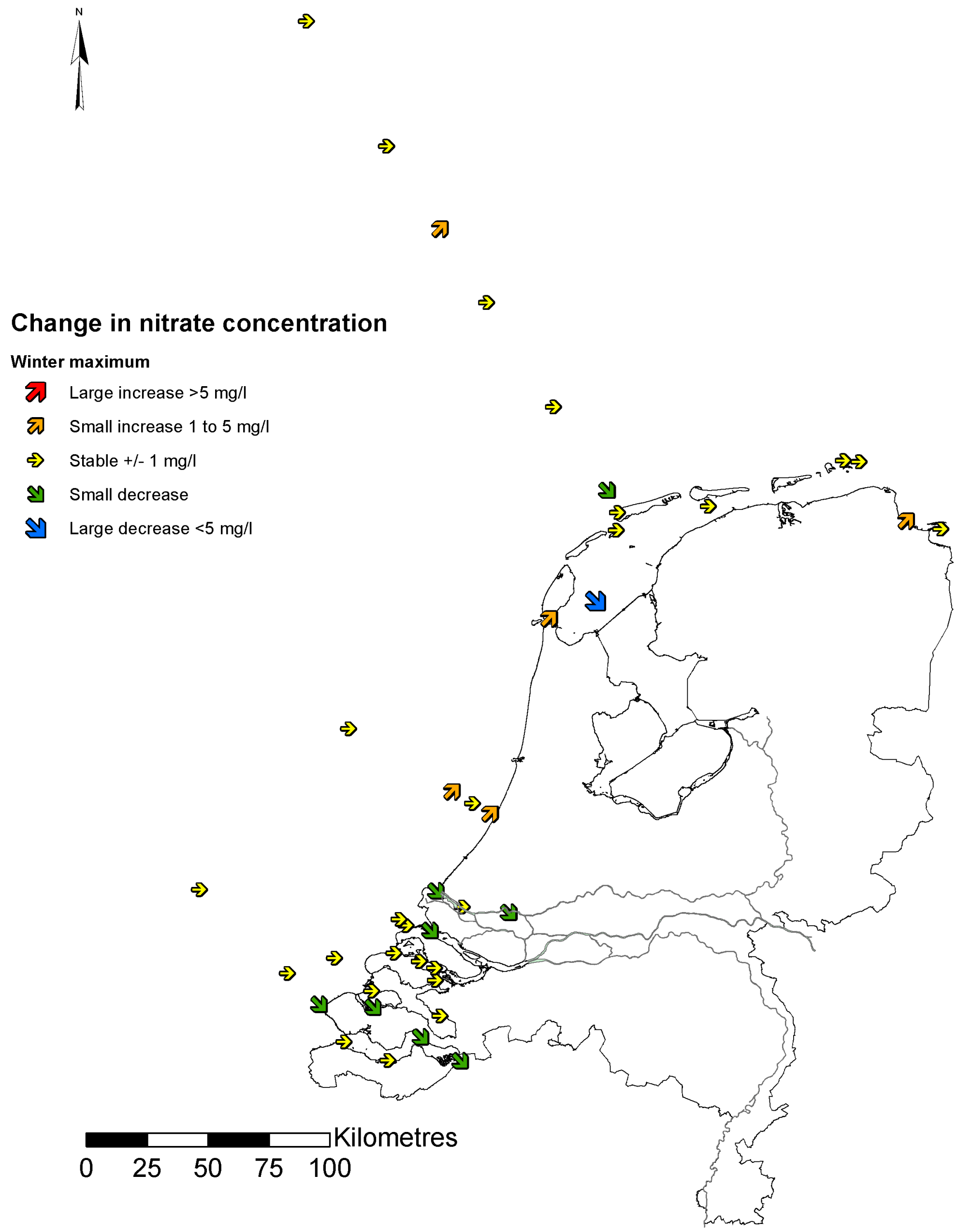
Map 4.1 Winter average nitrate concentration in Dutch coastal and transitional waters and open sea per measurement location in the period 2012-2015



Map 4.2 Change in the winter average nitrate concentration in Dutch coastal and transitional waters and open sea between 2008-2011 and 2012-2015 per measurement location
The change is shown as the difference between the averages of 2008-2011 and 2012-2015.



Map 4.3 Winter maximum nitrate concentration in Dutch coastal and transitional waters and open sea per measurement location in the period 2012-2015



Map 4.4 Change in the winter maximum nitrate concentration in Dutch coastal and transitional waters and open sea between 2008-2011 and 2012-2015 per measurement location
The change is shown as the difference between the averages of 2008-2011 and 2012-2015.

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Annex 1

Improvements compared to the 2016 report

In the present report not only includes figures for 2015 but also a number of improvements compared to the report published in 2016 (Fraters et al., 2016).

Groundwater

For groundwater (chapter 2 in this report) the values reported in the trend figures for the years 2014 may differ slightly in this report from those reported for 2014 in the 2016 report. This is due to the procedure which was developed to adjust for missing values. This occurs primarily in the case of groups for which there are few observations.

In 2016 one measuring point was included that was excessively influenced by the local circumstances and it should have been removed for that reason. This was a measuring point in the shallow groundwater (5-15 m) close to a river. It was eventually removed. Four monitoring sites appeared to be influenced by agriculture but were not included as such in the report in 2016. These were for monitoring sites in medium-deep groundwater (15-30 m). This has been rectified.

An error was made in 2016 when creating map 5.4. This error has been rectified so that the current map 2.4 contains the correct information and the number of increases and decreases is in accordance with those given in Table 2.5.

The number of monitoring sites in the Sand Region reported per sand area is now based on the classification into four sand areas (North, Central, South and West). The number for Sand West is not stated in the tables because it was so low. In the 2016 report the numbers were still based on a classification into three areas (North, Central and South). In 2016 the figures were already based on the classification into four areas.

When creating the maps for the water quality at drinking water production locations (groundwater at a depth of more than 30 m) the locations where no data was available for the period 1992-1995 have now also been included, albeit for the last two reporting periods (2008-2011 and 2012-2015). As a result, the map in this report contains more locations than the map in the 2016 report.

Surface water

For surface water (chapters 3 and 4 in this report) nitrate concentrations were calculated based on the difference between the concentration of nitrate + nitrite and the concentration nitrite for locations when no data was available for nitrate, insofar as this information was available. As a consequence, the number of nitrate observations in this report is higher than in the 2016 report.

In the 2016 report it transpired that almost 30 locations had been wrongly designated as measuring site for the monitoring network for the Water Framework Directive, and were therefore regarded as WFD locations. In addition, one freshwater location was wrongly allocated to transitional waters in the 2016 report. Moreover, the wrong figures were stated in Table 7.4 for transitional and coastal water and in Table 7.6 for open sea. This has been rectified and the points for improvement referred to have been implemented in this current addendum.

Compared to Figure 7.3 from the 2016 report, Figure 4.3 differs in the case of transitional waters. The slight increase in the inorganic nitrogen DIN concentrations in transitional waters presented for the last years has been changed into a clear decrease. In addition, the concentrations were higher than previously reported.

The trend lines presented in the current report have been calculated using the LOWESS method, based on the entire time series, so also with measurement data from before 1990. In the 2016 report the trend lines were calculated using data since 1990. As a result, there are clear differences for agriculture-specific waters between Figure 3.7 in this report and Figure 6.7 in the 2016 report.

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