Ministry of Green Transition
Agency for Green Transition
and Aquatic Environment

# Status and trends of the aquatic environment and agricultural practice in Denmark

## Report to the European Commission for the period 2020-2023 in accordance with article 10 of the Nitrates Directive (1991/676/EEC)

Editor: The Ministry for Green Transition

Authors/responsible institutions of the different chapters of this report can be found under the heading to the respective chapters. Where no one is mentioned it is the Ministry for Green Transition

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# 1. Introduction

Council Directive 91/676/EEC aims to protect waters against pollution caused or induced by nitrates from agricultural sources.

According to Article 10 in the Nitrates Directive Member States shall, in respect of the four-year period following the notification of this Directive and in respect of each subsequent four-year period, submit a report to the Commission containing the information outlined in the Directives Annex V.

The aim of the present report is to give a status and trend in the aquatic environment and agricultural practice, compared to previous reporting period and as well evaluate the impact of the action programme.

On the basis of the information received pursuant to Article 10, the Commission shall publish summary reports and shall inform the European Parliament and the Council on the state of the implementation of the Nitrates Directive, in accordance with article 11. The summery report will be based on the information submitted by Member States referring to the period 2019-2023 and is accompanied by aggregated maps of nutrient pressures from agricultural sources, of water quality and of designated nitrate vulnerable zones.

In Denmark, tasks related to the Nitrates Directive have been divided between the Ministry of Environment and the Ministry of Food, Agriculture and Fisheries of Denmark, such that the monitoring of water quality primarily fell under the Ministry of Environment, while compliance with the Nitrate Action Programme was the responsibility of the Ministry of Food, Agriculture and Fisheries of Denmark. Following the Agreement on the Green Transition of Danish Agriculture from October 2021 and the Agreement on a Green Denmark from June 2024, a new Ministry of Green Transition was established on August 29, 2024. The new ministry now handles all tasks related to the Nitrates Directive, including this report. Authors/responsible institutions of the different chapters of this report can be found under the heading to the respective chapters. Where no one is mentioned it is the Ministry for Green Transition

# 2. Summary

## 2.1. Watercourses

The report summarizes nitrate data from Danish watercourses, extracted from the ODA database for the period 2020-2023. Nitrate concentrations were analyzed across 443 stations, focusing on flow-weighted averages for annual and winter periods. A minimum of seven samples per year is required for a reliable annual average. Results show that 97% of stations experienced stable or declining nitrate levels, continuing a long-term trend of nitrate reduction since 1989.

From 2016-2019 to 2020-2023, nitrate concentrations decreased in 55% of watercourses, with stronger reductions seen during winter. Only a small fraction (3%) showed increases. Eutrophication indicators were monitored, but Danish streams are generally too small for planktonic algae growth, so the focus remained on nutrient loading in lakes and coastal waters.

## 2.2. Lakes

In general, annual average nitrate concentrations are low – compared to the Nitrates Directive limit on 50 mg/l: 45 % of the lakes have an annual mean concentration less than 2 mg $NO_3^-$/l.

Despite the nitrate concentrations are influenced by climatic conditions (such as precipitation), there are no changes from the 7th and 8th period for the majority of lakes. The concentration levels are stable in 85 % of the monitored lakes. The annual average nitrate concentrations in the 8th period (2020-2023) in Danish lakes range from 0.05-19.6 mg $NO_3^-$/l with an average of 3.6 mg $NO_3^-$/l.

Winter average concentrations are generally higher than the annual average concentrations (63 out of 65 lakes) and vary between 0.08 and 34.02 mg $NO_3^-$/l with an average of 6.4 mg $NO_3^-$/l. This is due to higher loading, low primary production and less denitrification during winter. The maximum concentrations vary between 0.08 and 62.0 mg $NO_3$-/l. One lake had a maximum concentration above 50 mg $NO_3$-/l.

## 2.3. Estuarine, coastal and marine waters

During the 8th period (2020-2023) the highest average $NO_3^-$ winter concentrations were observed in coastal waters with a maximum average concentration of 11 mg $NO_3^-$/l and with the lowest concentrations monitored in the open marine waters, where the average $NO_3^-$ concentration did not exceed 0.4 mg $NO_3^-$/l.

For annual averages, long-term trends (difference between 2020-2023 and 1996-1999) and short- term trends (difference between 2020-2023 and 2016-2019) were calculated for 52 and 62 monitoring stations, respectively. For long-term trends (annual averages), concentrations are stable at 27 stations, while a weak and strong decrease in concentrations are observed on 17 and 6 stations, respectively. For short-term trends (annual averages), the concentrations are stable at 52 stations, while a weak and strong decrease in concentrations are observed on 8 and 1 stations, respectively. The calculations showed only an increase at 2 stations (long-term) and 1 station (short-term).

For winter averages, long-term trends and short-term trends can be calculated for 69 and 79 stations, respectively. For long-term trends (winter averages), concentrations are stable at 38 stations, while a weak and strong decrease in concentrations are observed at 16 and 8 stations, respectively. For short-term trends (winter averages), concentrations are stable at 65 stations, while a weak and strong decrease in concentrations are observed at 7 and 4 stations, respectively.

Fifty-five of the 79 marine monitoring stations included in the 8th reporting under article 10 of the Nitrates Directive, represented 55 water bodies assessed under the WFD. Out of the 55 water bodies, 3 were in the third RBMP (2021-2027) classified as non-eutrophic based on nutrient sensitive biological quality elements, while the remaining 52 were classified as eutrophic.

## 2.4. Groundwater

The Danish groundwater-monitoring program was originally designed to monitor recent groundwater recharged after approx. 1940. Implementation of the Water Framework Directive has required adjustments of the groundwater-monitoring network and thus some monitoring points used for previous reporting periods have been terminated and new monitoring points established during the previous reporting periods. This adjustment of the monitoring network was finalised in 2019. This means that the current reporting period has nearly the same monitoring network as the previous 2016-2019.

The monitoring programme is adjusted every 6th year, and recently the whole programme (Surface waters, marine waters, groundwater etc.) has been subject to a “fit for purpose” analysis. This resulted in a streamlining of the network assigned for the nitrates directive, so only monitoring points relevant to agricultural pressures are to be used in monitoring and reporting for the nitrates directive. A cutoff at less than 25% agricultural area within a 200 m circle around the individual monitoring points was used to delineate the relevant monitoring points.

This reporting focus mainly on the last 12 years, i.e. over the last three reporting periods, where groundwater from in total 1,151 monitoring points have been analysed for nitrate over time and of those 868 points are common for the three periods (2012-2015, 2016-2019 & 2020-2023).

When comparing the average nitrate concentrations of 996 monitoring points common for the latest two reporting periods (2016-2019 & 2020-2023), decreasing groundwater nitrate concentrations (29.4%) can be found in more monitoring points than increasing concentrations (18.4%) while no trend can be observed at 52.2% of the monitoring points. The major part (77.9%) of the monitoring points has an average nitrate concentration below 40 mg/l, as shown in Figure 3.17, where the distribution of the average nitrate concentrations in all monitoring points (2020-2023) is illustrated. In general, both increasing and decreasing trends can be found all over the country.

When comparing with the first reporting period a clear decrease in nitrate is identified.
Table **3.20** shows that of the 369 common monitoring points 50% had a decreasing trend, while only 15% has an increasing trend.

Groundwater from a large number of monitoring points has been dated with CFC (chlorofluorocarbon) and recently tritium/helium, where possible. These data have been used to assess the general nitrate trend in oxic groundwater in Denmark (Figure 3.26 and Figure 3.27, Hansen et al., 2017). The results indicate an overall deceasing nitrate trend in Danish oxic groundwater during the last almost 30 years, which can be assigned to reduced nitrate leaching from Danish agricultural activities since the 1980ies. The overall trend in regard to reducing the groundwater nitrate content is generally positive, but several locations still record increases (Figure 3.23, Hansen et al., 2017) and/or nitrate concentrations above the threshold value of 50 mg/l. This includes some of the most recently infiltrated groundwater, which originates from after the implementation of consecutive national environmental action plans. The monitoring data for nitrate in oxic groundwater indicate that the nitrate content in the youngest groundwater remains stable over approx. the last 10 years (Thorling et al, 2024).

## 2.5. Nitrate Vulnerable Zones

Denmark is, according to Article 3 (5), exempt from the obligation to identify specific vulnerable zones, as Denmark has established and applied the action programme throughout the whole national territory.

## 2.6. Code of good practice

Measures according to code of good practice pursuant to the Nitrates Directive, annex II, are included in the Nitrate Action Programme as mandatory measures equivalent to the measures included in the programme pursuant to the directive, annex III. Description of the measures according to code of good practice is therefore included in the description of the Nitrates Action Programme.

## 2.7. Nitrates Action Programme

An overview of the implementation of Annex II and Annex III of the Nitrates Directive as mandatory measures in the Danish Nitrate Action Programme in 2023 is given in chapter 6 of this report. The specific measures are described for each litra in the directive, annex II and annex III and measures according to the directive art. 5 (5), respectively.

The overview of the implementation of the Nitrates Directive as described in the Nitrates Action Programme is given of the legal texts valid by the end of 2023. Changes in the implementation of the directive during the reporting period are described for each element in the overview. In general, it has primarily been technical changes that have been amended to the programme during 2020-2023

## 2.8. Evaluation of the implementation and impact of the action programmes' measures

The amount of Nitrogen, which has been discharged to the sea in the years 2019 to 2022, was within a similar range as in the previous reporting period. For the loamy catchments, modelled annual nitrate leaching was relatively stable around 40 kg N $ha^{-1}$ during the period 2003-2014 decreasing to a level below 40 kg N $ha^{-1}$ in the period 2015-2022. For the sandy catchments, the modelled annual nitrate leaching was relatively stable around 67-68 kg N $ha^{-1}$ during the period 2003-2022.

In the Agricultural Catchment Monitoring Programme (LOOP) on loamy catchments, the measured nitrate concentrations in the upper oxic groundwater decreased from 40-47 mg $NO_3$ $l^{-1}$ in the 5-year period 1990/91-1994/95 to 33-39 mg $NO_3$ $l^{-1}$ in the 5-year period 2017/18-2021/22. On sandy catchments, the nitrate concentration decreased from 87-112 (±27-65) mg $NO_3$ $l^{-1}$ in the 5-year period 1990/91- 1994/95 to 54-83 (±24-46) mg $NO_3$ $l^{-1}$ in the 5-year period 2017/18-2021/22.

The annual nitrogen surplus in the national field balance (added minus harvested) has fallen: from approx. 405,000 tons N in 1990 to 199,700 tons N in 2022, which corresponds to a reduction of approx. 51%.

## 2.9. Control and inspection

The Danish Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures and associated statutory orders regulate crop rotation, fertilizer planning, and manure use, with a focus on reducing nutrient loss and protecting water bodies. The Agency for Green Transition and Aquatic Environment (formerly: The Danish Agricultural Agency) oversees compliance through administrative and on-site inspections. In the 2020/2021 planning period, 683 controls were conducted, with a small percentage of farms violating nitrogen quotas or manure application rules. Minor violations received warnings, while serious cases led to fines or police reports.

In 2017 a new scheme on livestock catch crops was introduced. The individual requirement to establish catch crops for holdings using organic manure such as livestock manure was aimed at ensuring the sufficient protection towards nitrogen leaching to sensitive Natura 2000-areas in catchment areas, where the amount of applied organic manure has increased since 2007 and at contributing to the reduction of nitrogen leaching to coastal water bodies, where a reduction of nitrate leaching is necessary in order to obtain the environmental objective according to the River Basin Management Plans (RBMP).

In 2023, the agency conducted 93 inspections for catch crops, with fewer violations compared to 2019. The overall compliance rates have improved, due to a stricter sanctioning with fines and potentially further reductions in overall agricultural support (due to cross-compliance/conditionality), whereas previously, it involved a reduction in the nitrogen quota and an earlier calculation of the catch crop requirements, so the actual requirements are known before the establishment of the catch crops.

## 2.10. Cost effectiveness

Institute of Food and Resource Economics (IFRO), University of Copenhagen analyses Denmark's efforts to reduce nitrogen (N) losses in agriculture from 2020 to 2023.

Key measures include increasing nitrogen utilization in animal manure by 5%, leading to a reduction in mineral fertilizer use by 15,000 tons N annually (from 2019/2020) compared to the two following years.

Analyses have shown that, since the last adjustment in 2003, it was now possible to increase utilisation of N in manure for selected types of manure with limited costs. Around 30% of Denmark’s manure was processed through biogas plants, enhancing nitrogen efficiency.

A significant policy shift came with the 2021 Green Transition Agreement, targeting a 13,100-ton reduction in nitrogen losses by 2027, with 10,400 tons planned through direct actions like catch crops and wetlands. However, collective measures, such as wetlands, mini wetlands, and afforestation, underperformed, achieving only 62% of the target by 2021. Costs for wetlands increased, while phosphorus and potassium usage decreased by 30% due to rising fertilizer prices.

Targeted regulation, introduced in 2019, allowed flexibility for farmers to choose measures such as precision farming and early sowing, though catch crops remained the dominant method. Precision farming now covers 100,000 hectares, but many collective measures still face administrative delays.

The 2020-2023 period continued the transition to more targeted measures, increasing flexibility for farmers to replace catch crops with alternatives of equal environmental impact. Catch crops and early sowing remain key measures, while precision farming has gained popularity. Set-aside and lower nitrogen application are still rarely used. The current targeted regulation approach has been highly effective in ensuring the expected implementation of catch crops or equivalent measures.

### 2.11. Future evolution of the water body quality

The 3rd River Basin Management Plan (RBMP) for 2021-2027 shows that only 5 of 109 Danish coastal water bodies are in good ecological status, mainly due to high nitrogen levels, mostly from agriculture. The RBMP aims to reduce nitrogen loads to 38,300 tons N/year to meet ecological standards, relying on both Danish and international efforts. By 2027, the nitrogen load is forecasted to reach 51,300 tons N/year, with a gap of 13,000 tons N/year needing reduction. In 2021, a political agreement set measures to cut nitrogen by 10,400 tons, with the remaining 2,600 tons to be addressed in 2024. A "Second Opinion" in 2024 suggested the nitrogen reduction need is between 12,900 and 14,100 tons, which was consolidated to 13,800 tons with the political “Agreement on the Implementation of a Green Denmark” from November 2024.

The “Green Tripartite” Agreement of 2024 introduced a historic land reform and restructuring of Danish agriculture to address nitrogen pollution, with measures like afforestation and land conversion, supported by a 40 billion DKK fund. Despite this, the agreement acknowledges that good ecological status in all coastal waters will not be achieved by 2027. Improvements will take time, with some measures expected to be implemented by 2030, and in extreme cases, farm expropriation may be necessary.

Groundwater assessments show that 1,604 of 2,043 groundwater bodies are in good chemical status, with 45 in poor status due to nitrate pollution. Good status for these bodies is expected after 2027. Phosphorus pollution is the main obstacle to good status in lakes, and new measures like improved wastewater treatment are being considered. For rivers, the focus is on physical restoration and removing barriers, though nitrogen measures may also have positive effects.

Overall, the RBMP is set to be updated in 2024-2025 following the Green Tripartite Agreement and the revisit of the 2021 agricultural agreement.

# 3. Water quality: Assessment and maps

## 3.1. Surface water: Watercourses

In Denmark, watercourses are dominated by numerous small streams and only very few larger rivers, which still – on a European scale – have relatively short distance between source and outlet. Therefore, Danish streams are generally not liable to eutrophication, and nitrate constitutes a major part of total nitrogen during all seasons.

### 3.1.1. Presentation of monitoring stations

The maps are based on stations where the annual flow-weighted average concentrations of Nitrate have been calculated. The stations represent both larger and smaller catchment areas, and cover several different types of nutrient sources. Some are located in areas with point sources, while others are only influenced by losses from agricultural activities.

### 3.1.2. Status for nitrate concentrations

Data for nitrate are extracted from the “ODA database”, a database holding monitoring data from watercourses, lakes and marine areas. The extract is made by selecting all watercourse stations in the relevant periods with data for nitrate. Data from analyses marked as "under control" or "academic reservation" are not included. Subsequently, a selection of relevant stations has taken place, which has continuous sampling.

Flow-weighted mean nitrate concentrations (annual and winter value) and max value in streams for the period 2020-2023 shown in **Table 3.1** and in **Figure 3.1** and **Figure 3.2**.

**Table 3.1. Annual and winter average NO3 concentration as well as max NO3 concentration for the period 2020-2023**

| | No of Samples | Avg. Annual Value (mg/l) | Avg. Winter Value (mg/l) | Max Value (mg/l) |
|---|---|---|---|---|
| **Minimum** | **12** | **0.06** | **0.06** | **0.12** |
| **Mean** | 64 | 12.8 | 15.5 | 27.4 |
| **Median** | 72 | 12.0 | 14.7 | 24.6 |
| **Maximum** | **104** | **45.5** | **46.8** | **115** |

In freshwater, the analytical technique used as determined by the method data sheets, and the analysis result is stated as nitrite + nitrate-N. In the vast majority and normal cases, it can be assumed that the concentration of nitrite is vanishingly small, and therefore nitrate-N can be converted via this formula: Nitrate-NO3 (mg / L) = 4.4268 x nitrite + nitrate-N (mg / L).

The average annual values from 443 stations are calculated as the average of all nitrate analyses for each measuring station for each year in the period. However, an average annual value is only calculated if at least 7 samples are taken per year. The number of 7 samples has been chosen to obtain a representative average value of the year's measurements.

Average winter values are the average of all nitrate analyses for each station for each year in the period, in which the sample was taken, from and including first of October and up to and including 31$^{st}$ of March (winter). After this an average has been calculated. This method is used to avoid that individual analyses are included with different weightings in relation to the average, if the sampling frequency has varied within the 4-year period.

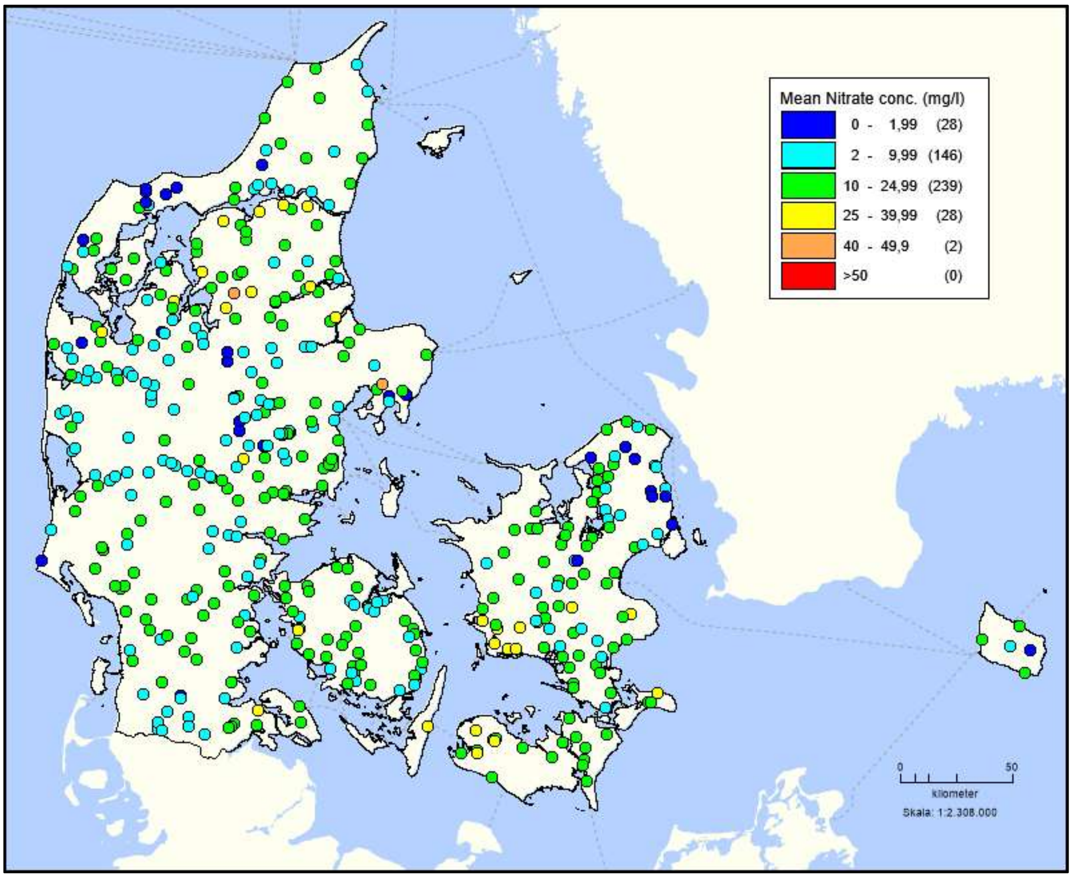


**Figure 3.1. Mean nitrate concentration in watercourses during the current reporting period (2020-2023)**

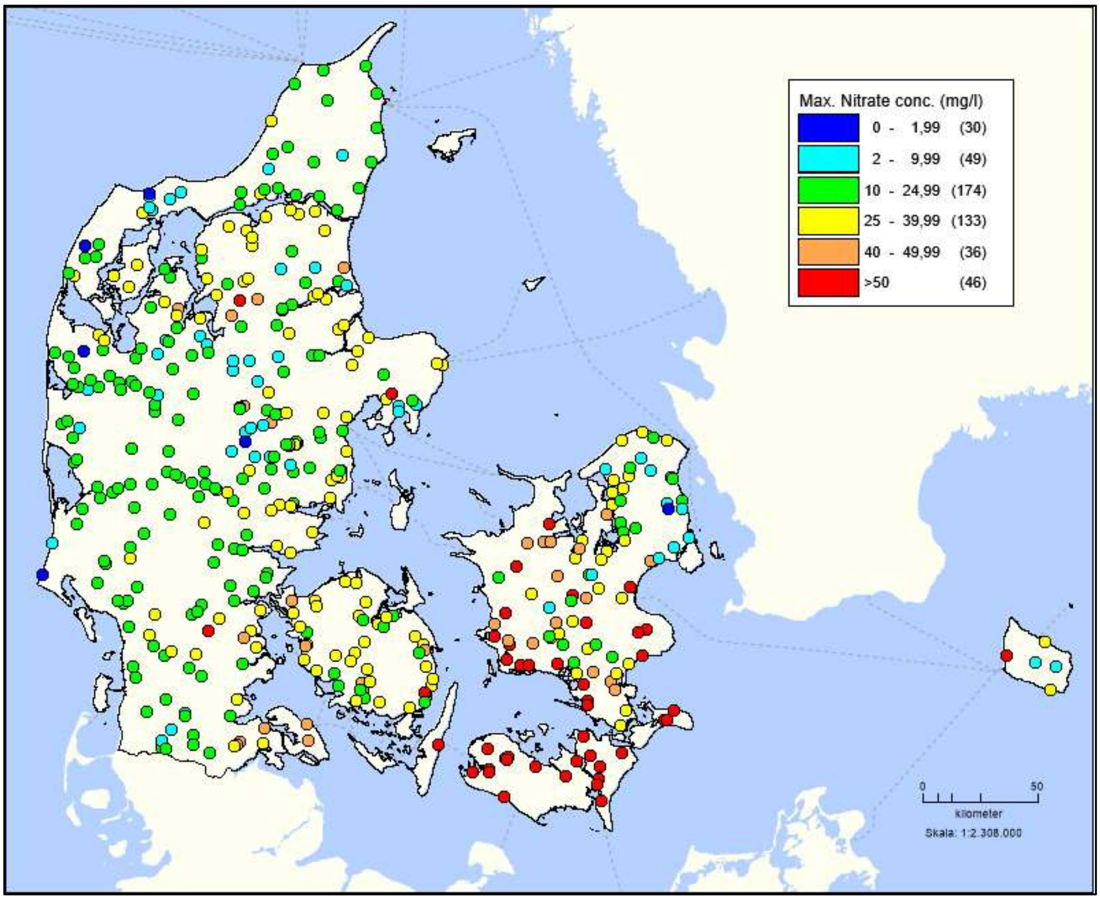


**Figure 3.2. Max nitrate concentration in watercourses during the current reporting period (2020-2023)**

### 3.1.3. Trend in nitrate concentrations

As nitrate concentrations are very dependent on precipitation and run-off, conclusions regarding changes between two specific periods should be drawn with caution. Although the use of flowweighted annual mean and inter-mean concentrations reduces the climate dependency, it does not completely eliminate it.

In the 2008-2011 reporting, most monitoring stations displayed lower nitrate concentrations compared to the previous period. In the 2012-2015 reporting, the changes were minor and in both directions. In the 2016-2019 reporting, the nitrate concentrations were stable for most stations, although there appeared to be an increasing trend at some monitoring stations. The most recent period (2020-2023) shows that almost all stations (97%) have had a stable or decrease in nitrate concentrations.

Long-term time-series and statistical tests on flow-weighed concentrations show that there have been significant reductions in both nitrate and total nitrogen concentrations since the implementation of the nationwide Danish monitoring programme in 1989. **Table 3.2** shows changes in nitrate concentrations between the two periods 2016-2019 and 2020-2023.

**Table 3.2. Changes in annual and winter average NO3 concentration in streams from the previous period (2016-2019) to the current period (2020-2023)**

| ($NO_3$) Trend | | Change in nitrate | Numbers annual average | Percentage (%) annual average | Numbers winter average | Percentage (%) winter average |
|---|---|---|---|---|---|---|
| Increasing | Strong | > +5 mg/l | 0 | 0.0 % | 1 | 0.3 % |
| | Weak | > +1 and ≤ +5 mg/l | 11 | 3.0 % | 7 | 2.0 % |
| Stable | | ≥-1 and ≤+1 mg/l | 150 | 42.0 % | 109 | 30.6 % |
| Reduction | Weak | > -1 and ≤ -5 mg/l | 182 | 51.0 % | 198 | 55.6 % |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Strong | < -5 mg/l | 14 | 4.0 % | 41 | 12.0 % |

Long-term time series and statistical trend tests show that there have been significant reductions in both flow-weighted nitrate and total nitrogen concentrations since 1989.

Changes in flow-weighted nitrate concentrations between the previous period (2016-2019) and the current period (2020-2023) show a significant reduction for the average nitrate concentration. In 55% of the watercourses, there has been a weak or strong reduction in the flow-weighted values. The percentage is slightly higher (68%) regarding the winter average.

There has only been an increase in 3.1 % of the watercourses (2.3 % for the winter average), and in 41 % of the watercourses, the concentrations are unchanged (31 % for winter average).

Changes in mean nitrate and winter average concentrations in watercourses between the previous and current period (2016-2019 and 2020-2023) are shown in **Figure 3.3** and **Figure 3.4**.

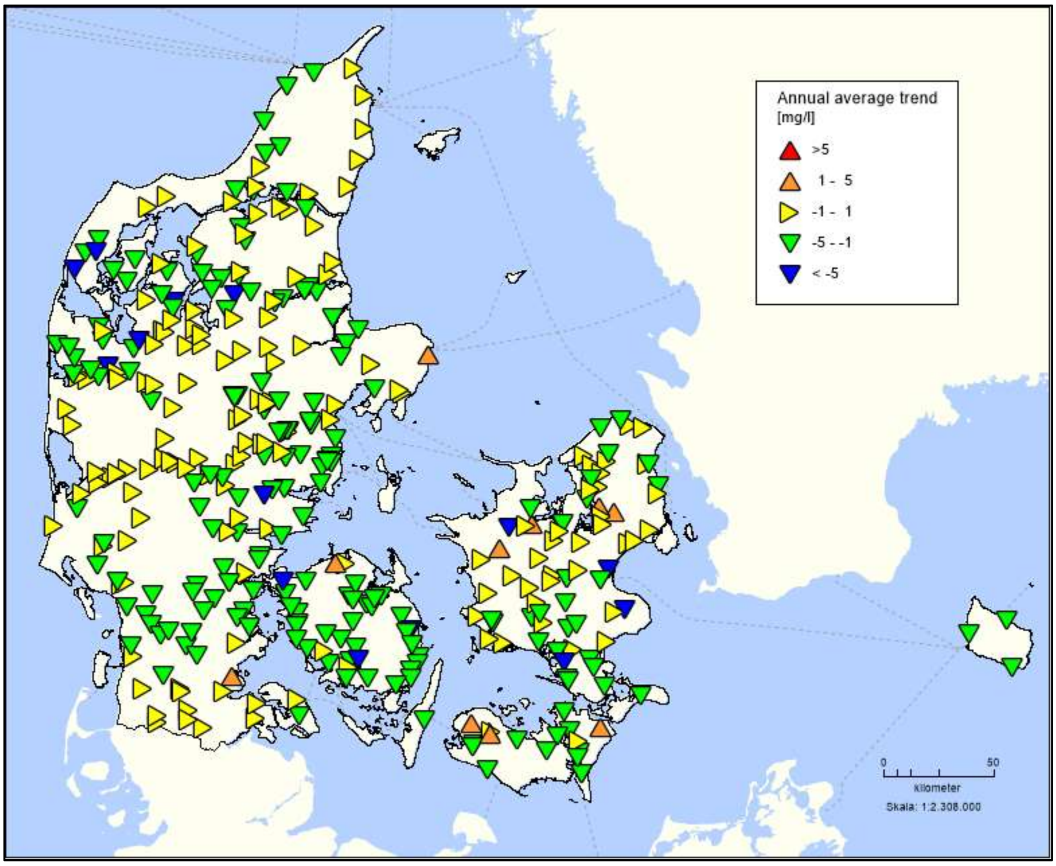


**Figure 3.3. Changes in mean nitrate concentration in watercourses from the previous to the current period (2016-2019 to 2020-2023)**

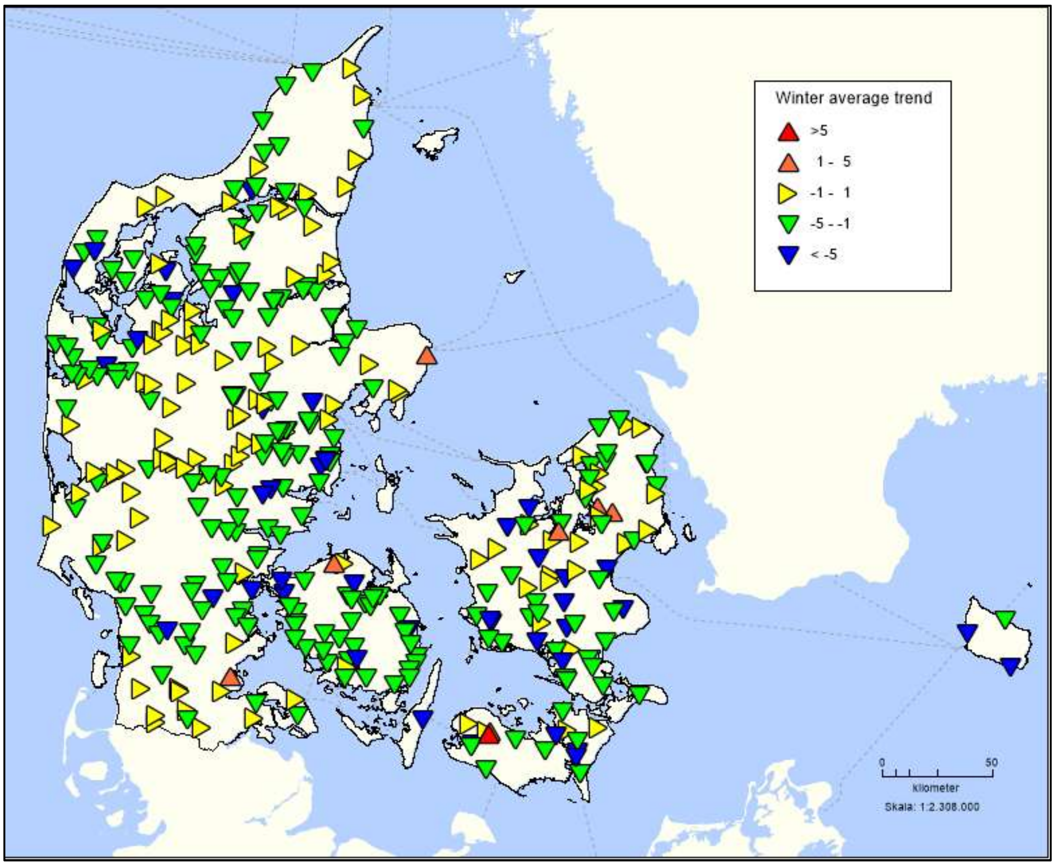


**Figure 3.4 Changes in winter average nitrate concentration in watercourses from the previous to the current period (2016-2019 to 2020-2023)**

### 3.1.4. Indicators for eutrophication in Danish water courses

Eutrophication caused by excess amounts of nutrients is mainly a problem in lakes and marine waters, and large or slowly flowing rivers. In Danish streams, the residence time is too short for planktonic algae to become a problem. Thus, monitoring of eutrophication indicators such as chlorophyll-a concentration is only relevant in lakes, coastal waters and large rivers. Dissolved nutrients may have an effect on benthic algae and macrophytes in streams, but Denmark has not yet established a classification scheme for this kind of nutrient enrichment effects in watercourses.

For many years, the main problem with water quality in Danish streams has been pollution with organic matter. Denmark is a country with very short distances from any point on land to the coast. Only very few larger rivers (with a maximum length from source to outlet of approx. 150 km) can be found, while the majority of the area is drained by numerous small streams. Danish streams are generally too small for planktonic algae to become very abundant. Therefore, Denmark has focused its environmental monitoring in streams on organic matter indicators such as BOD, and there is no monitoring of secchi depth, chlorophyll a or similar eutrophication indicators. Moreover, the Danish monitoring of nutrients in streams focus on the resulting nutrient loadings in vulnerable surface waters, that is, lakes and coastal waters.

In this reporting for the 8$^{th}$ period (2020-2023) we have included data for eutrophication indicators as phosphorous, total-P, orthophosphate-P and nitrogen, total N, but the data cannot be used to describe status for eutrophication in the light of the above-mentioned contexts.

### 3.1.5. Ecological state

The classification of ecological state is based on data from the third RBMP in line with the Guidelines. According to these it´s proposed, that the term “non-eutrophic” of the Nitrates Directive relates to the WFD high and good status, and the term "eutrophic" of the Nitrates Directive relates to situations where undesirable disturbances are common or severe and equates to moderate, poor or bad status. The same approach for classification of ecological state is used for watercourses, lakes and Estuarine, coastal and marine waters.

The classification of ecological state of the 443 monitoring station in watercourses in connection with the latest RBMP can be found in **Table 3.3**. The ecological state at 26 percent of the 397 monitoring station in watercourses with known status are non-eutrophic.

If a similar approach as in **Table 3.3** is used on all Danish river-waterbodies in WFD with an ecological classification in the third RBMP then 36 % will be categorized as non-eutrophic and 64 % will be categorized as eutrophic.

**Table 3.3 Distribution of the 443 monitoring stations in watercourses monitored for the parameters nitrate during the 8th reporting period with respect to ecological state in the third river basin management plan.**

| River type | Eutrophic | Non-eutrophic | Unknown | Total |
|---|---|---|---|---|
| 1 (small) | 45 | 12 | 3 | **60** |
| 2 (medium) | 210 | 65 | 20 | **295** |
| 3 (large) | 38 | 27 | 2 | **67** |
| Unknown | | | 21 | **21** |
| **Total** | **293** | **104** | **46** | **443** |
| **Percentage of total with known status (397)** | **74 %** | **26 %** | | |

The classification “Unknown” is either caused by monitoring stations placed in watercourses not included in the RBMP or where there is not sufficient data to make a classification at the specific monitoring station.

## 3.2. Surface water: Lakes

There are approximately 120,000 lakes in Denmark. The vast majority of the lakes are small - only a few are larger than 5 hectares. Many of the Danish lakes are subject to eutrophication due to an excessive supply of nutrients. The ecological state is most often controlled by the level of phosphorus in the lakes.

### 3.2.1. Presentation of monitoring stations

Danish lake monitoring stations for the 8th period (2020-2023) are shown in Figure 3.5.

The lakes included are a selection of Danish lakes > 5 hectares covered by the Water Framework Directive. Data from the 8th reporting period of the Nitrates Directive (2020-2023) include 65 lakes with analysis of lake water for nitrate concentration.

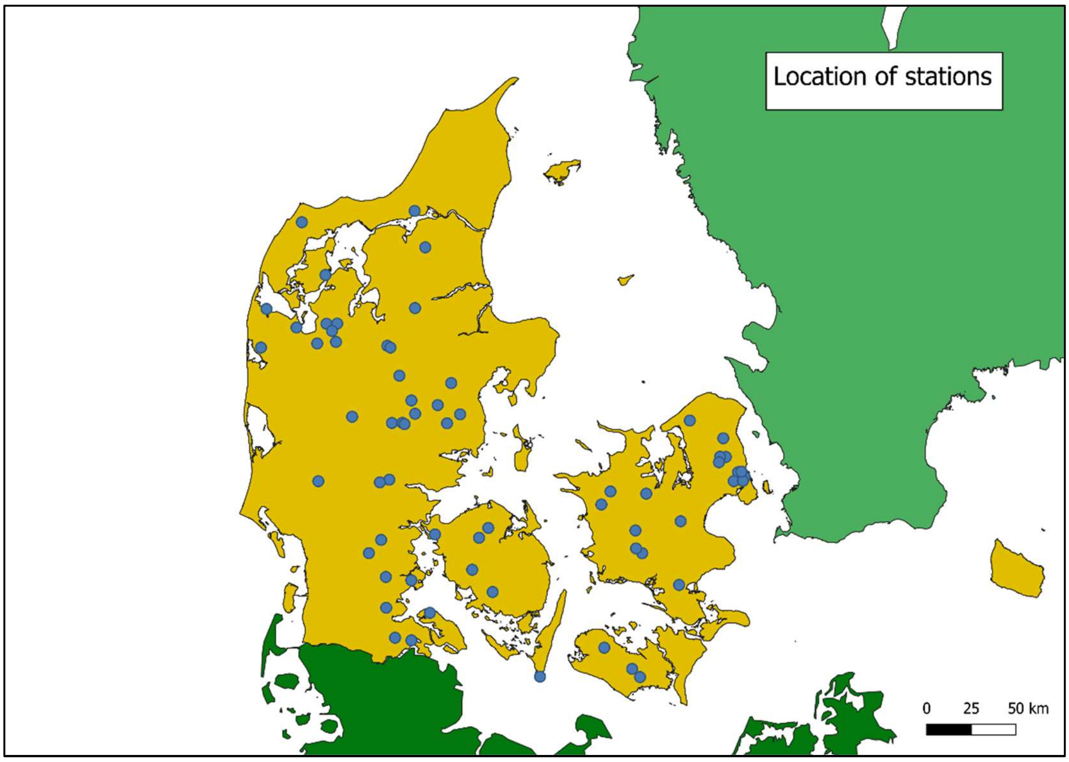


**Figure 3.5. The location of 65 Danish lake monitoring stations used to measure the concentrations of nitrate in the lake water.**

Nitrate concentration were monitored once during the period in 47 lakes, while the other 18 lakes were monitored every second year during the period and thus two years of data are included. Sampling frequency for nitrate concentration was 15-19 times in the period 1st of January to 31st of December for the 18 lakes. The other two lakes were measured 4-5 times in the period 1st of April – 30th of September and once in the period January-February. Nitrate concentrations below the detection limit of 0.011 mg NO$^3$/L was set to 0.0055mg NO$^3$/L. Nitrate concentrations are given as time-weighted annual and time-weighted winter averages (1st of October to 28th of February). For the lakes measured biannually, the nitrate concentrations represent simple averages of the time-weighted annual averages and winter averages for the period.

The number of lakes monitored for the parameter nitrate during either the 7th, 8th or both reporting periods can be found in Table 3.4.

**Table 3.4. Number of lakes monitored in the 7th and 8th monitoring period for nitrate (NO3) in lake water.**

| Number of lakes | 7th period | 8th period | Common lakes |
|---|---|---|---|
| $NO_3$ | **20** | 65 | 20 |

### 3.2.2. Status for nitrate concentrations

The number of Danish lakes within different classes of nitrate concentrations in the 8th period (2020-2023) with respect to annual average, winter average and maximum nitrate concentrations are shown in Table 3.5. The annual average nitrate concentrations in the 8th period (2020-2023) in Danish lakes range from 0.05-19.6 mg $NO_3^-$/l with an average of 3.6 mg $NO_3^-$/l.

Winter average concentrations are generally higher than the annual average concentrations (63 out of 65 lakes) and vary between 0.08 and 34.02 mg $NO_3^-$/l with an average of 6.4 mg $NO_3^-$/l. This is due to higher loading, low primary production and less denitrification during winter.

In general, annual average nitrate concentrations are low – compared to the Nitrates Directive limit of

3

50 mg/l 45 % of the lakes have an annual mean concentration less than 2 mg $NO_3^-$/l. The maximum concentrations vary between 0.08 and 62.0 mg $NO_3^-$/l. One lake had a maximum concentration above 50 mg NO -/l.

**Table 3.5. The number of lakes within a certain class of nitrate concentration (annual average, winter average and maximum, respectively).**

| $NO_3^-$ (mg/l) | Annual average – number of lakes | Winter average – number of lakes | Maximum – number of lakes |
|---|---|---|---|
| 0 – 1.99 | 29 | 20 | 12 |
| 2 – 9.99 | 29 | 31 | 35 |
| 10–24.99 | 7 | 12 | 16 |
| 25–39.99 | 0 | 2 | 1 |
| 40–49.99 | 0 | 0 | 0 |
| ≥50 | 0 | 0 | 1 |

### 3.2.3. Trend in nitrate concentrations

Table 3.6 and the maps in Figure 3.6 and Figure 3.7 show the development in nitrate concentrations in the lake water in the 20 common monitored lakes between the 7th period (2016-2019) and the 8th period (2020-2023) with respect to annual average and winter average nitrate concentrations, based on the intervals/thresholds given in the reporting guidelines ("Nitrates Directive (91/676/CEE) – 'Status and trends in aquatic environment and agricultural practice - Development guide for Member States' reports").

**Table 3.6. Change in annual average and winter average $NO_3$ concentration in the lake water (mg/l) from 7th to 8th period**

| Trend in $NO_3$ (mg $NO_3^-$/l) | Annual average $NO_3$ | | Winter average $NO_3$ | |
|---|---|---|---|---|
| | Number of lakes | Percentage of lakes (%) | Number of lakes | Percentage of lakes (%) |
| Strong increase (>5) | 0 | 0 | 0 | 05 |
| Increase (> +1 and ≤5) | 1 | 5 | 2 | 10 |
| Stability (≥ -1 and ≤1) | 19 | 95 | 17 | 85 |
| Reduction (> -1 and ≤ -5) | 0 | 0 | 1 | 5 |
| Strong reduction (<-5) | 0 | 0 | 0 | 0 |

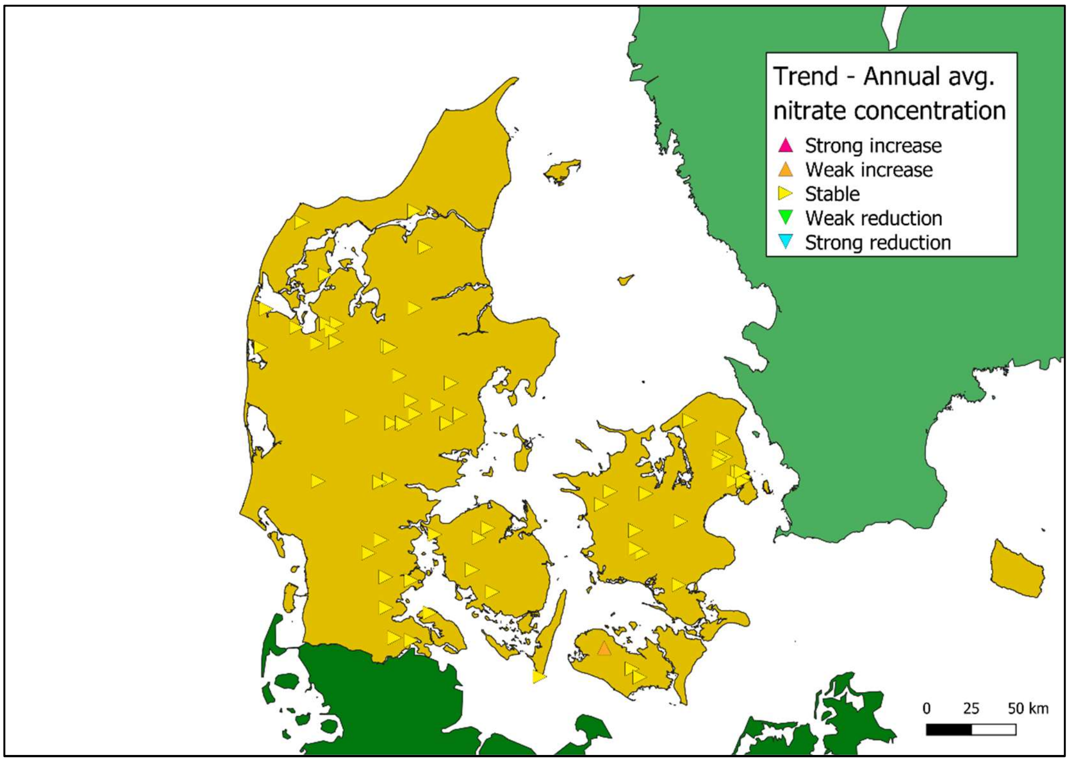


**Figure 3.6. Change in annual average nitrate concentration in the lake water (mg/l) from 7th (2016-2019) to the 8th (2020-2023) period.**

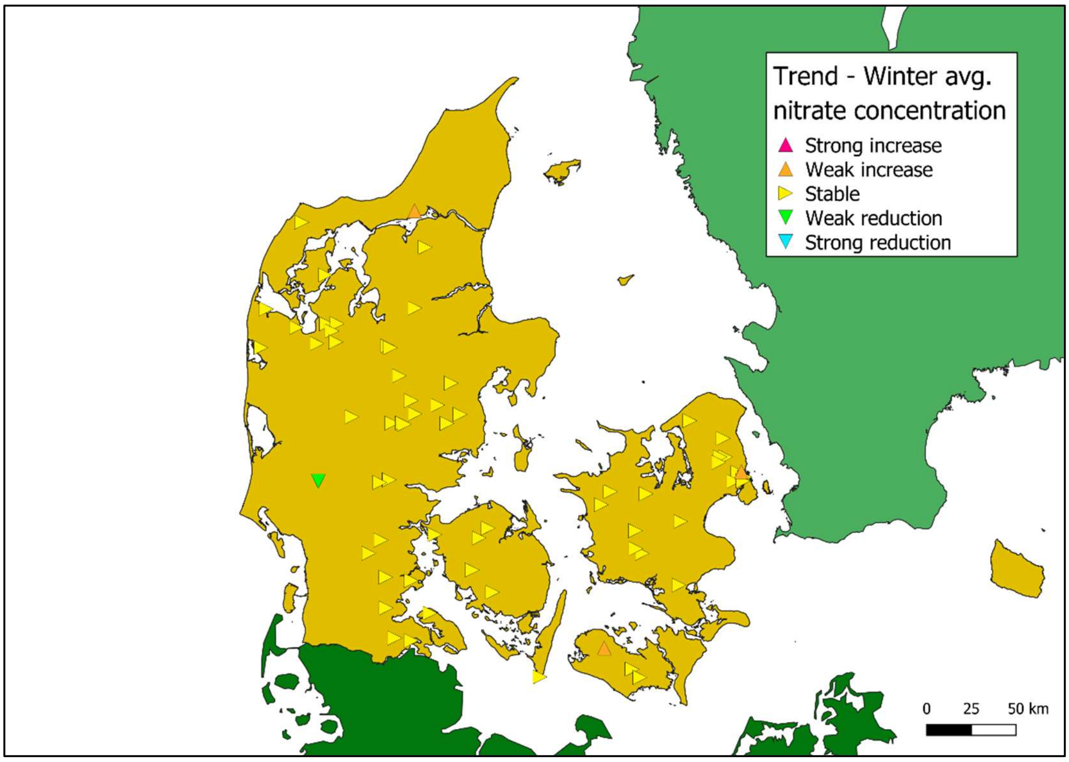


**Figure 3.7. Change in winter average nitrate concentration in the lake water (mg/l) from 7th (2016-2019) to the 8th (2020-2023) period.**

### 3.2.4. Data used for the classification of the ecological state of lakes

The classification of the ecological state of the 65[1] lakes monitored for the parameter nitrate during the 8th reporting period is based on monitoring data from the third river basin management plan (RBMP) for

[1] Lakes established for the purpose of nutrient retention or lakes with less stringent environmental objectives are not included.

the biological elements (chlorophyll a[2], phytoplankton[3], other aquatic flora[4], macrophytes[5], benthic invertebrates[6] and fish[7]) and chemical and physio-chemical elements supporting the biological elements (transparency, oxygenation conditions, nutrient conditions and river basin specific pollutants) sampled during the period 2014-2020.

Data include 7 lakes with measurements of chlorophyll a, 58 lakes with measurement of phytoplankton, 49 lakes with measurement of other aquatic flora, 10 lakes with measurements of macrophytes, 21 lakes with measurement of benthic invertebrates, 59 lakes with measurements of fish fauna, 64 lakes with measurement of transparency, 65 lakes with measurement of oxygenation conditions, 64 lakes with measurement of phosphorus conditions, 64 lakes with measurement of nitrogen conditions and 44 lakes with measurement of river basin specific pollutants.

### 3.2.5. Ecological state

The classification of ecological state of the 65 monitoring lakes in connection with the latest RBMP can be found in table 3.7. Three percent of the 65 lakes are non-eutrophic. If a similar approach as in table 3.7 is used on all 760[8] lakes with an ecological classification in the third RBMP then 21 % will be categorized as non-eutrophic and 79 % will be categorized as eutrophic.

**Table 3.7. Distribution of the 65 lakes monitored for the parameters nitrate during the 8$^{th}$ reporting period with respect to ecological state in the third river basin management plan**

| Ecological state | Non-eutrophic | Eutrophic |
|---|---|---|
| Low alkaline lakes | 0 | 3 |
| Shallow alkaline lakes | 2 | 31 |
| Deep alkaline lakes | 0 | 29 |
| **Percentage of total lakes** | **3** | **97** |

### 3.2.6. Development in ecological state

The development in ecological state of the lakes is based on a comparison of the ecological state presented in in the second (2015-2021) and the third (2021-2027) river basin management plans. Lakes measured for the parameters nitrate during the 8$^{th}$ reporting period are selected. 64 of the 65 lakes have been monitored in both river basin plan periods. The development in ecological state of these lakes is shown in table 3.8. Generally, most lakes have been stable over the course of the two river plan periods and only a minor fraction has increased (2 %) or decreased (9 %).

**Table 3.8. Development in ecological state in the 64 lakes monitored in both the second river basin management plan and the third river basin management plan.**

| Trend in ecological state | | Number of lakes | Percentage of lakes |
|---|---|---|---|
| Increase | Eutrophic → Non-eutrophic | 1 | 2 |
| Stable | | 57 | 89 |
| Decrease | Non-eutrophic → Eutrophic | 6 | 9 |

---

[2] Chlorophyll a is only used as an element for the classification of ecological status of a lake, when there exists no measurements of the quality element phytoplankton

[3] Phytoplankton can only be included as a quality element in the classification of the ecological state in lakes of the Danish typology 1, 5, 9, 10 and 11.

[4] Other aquatic flora can only be included as a quality element in the classification of the ecological state in lakes of the Danish typology 9 and 10.

[5] Macrophytes can only be included as a quality element in the classification of the ecological state in lakes of the Danish typology 1, 5, 9, 10 and 13.

[6] Benthic invertebrates can only be included as a quality element in the classification of the ecological state in lakes of the Danish typology 9 and 10.

[7] Fish can only be included as a quality element in the classification of the ecological state in lakes of the Danish typology 1, 9, 10, 11 and 13.

[8] Lakes established for the purpose of nutrient retention or lakes with less stringent environmental objectives are not included.

### 3.3. Surface water: Estuarine, coastal and marine waters

#### 3.3.1. Presentation of monitoring stations

The presented nitrate (NO3-) concentrations, status and trends are based on data from a total of 79 stations (Figure 3.8).

The 8th reporting include the same 79 stations that were included in the 7[th] reporting. The positions of the stations are the same, but the station names have been changed compared to previous reportings, so that they are compatible with the station number used in national databases used for storing monitoring data.

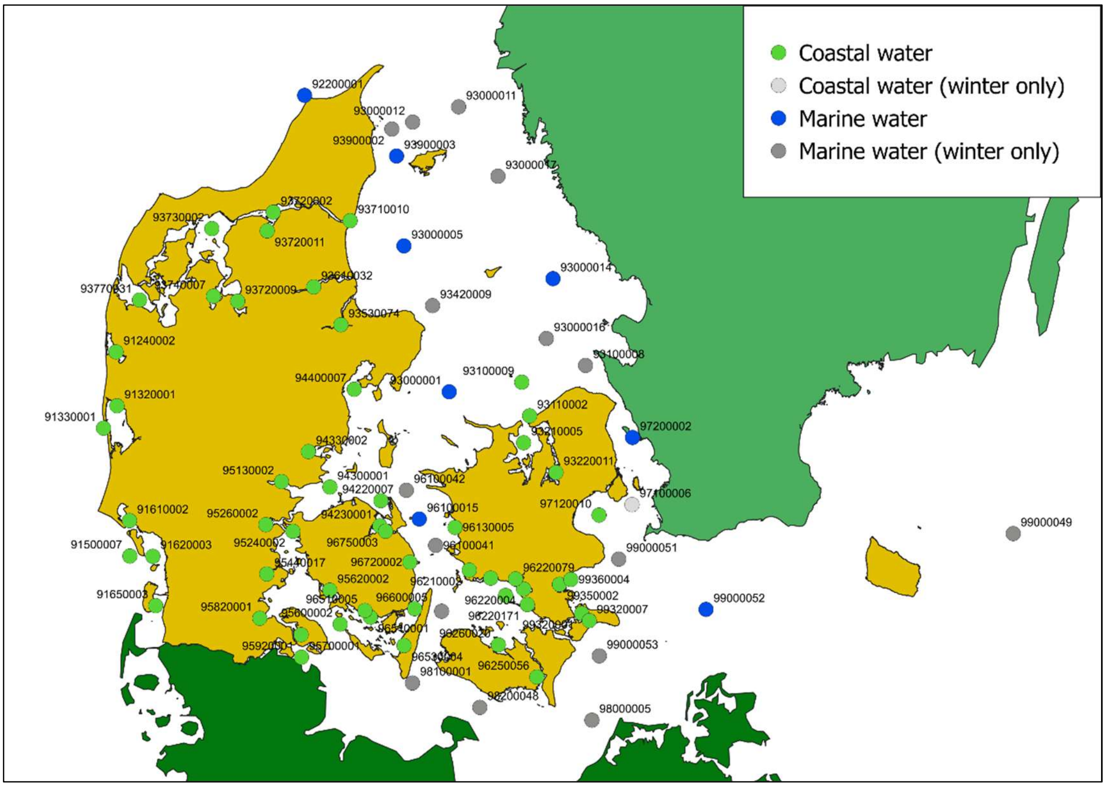


**Figure 3.8. Stations with NO3- concentrations being monitored every year during the 8th reporting period 2020 – 2023. Out of the 79 stations shown, 55 stations represent coastal waters and 24 stations represent marine waters. Out of the 55 stations representing coastal waters, 54 stations have data for both annual and winter NO3-, while 1 station only have data for winter NO3-. Out of the 24 stations representing marine waters, 8 stations have data for both annual and winter NO3-, while 16 stations only have data for winter NO3-.**

From the 2nd period (1996-1999) until present, i.e. the 8th period (2020-2023), the total number of monitoring stations has been reduced as shown in table 3.9. The numbers of monitoring stations is the same as the last reporting period.

In coastal waters, the number of monitoring stations decreased by 29 from 56 to 27 stations between the 2nd and 6th reporting period. More stations was included in the 7th reporting (Table 3.9) and for the 8[th] monitoring period the division of monitoring stations into water body types (coastal and marine water) has been revised, so that all monitoring stations located within a coastal water body administered under the WFD (i.e. corresponding to stations within 1 nautical miles from the coast) are characterized as a coastal water station, while all marine monitoring stations located outside WFD water bodies are characterized as marine stations. Thus, in the 8[th] reporting a total of 55 stations represent coastal waters.

For marine open water stations, the number of marine stations has also been reduced between the 2nd and the 6th reporting period (Table 3.10), mainly because of a stop in North Sea/Skagerrak monitoring between the 4th and 5th period, when 48 stations were abandoned. Monitoring on some of these stations has been reintroduced. Furthermore, 7 stations have that were previously characterized as marine stations are now characterized as coastal water stations due to the revision mentioned above. A total of 24 stations are characterized as marine stations in the 8th reporting.

**Table 3.9. Monitoring points (i.e. number of stations) for Danish coastal waters.**

| Number of monitoring points | 2nd period 1996-1999 | 3rd period 2000-2003 | 4th period 2004-2007 | 5th period 2008-2011 | 6th period 2012-2015 | 7th period 2016-2019 | **8th period 2020-2023** |
|---|---|---|---|---|---|---|---|
| **Winter $NO_3$** | 56 | 54 | 51 | 36 | 27 | 48 | 55 |
| **Annual $NO_3$** | 56 | 54 | 51 | 36 | 27 | 48 | 54 |

**Table 3.10. Monitoring points (i.e. number of stations) for Danish marine waters.**

| Number of monitoring points | 2nd period 1996-1999 | 3rd period 2000-2003 | 4th period 2004-2007 | 5th period 2008-2011 | 6th period 2012-2015 | 7th period 2016-2019 | **8th period 2020-2023** |
|---|---|---|---|---|---|---|---|
| **Winter $NO_3$** | 87 | 87 | 82 | 34 | 32 | 31 | 24 |
| **Annual $NO_3$** | 87 | 87 | 82 | 34 | 17 | 17 | 8 |

Additionally, there was insufficient data at 16 marine water stations to calculate the annual NO3- concentration, during the 8th period. Annual NO3- concentration could therefore only be calculated for 8 of the 24 marine water stations included in the 8th reporting, while winter NO3- could be calculated for all 24 marine water stations (Table 3.10).

The coastal water monitoring stations abolished since the 2nd reporting period have been carefully singled out to secure an adequate, though less dense, coverage of Danish coastal waters. Thus, the reported data are still expected to be sufficient to give a true and fair view of nitrate concentrations in coastal waters. The same can be said for Danish marine waters with the exceptions of the North Sea where no monitoring stations was included due to insufficient data, and Eastern Kattegat, the Belt Sea, and Southern Baltic Sea, where summer concentrations of nitrate could only be calculated for 8 out of 24 marine stations in the 8th period due to insufficient data in the summer months in these water bodies.

### 3.3.2. Status for nitrate concentrations

During the 8th period (2020-2023) the highest average NO3- winter (October – March) surface (0-10 m) concentrations were observed in the coastal waters with a maximum average concentration of 11 mg NO3-/l at Station 96220079 located in Holckenhavn Fjord and with the lowest concentrations generally monitored in the open marine waters (i.e. Kattegat, the Belt Sea, and Arkona Basin) (Figure 3.9) where the average winter NO3- concentration did not exceed 0.4 mg NO3-/l. In the 8th reporting period The NO3- concentration decreased during the summer half compared to the winter at all stations (data not shown). Hence annual average NO3- concentrations were lower than winter averages as seen in (Figure 3.10).

Annual means are only reported when the stations are monitored monthly - i.e. an annual average value is not reported for stations with only 1-3 measurements in winter (corresponding to the stations marked ‘winter only’ in Fig. 3.6).

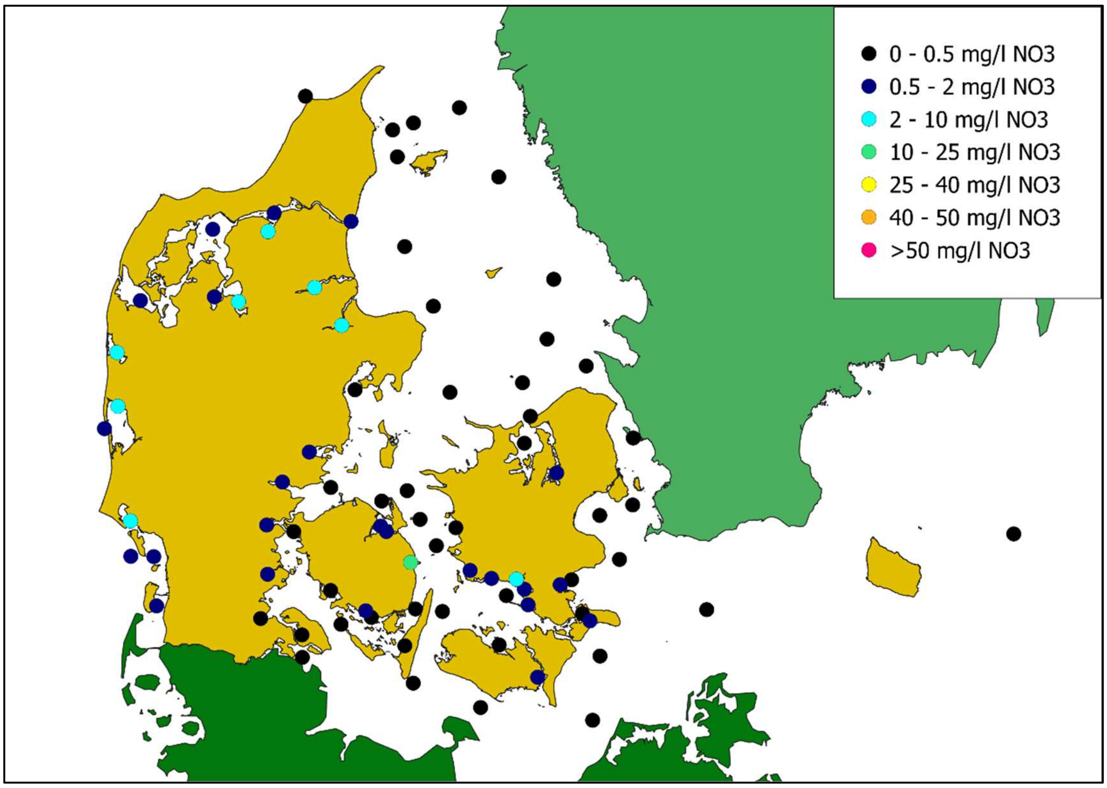


**Figure 3.9. Average surface (0-10 m) winter (October – March) NO3- concentrations in mg NO3-/l for the 8th monitoring period (2020 – 2023) at 79 stations in Danish coastal and marine waters.**

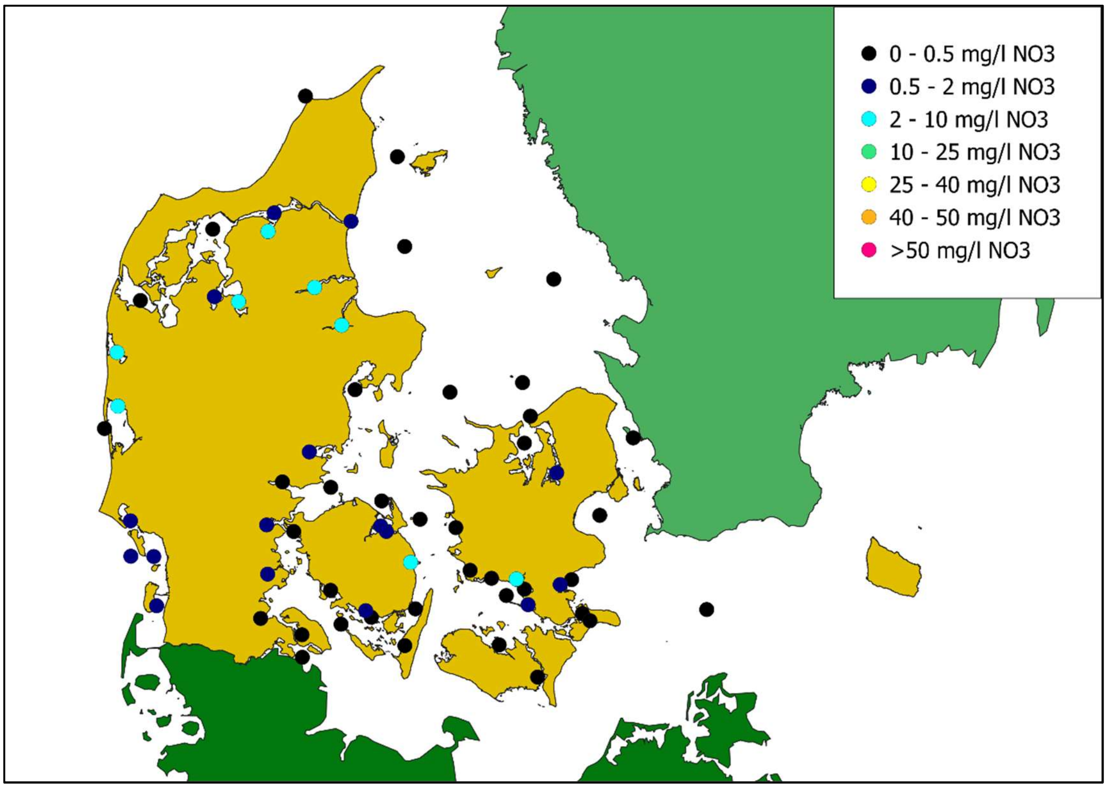


**Figure 3.10. Average surface (0-10 m) annual NO3- concentrations in mg NO3-/l for the 8th monitoring period (2020 – 2023) at 62 stations in Danish coastal and marine waters.**

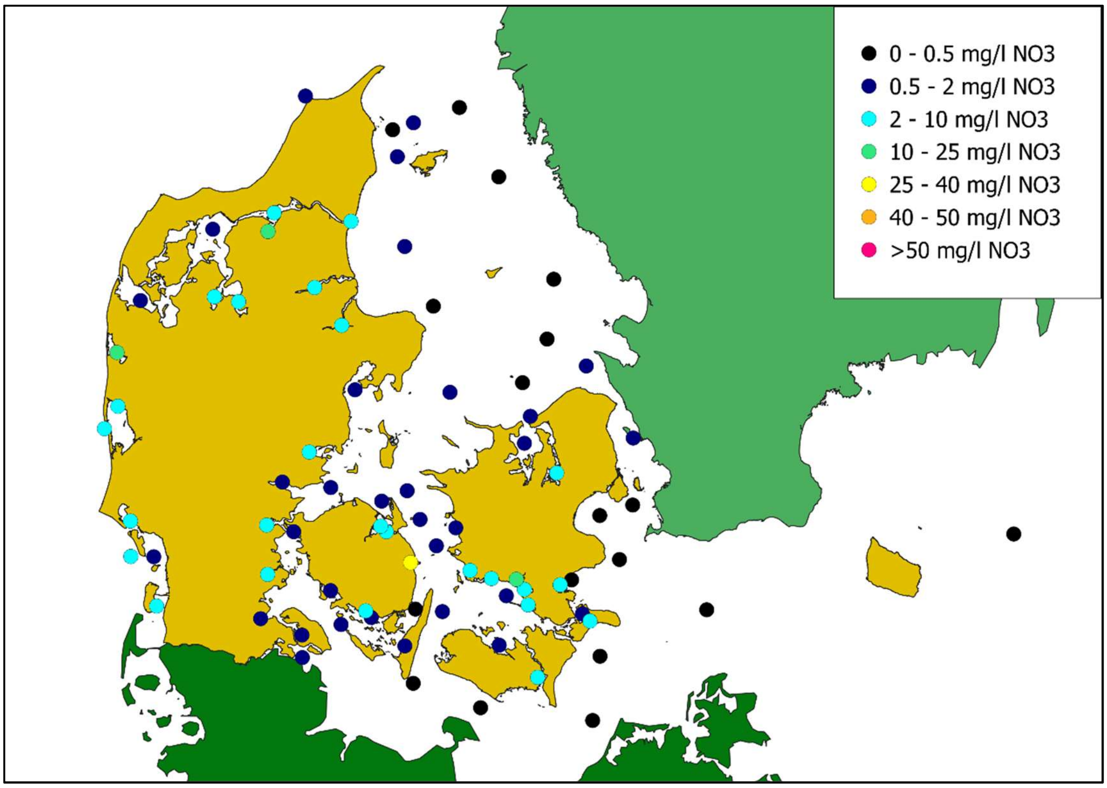


**Figure 3.11. Maximum surface (0-10 m) NO3- concentrations in mg NO3-/l for the 8th monitoring period (2020 – 2023) at 79 stations in Danish coastal and marine waters.**

### 3.3.3. Trend in nitrate concentrations

Surface water nitrate concentrations in coastal and marine waters are generally much lower than observed in groundwater and fresh water systems, and until the 7$^{th}$ reporting the proposed concentration changes to detect changes in trends in the NID-reporting guidelines were are too large for a marine context (i.e. changes >± 1 mg NO3-/l). Hence in previous reports for Danish coastal and marine waters trends between monitoring periods were estimated by a statistical approach rather than using absolute concentration changes.

For the 8$^{th}$ reporting there has been a change in the proposed concentration changes to detect changes in trends for coastal and marine waters in the NID-reporting guidelines, so that a concentration change between periods of >1mg/l NO3- is characterized as a strong change, a concentration change between 0,2-1 mg/l NO3- is characterized as a weak change and a concentration change between ±0,2 mg/l NO3- is defined as stable conditions. The new method has been adopted for Danish coastal and marine waters.

For winter averages, long-term trends (difference between 2020-2023 and 1996-1999) and short-term trends (difference between 2020-2023 and 2016-2019) can be calculated for 69 and 79 stations, respectively (Fig. 3.12 and Fig. 3.13). For long-term trends (winter averages), 8 and 16 stations show a strong and weak reduction, respectively, concentrations are stable at 38 stations and concentrations show a weak increase on 7 stations. For short-term trends (winter averages), 4 and 7 stations show a strong and weak reduction, respectively, concentrations are stable at 65 stations and concentrations show a weak increase on 3 stations.

**Table 3.11. Trends in average surface (0-10 m) winter (October – March) NO3- concentrations in Danish coastal waters. Percentage of points (i.e. monitoring stations) with increasing, stable or decreasing average concentrations of nitrate at 55 stations for short term trends (diff. between 7th and 8th period) and 46 stations for long term trends (diff. between 2nd and 8th period, Figure 3.12 and Figure 3.13).**

| Trend | Significance | 7th period to 8th period 2016-2019 to 2020-2023 | 2nd period to 8th period 1996-1999 to 2020-2023 |
|---|---|---|---|
| Increasing | strong | 0% | 0% |
| | weak | 5.5 % | 10.9% |
| Stable | | 74.5% | 37.0% |
| Decreasing | weak | 12.7% | 34.8% |
| | strong | 7.3% | 17.4% |

**Table 3.12. Trends in average surface (0-10 m) winter (October – March) NO3- concentrations in Danish marine waters. Percentage of points (i.e. monitoring stations) with increasing, stable or decreasing average concentrations of nitrate at 24 stations for short term trends (diff. between 7th and 8th period) and 23 stations for long term trends (diff. between 2nd and 8th period, Figure 3.12 and Figure 3.13).**

| Trend | Significance | 7th period to 8th period 2016-2019 to 2020-2023 | 2nd period to 8th period 1996-1999 to 2020-2023 |
|---|---|---|---|
| Increasing | strong | 0 % | 0% |
| | weak | 0% | 8.7% |
| Stable | | 100% | 91.3% |
| Decreasing | weak | 0% | 0% |
| | strong | 0% | 0% |

For annual averages, long-term trends (difference between 2020-2023 and 1996-1999) and short-term trends (difference between 2020-2023 and 2016-2019) can be calculated for 52 and 62 stations, respectively (Fig. 3.14 and Fig. 3.15). For long-term trends (annual averages), 6 and 17 stations show a strong and weak reduction, respectively, concentrations are stable at 27 stations and concentrations show a weak increase on 2 stations. For short-term trends (annual averages), 1 and 8 stations show a strong and weak reduction, respectively, concentrations are stable at 52 stations and concentrations show a weak increase on 1 stations.

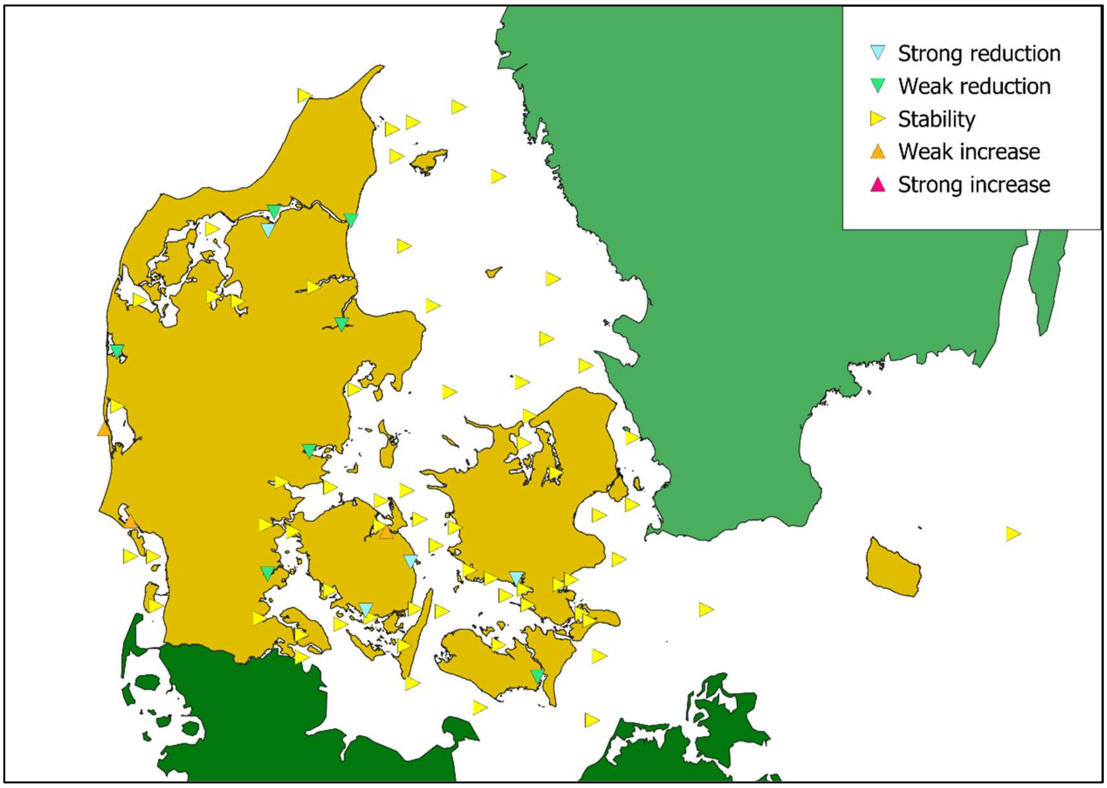


**Figure 3.12. Trends in average surface (0-10 m) winter (October – March) NO3- concentrations between the 7th reporting period (2016-2019) and the 8th period (2020-2023) at 79 stations in Danish coastal and marine waters.**

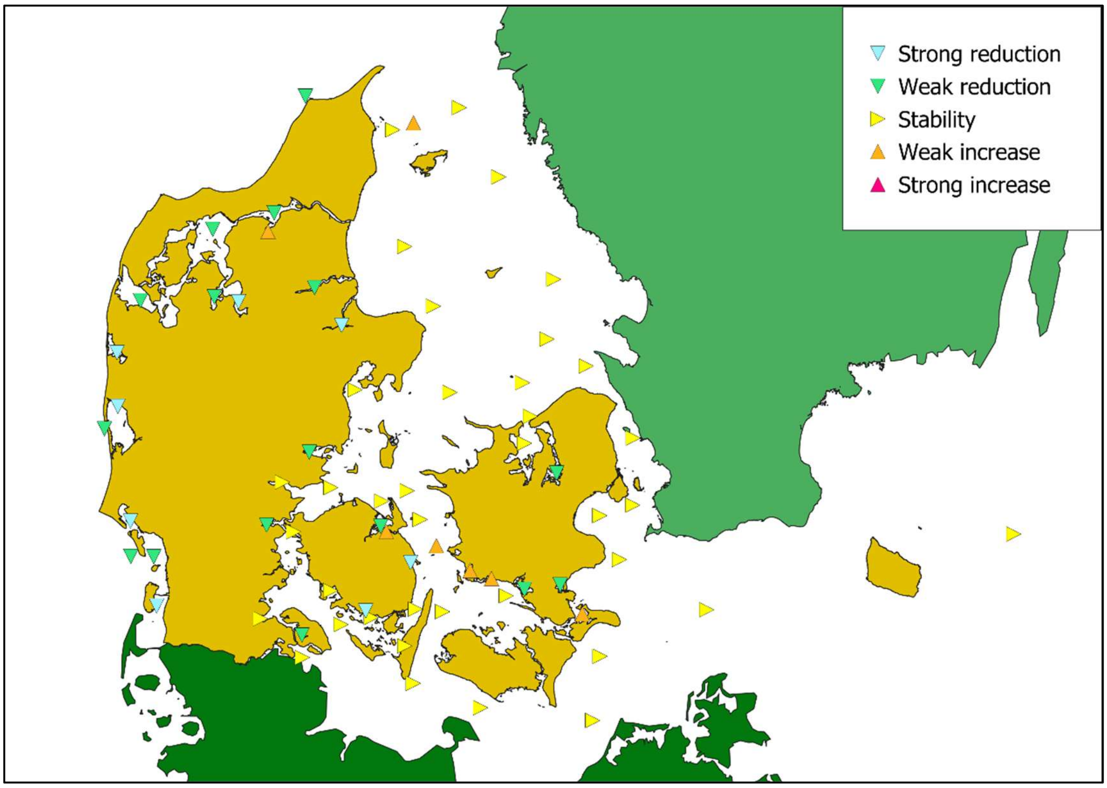


**Figure 3.13. Trends in average surface (0-10 m) winter (October – March) NO3- concentrations between the 2nd reporting period (1996-1999) and the 8th period (2020-2023) at 69 stations in Danish coastal and marine waters.**

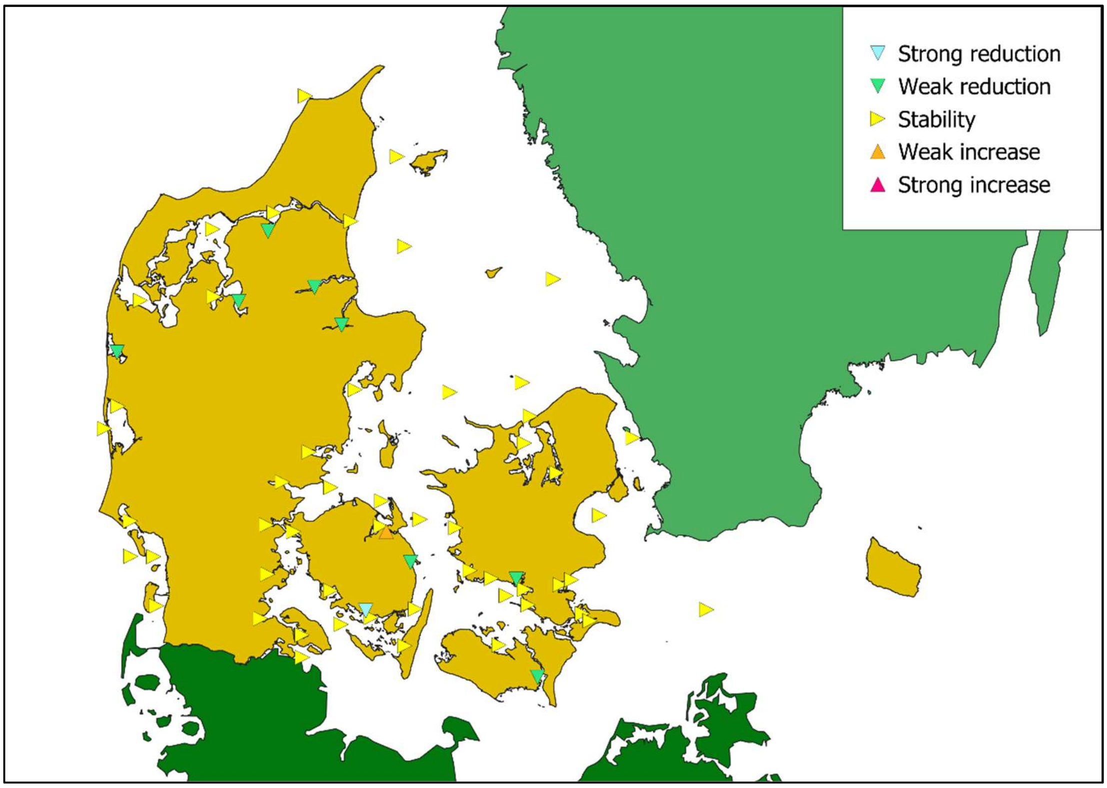


**Figure 3.14. Trends in average surface (0-10 m) annual NO3- concentrations between the 7th reporting period (2016-2019) and the 8th period (2020-2023) at 62 stations in Danish coastal and marine waters.**

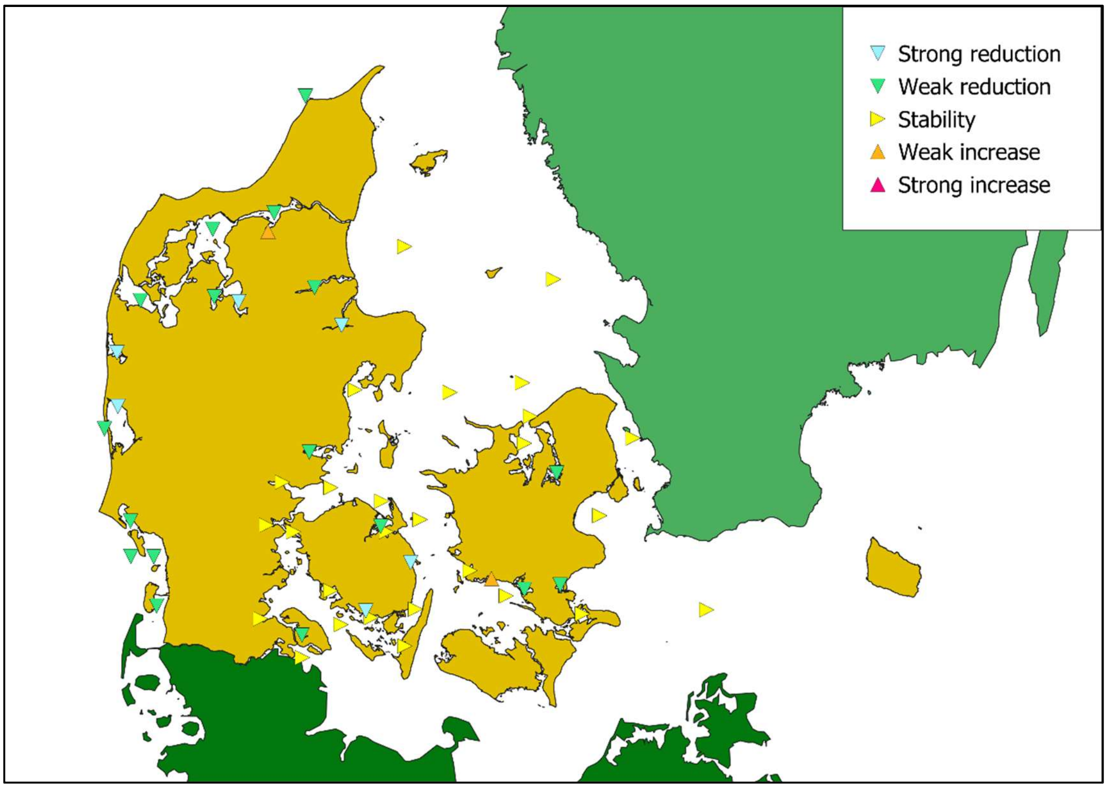


**Figure 3.15. Trends in average surface (0-10 m) annual NO3- concentrations between the 2nd reporting period (1996-1999) and the 8th period (2020-2023) at 52 stations in Danish coastal and marine waters.**

#### 3.3.4. Ecological State

A total of 79 Danish monitoring stations are included in the 8th reporting for the Nitrates Directive covering the period 2020-2023, and 55 out of the 79 stations are located within 1 nautical miles from the coast in 55 coastal water bodies that are administered in the Danish River Basin Management Plans (RBMP). The 24 remaining stations are open water stations located outside the coastal water bodies, where ecological status is not assessed under the WFD. The 55 stations in coastal water bodies represent approximately half of the 109 coastal water bodies included in the Danish RBMP.

The ecological status of the 55 coastal water bodies represented by the 55 monitoring stations included in the 8th Nitrates directive reporting was recently assessed in relation to the 3rd generation RBMP (2021-2027). The 6-year data period used for the assessment of ecological status was 2014-2019.

Based on nutrient sensitive BQE's, 52 out of the 55 coastal water bodies containing the stations reported in the 8th reporting are classified as 'Eutrophic', while the remaining 3 stations are classified as 'Non-eutrophic' (Table 3.15). Hence these data suggest that 5,5% of coastal water bodies can be categorized as non-eutrophic while 94,5% can be categorized as eutrophic. If a similar approach is used on all marine waterbodies with an ecological classification in the third RBMP then 5 % will be categorized as non-eutrophic and 95 % will be categorized as eutrophic

Since the basic typology of Danish water bodies, reference conditions and environmental targets for key nutrient sensitive BQE's was adjusted for the 3rd generation RBMP, it is not meaningful to compare the trophic status presented in Table 3.15 to previous assessments.

**Table 3.13. Trophic status of the 55 coastal water bodies containing 55 of the monitoring stations included in the 8th Nitrates directive reporting. The classification of water bodies is a translation of the ecological status assessment made for the 3rd generation RBMP (2022-2027) based on nutrient sensitive Biological Quality Elements.**

| | Non-eutrophic | Eutrophic |
|---|---|---|
| **Number of water bodies** | 3 (5.5 %) | 52 (94.5%) |

## 3.4. Groundwater

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### 3.4.1. Presentation of monitoring network

In Denmark, the monitoring network, which is used for complying the monitoring requirements according to the Nitrates Directive, ND, is an integrated part of the national monitoring network, NOVANA, which is used to assess groundwater quality according to the Water Framework Directive, WFD. Implementation of the WFD has required large adjustments of the groundwater-monitoring network, in order to obtain a geographically more distributed monitoring network, representing the Danish groundwater bodies, in-stead of the previous clustered network (Jørgensen and Stockmarr, 2009). The major adjustments took place in the period 2010-2017 and involved establishment of new monitoring wells as well as closure of existing monitoring wells and was finalised in 2019 (Thorling et al. 2024).

The overall monitoring programme is adjusted according to political needs every 6th year, and recently the whole NOVANA programme (Surface waters, marine waters, groundwater etc.) has been subject to a “fit for purpose” analysis. This resulted in a streamlining of the network assigned for the Nitrates Directive, so only monitoring points relevant to agricultural pressures are to be used in monitoring and reporting in relation to the nitrates directive. A cutoff at less than 25% agricultural area in a 200 m circle around the individual monitoring points was used to delineate the relevant monitoring points. As a consequence, this report builds only on the agriculturally affected monitoring points for all re-porting periods included in this report.

Many monitoring wells have several screens in different depths. The term “monitoring point” is used in the following, when referring to samples from individual monitoring screens. Different concentrations of nitrate are thus found at the same geographical location. To handle this, maps are drawn in two versions: with either the highest or the lowest concentrations drawn last / uppermost at each geographical location.

Figure 3.16 shows the location of the 1,151 groundwater monitoring points in Denmark de-lineated for this reporting. Due to the 3D setup of the monitoring network, it is not possible to show the terminated monitoring wells on the same map.

A detailed overview on the terminated monitoring points and their respective replacement points are given in Appendix 4. In this overview, terminated monitoring points have been categorized by the character of their respective replacement point, which can either be found in close proximity, within the same groundwater body or even within the same groundwater monitoring well (in cases where one well contains several screens).

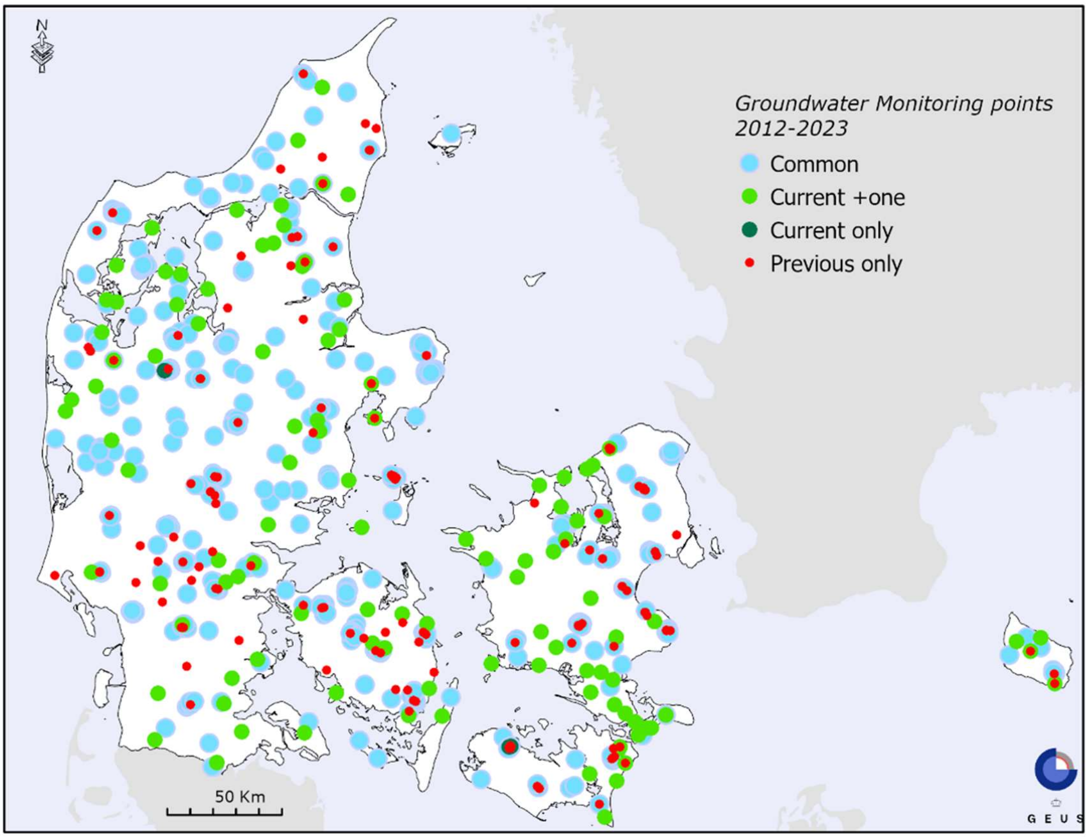



**Figure 3.16. The location of the 1,151 groundwater monitoring points in Denmark available for this reporting. The large blue signature shows the 868 common monitoring points for the last three periods (2012-2023). Dark green signature shows the 3 monitoring points only available for the current 8th reporting period (2020-2023). 125 monitoring points used in the current period and one of the previous periods in this report (2012-2015 or 2016-2019) are shown in light green. Finally, the red signature shows 155 monitoring points with data only from one or both of the previous periods (2012-2015 / 2016-2019).**

The number of groundwater monitoring points for the current and previous reporting period is shown in Table 3.14. A total of 1,151 monitoring points has been used at some stage in the monitoring network in the period 2012-2023. All monitoring points are designated for monitoring only and are not used for drinking water abstraction.

**Table 3.14. Number of groundwater monitoring points (screens in monitoring wells) for the current (2020-2023) and the two previous reporting periods.**

| | 2012-2015 6th reporting period | 2016-2019 7th reporting period | 2020-2023 8th reporting period | common points all 3 periods | common points 7th and 8th period |
|---|---|---|---|---|---|
| Number of points | 1012 | 1045 | 996 | 868 | 992 |

The national groundwater monitoring programme has been designed to monitor groundwater recharged after approx. 1940. The monitoring wells are either placed in quaternary glacial deposits, in underlying tertiary fluvial deposits or in underlying cretaceous limestone. Many monitoring points are placed in partly artesian aquifers, due to hydraulic inactive clay layers, but most monitored aquifers are characterised as having a significant flowrate and groundwater with a residence time below 60-70 years. There is no monitoring of captive or karstic groundwater, as the karstic properties of the limestone aquifers are considered insignificant and the typical captive groundwaters have a natural quality unsuitable for drinking water, due to salt, fluoride etc. Tables with nitrate content in the current reporting period and trends since the previous period subdivided according to depth can be found in

Appendix 4.

### 3.4.2. Status for nitrate concentrations

Nitrate data for the 2020-2023 period have been aggregated and the average value and the maximum value for each monitoring point calculated as the average/maximum of the annual average/maximum, respectively. For comparison the same aggregation is done for the two previous periods 2012- 2015 and 2016-2019. Due to the revision of the monitoring network, data is aggregated not only for all the monitoring data from each year, as described in the guidelines, but for the common monitoring points mainly.

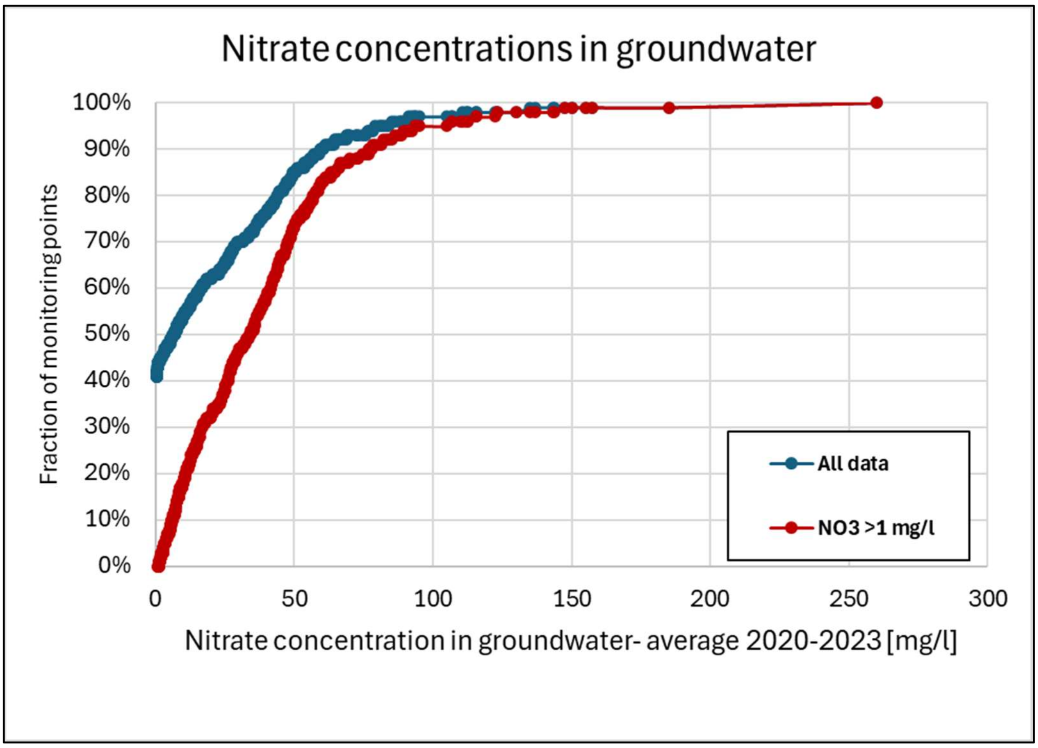



**Figure 3.17. The distribution of the average nitrate concentrations of the 996 individual monitoring points 2020-2023. The distribution is shown for all monitoring points (blue data series) and monitoring points with an average nitrate concentration above 1 mg/l (red data series).**

Figure 3.17 shows the distribution of nitrate in all the 996 monitoring points from the current period 2020-2023. As groundwater from approximately 45% of the monitoring points does not contain nitrate (defined as concentrations below 1 mg/L), the blue data series for all data does not start in the point of origin in the diagram. 57% of the monitoring points had an average nitrate concentration above 1 mg/l, and about 42% of all the monitoring points did hold nitrate contents between 1 and 50 mg/l, and are as such neither considered nitrate free, nor reduced. 15% of all the monitoring points had a mean nitrate concentration above 50 mg/l nitrate. As also shown in Figure 3.17, approximately 30% of the monitoring points with > 1 mg/l nitrate (red data series) exceed 50 mg/l.

### 3.4.3. Status for the 6th to 8th reporting periods 2012-2023

Status for the 6th to the 8th reporting periods 2012-2023 is given for the maximum and average nitrate from agricultural areas for each period. These aggregated data are found in Table 3.15 and Table **3.16**. Table 3.15 gives an overview for all monitoring points while Table 3.16 focus on the common points.

A nitrate concentration above the threshold value of 50 mg/l is for the maximum values found in 21.5% of all the monitoring points and in 14.8% for the average nitrate in the reporting period 2020-2023. The percentage of monitoring points ≥ 40 mg/l nitrate is for the maximum and average concentrations 28.1% and 23.1% respectively.

The major part, 76.9% of the monitoring points has an average nitrate concentration below 40 mg/l (Table 3.15). For the maximum values this holds for 71.9%.

In both Table 3.15 and Table **3.16** a decreasing percentage of monitoring points with a nitrate concentration ≥ 40 mg/l and ≥ 50 mg/l can be found for the maximum values as well as the average values of nitrate over the succession of the latest 2 reporting periods. A comparison between Table 3.15 and Table **3.16** indicates that a slightly higher percentage of monitoring points with nitrate concentrations above 40 and 50 mg/l, respectively, is monitored in the adjusted network used in the current reporting period, giving a larger share of monitoring points with nitrate concentrations above these levels for the common points in table 3. This explains why the overall tendency of decreasing nitrate concentrations in the groundwater is only weakly reflected in Table 3.15, when comparing the current two previous reporting periods. The weaker indication of a trend in Table 3.15 is caused by the overruling effect of the adjustments of the monitoring network.

**Table 3.15. Distribution of average and maximum nitrate concentration, for the previous (2012-2015 and 2016-2019) and current (2020-2023) reporting periods. All monitoring points from agricultural areas in each period are used. NB: The networks for the reporting periods are not identical. See Table 3.16 for common monitoring points only.**

| Percentage of All points | 2012-2015 n=1012 | 2016-2019 n=1045 | 2020-2023 n=996 |
|---|---|---|---|
| **≥ 50 mg/l** | | | |
| on max. values $NO_3$ | 22.2 | 21.5 | 21.5 |
| on avg. values $NO_3$ | 18.4 | 16.4 | 14.8 |
| **[40 - 50[ mg/l** | | | |
| on max. values $NO_3$ | 6.6 | 6.4 | 6.6 |
| on avg. values $NO_3$ | 6.7 | 7.0 | 8.3 |
| **[25 - 40[ mg/l** | | | |
| on max. values NO3 | 9.1 | 10.7 | 9 |
| on avg. values NO3 | 10 | 11.9 | 11.2 |
| **[0 - 25[ mg/l** | | | |
| on max. values NO3 | 62.1 | 61.3 | 62.9 |
| on avg. values NO3 | 64.9 | 64.8 | 65.7 |

**Table 3.16. Distribution of average and maximum nitrate concentration for the previous (2012-2015 and 2016-2019) and current reporting period 2020-2023. Only common monitoring points (n=868) are used.**

| Percentage of Common points | 2012-2015 n=868 | 2016-2019 n=868 | 2020-2023 n=868 |
|---|---|---|---|
| **≥ 50 mg/l** | | | |
| on max. values $NO_3$ | 24.2 | 23 | 22.9 |
| on avg. values $NO_3$ | 19.8 | 17.6 | 15.7 |
| **[40 - 50[ mg/l** | | | |
| on max. values $NO_3$ | 7.5 | 6.7 | 7.1 |
| on avg. values $NO_3$ | 7.6 | 7.6 | 9.1 |
| **[25 - 40[ mg/l** | | | |
| on max. values NO3 | 9.8 | 11.8 | 9.6 |
| on avg. values NO3 | 10.8 | 12.2 | 12 |
| **[0 - 25[ mg/l** | | | |
| on max. values NO3 | 58.5 | 58.5 | 60.4 |
| on avg. values NO3 | 61.8 | 62.6 | 63.2 |

The spatial distribution of nitrate in the groundwater reflects the importance and regional differences of natural nitrate reduction processes in the aquifers and spatial distribution of clayey layers covering the deeper parts of the groundwater (Figure 3.18). In the deeper aquifers, elevated concentrations of nitrate are mainly found in the western part of Denmark, whereas upper groundwater can contain elevated nitrate concentrations in all parts of Denmark (Hansen et al, 2012). In Denmark the depth to the redox interface varies from few centimetres in waterlogged soils to 50-100 m (Koch et al. 2019).

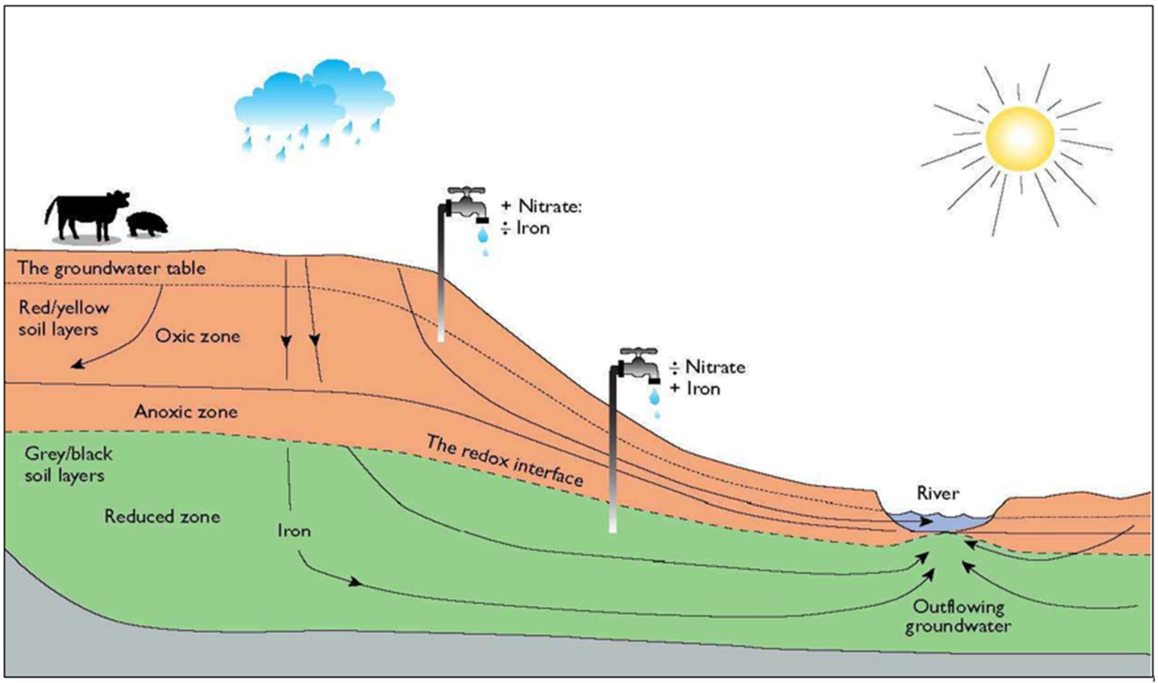



**Figure 3.18 Principle for spatial nitrate distribution in an aquifer.**

The geographical distribution of nitrate concentration levels in the current reporting period is shown in Figure 3.19 and Figure 3.20 for the maximum and average values respectively. On the maps, the distribution of the monitoring points according to nitrate concentration is presented in five quality classes: ≤1, <25, 25-40, 40-50 and ≥ 50 mg/l nitrate.

The average nitrate content from the 8th reporting period (2020-2023), is illustrated in Figure 3.20 (top and bottom), where the monitoring points are drawn in ascending and descending order respectively, and thus resulting in different monitoring points on top of the other signatures. It is evident that it is possible to make two very different maps. Figure 3.20 (top) gives an impression of a geographic widespread occurrence of nitrate in Danish groundwater, whereas Figure 3.20 (bottom) indicates that nitrate problems only can be found at a limited number of locations within the country, mainly to the west. If no active choice of drawing order for the monitoring points was taken, any possible combination of the map in the Figure 3.20 (top and bottom) would have resulted in a risk for drawing very different conclusions.

In general, the monitoring results show that nitrate can be found in all oxic groundwater layers in most of Denmark, but the infiltration depth of nitrate varies widely, and primarily gives rise to challenges for drinking water abstraction in the north/western parts of the country. On the other hand, nitrate is present in the very shallow ground waters in the eastern part of Denmark, where clay layers promote surface near runoff, and in these areas nitrate often finds a way to surface waters, and hence contributes eutrophication of coastal waters (Figure 3.18).

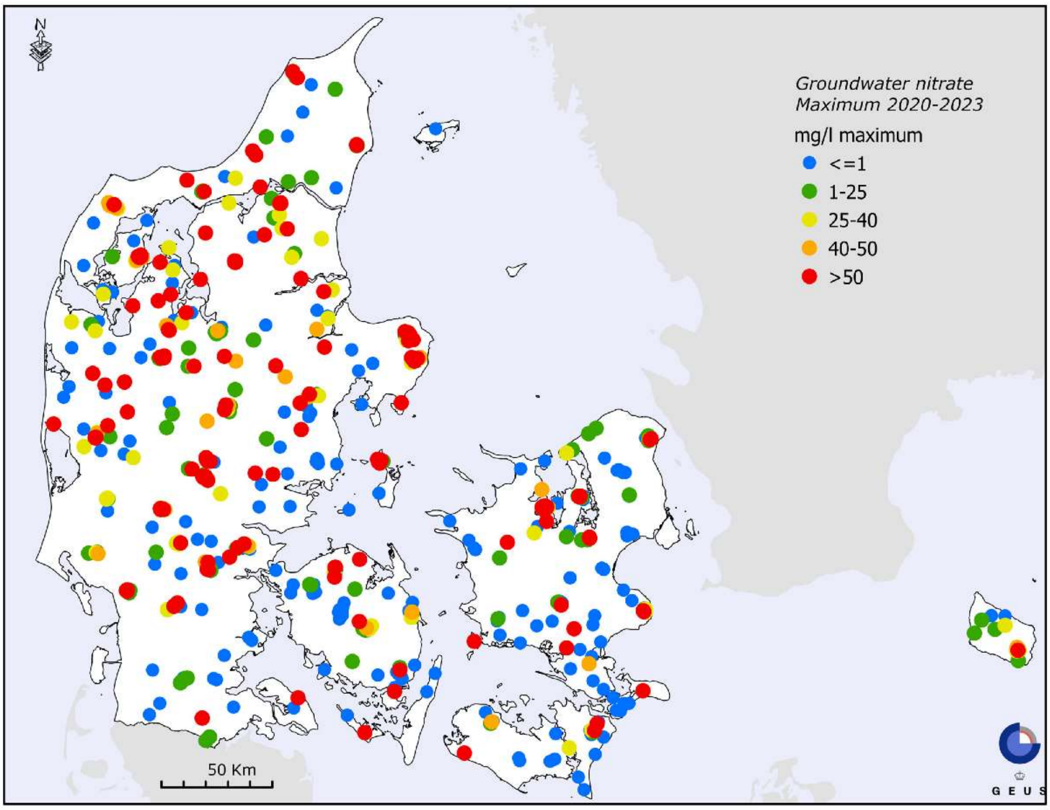
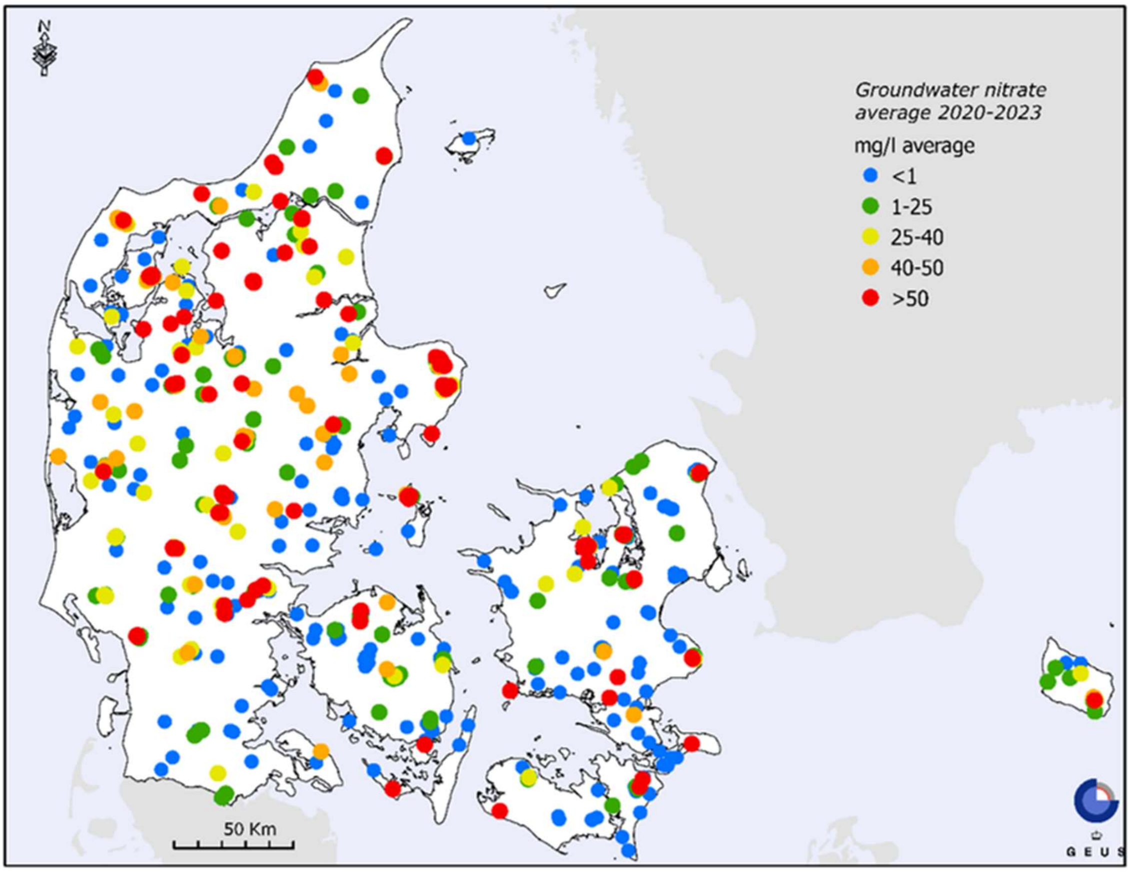



**Figure 3.19. Status for the maximum nitrate concentration 2020-2023 in all 996 monitoring points. Nitrate concentrations drawn in ascending order, values above 50 mg/l are drawn last.**



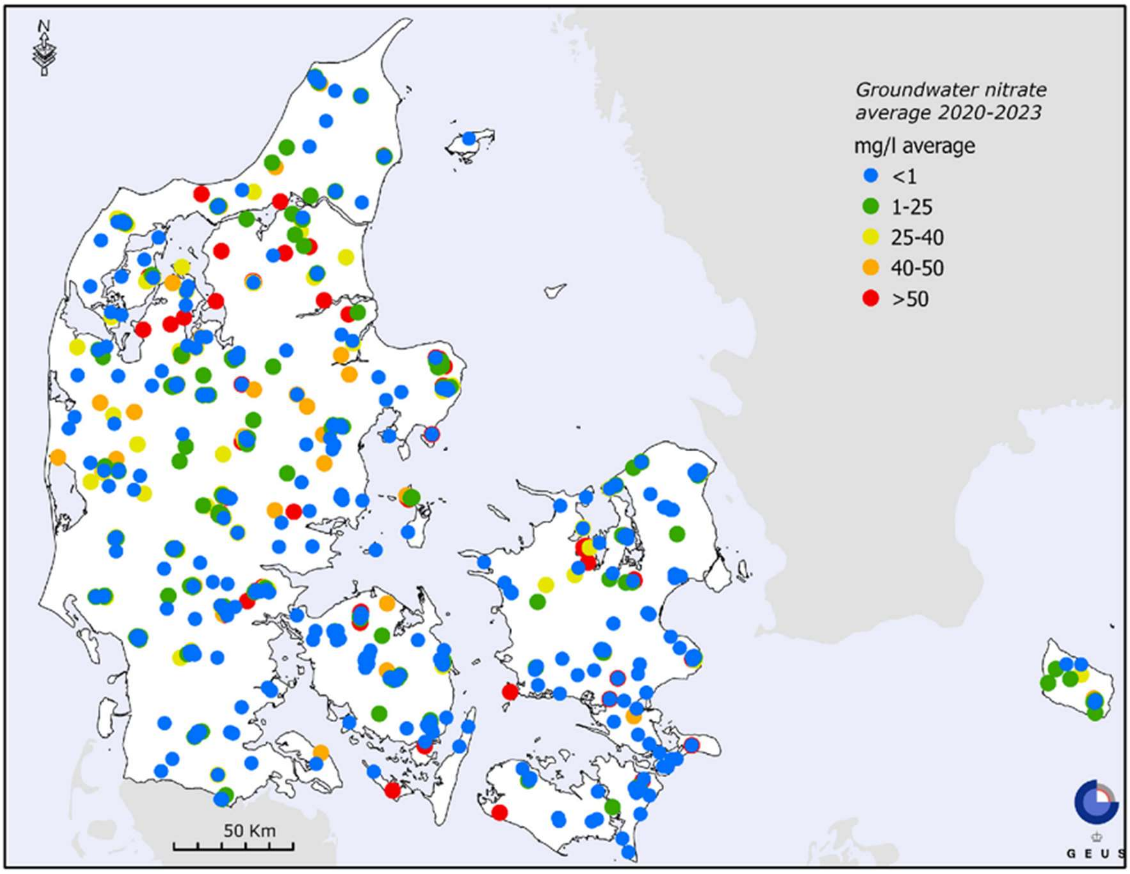




**Figure 3.20. Status for the average nitrate concentration 2020-2023 in all 996 monitoring points. The same dataset is shown in maps: on the top map, nitrate is drawn in ascending order (above 50 mg/l are drawn last), on the bottom map, nitrate is drawn in descending order (values below 1 mg/l are drawn last).**

### 3.4.4. Trend in nitrate concentrations between previous and current period

Trend in this reporting setup is defined as the difference of the average or maximum nitrate values, respectively, between to reporting periods. This paragraph focusses on the 992 common monitoring point between the previous period (2016-2019) and the current reporting period (2020-2023). This procedure was also followed in the previous reportings. The results are grouped in five classes, as shown in Table 3.17 to

Table **3.19**.

A major part of the monitoring points has trends in nitrate concentration in the range -1 to 1 mg/l from 7th to 8th reporting period 2016-19 and 2020-2023. For obvious reasons this holds for groundwater where nitrate concentrations are below 1 mg/l, which accounts for about 50% of the monitoring points, the stable fraction in Table 3.17. Table 3.18 and

**Table 3.19** focus on the data above and close to the threshold value of 50 mg/l nitrate.

The fluctuations from one year to another in the nitrate content in the monitoring wells with nitrate concentrations above 25 mg/l are often more than 5-10 mg/l/year (measured as standard deviations). This is reflected in Table 3.17 to

Table **3.19** as the large fraction of wells, with increasing and decreasing nitrate contents from one reporting period to another.

**Table 3.17. Trends in average and maximum nitrate concentrations in 992 common monitoring points between the previous period 2016-2019 and the current reporting period 2020-2023.**

| **Trend previous to current reporting period: 2016-2019 and 2020-2023** | | |
|---|---|---|
| **% of common points – all monitoring point** | **On max. NO3** | **On average $NO_3$** |
| **Increasing** | Nitrate mg/l-4years | Nitrate mg/l-4years |
| Strongly >+5 mg/l | 13.2 | 10.8 |
| Weakly >+1 to +5 mg/l | 8.2 | 7.6 |
| **Stable** | | |
| ±1 mg/l | 49.9 | 52.2 |
| **Decreasing** | | |
| Strongly <-5 mg/l | 18.2 | 18.2 |
| Weakly <-1 to -5 mg/l | 10.5 | 11.2 |

It is notable and in line with the decreasing fractions of monitoring points with high nitrate that a larger fraction of monitoring points has decreasing nitrate content than the fraction with increasing content. Table 3.17 shows that with respect to the average nitrate concentration, 29.4% of the monitoring points are decreasing, whereas 18.4% are increasing. Looking at the maximum nitrate concentration, 28.7% of the monitoring points are decreasing and 21.4% are increasing.

**Table 3.18. Trends in average and maximum nitrate concentrations between the previous period 2016-2019 and the current reporting period 2020-2023, in common monitoring points with a mean/max nitrate concentration in the 2020-2023 period of 37,5 mg/ - 50 mg/l. The number of points, n, is shown in the header of the table for each category.**

| **Trend previous to current reporting period: 2016-2019 and 2020-2023** | | |
|---|---|---|
| **% of common points 37,5 mg/l < $NO_3$ ≤ 50 mg/l** | **On max. $NO_3$** n=94 | **On average $NO_3$** n=104 |
| **Increasing** | Nitrate mg/l-4years | Nitrate mg/l-4years |
| Strongly >+5 mg/l | 25.8 | 27.9 |

| | | |
|---|---|---|
| Weakly >+1 to +5 mg/l | 10.8 | 10.6 |
| **Stable** | | |
| ±1 mg/l | 14.0 | 10.6 |
| **Decreasing** | | |
| Strongly <-5 mg/l | 37.6 | 34.6 |
| Weakly <-1 to -5 mg/l | 11.8 | 16.3 |

Table 3.18 shows that just below 50 mg/l (37,5-50 mg/l average nitrate in 2020-23) more monitoring point have decreasing than increasing nitrate concentration, as around 50% are decreasing and around 37% are increasing both for maximum and average values. This result does not count for the higher nitrate values > 50 mg/l in

Table **3.19**, where there is about as many increasing as decreasing points in Table 3.18 between the two periods.

**Table 3.19. Trends in average and maximum nitrate concentrations between the previous period 2016-2019 and the current reporting period 2020-2023, in common monitoring points with a mean/max nitrate concentration in the 2020-2023 period above 50 mg/l. The number of points, n, is shown in the header of the table for each category.**

| **Trend previous to current reporting period: 2016-2019 and 2020-2023** | | |
|---|---|---|
| **% of common points $NO_3$ > 50 mg/l** | **On max. $NO_3$** n=199 | **On average $NO_3$** n=143 |
| **Increasing** | Nitrate mg/l-4years | Nitrate mg/l-4years |
| Strongly >+5 mg/l | 40.0 | 33.6 |
| Weakly >+1 to +5 mg/l | 9.8 | 9.1 |
| **Stable** | | |
| ±1 mg/l | 4.9 | 7.7 |
| **Decreasing** | | |
| Strongly <-5 mg/l | 34.6 | 39.2 |
| Weakly <-1 to -5 mg/l | 10.7 | 10.5 |

Figure 3.21 shows a map of the spatial distribution of the trends in average nitrate of the monitoring wells from the 7th to the 8th reporting period. As for the status in Figure 3.19 and Figure 3.20, the overall trend shows very different pictures, depending on the drawing order. At the top of Figure 3.21 the trends are drawn in ascending order (strongly increasing nitrate > 5 mg/l per reporting period drawn in the top layer) and in the bottom in descending order (decreases in nitrate > 5 mg/l per reporting period bottom layer).

A similar picture would be found, if maps, showing the trend for the maximum nitrate contents, were presented.

Figure 3.21 shows that both increasing and decreasing trends can be found all over the country, as one would expect due to groundwater of different age having different distributions of trends (Figure 3.27).

A number of supplementary maps are also shown in this chapter to illustrate the nature of the nitrate trends in groundwater. Figure 3.22 shows the trends for average nitrate concentrations just below the threshold value (37.5-50 mg/l) and > 50 mg/l.

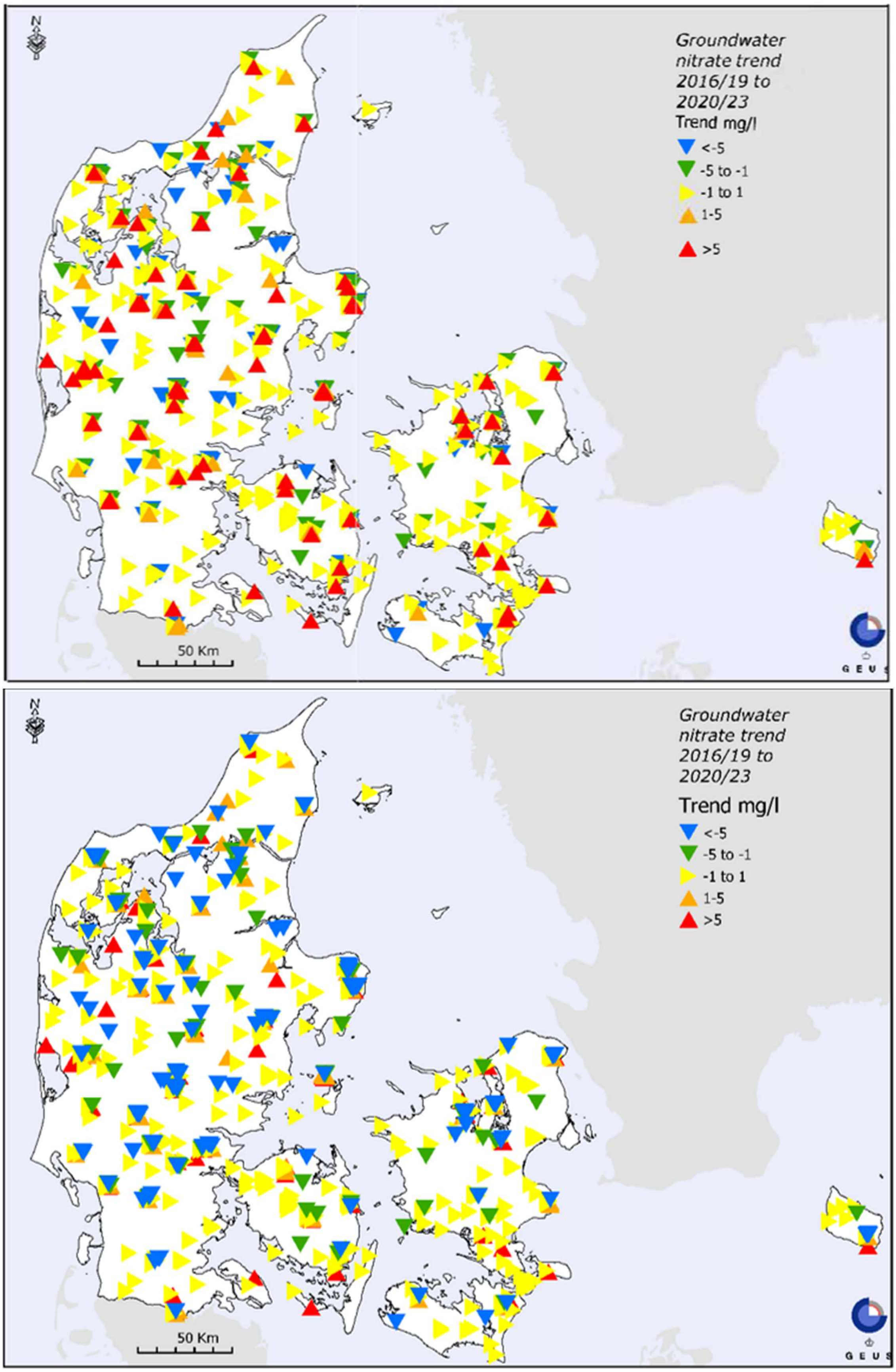
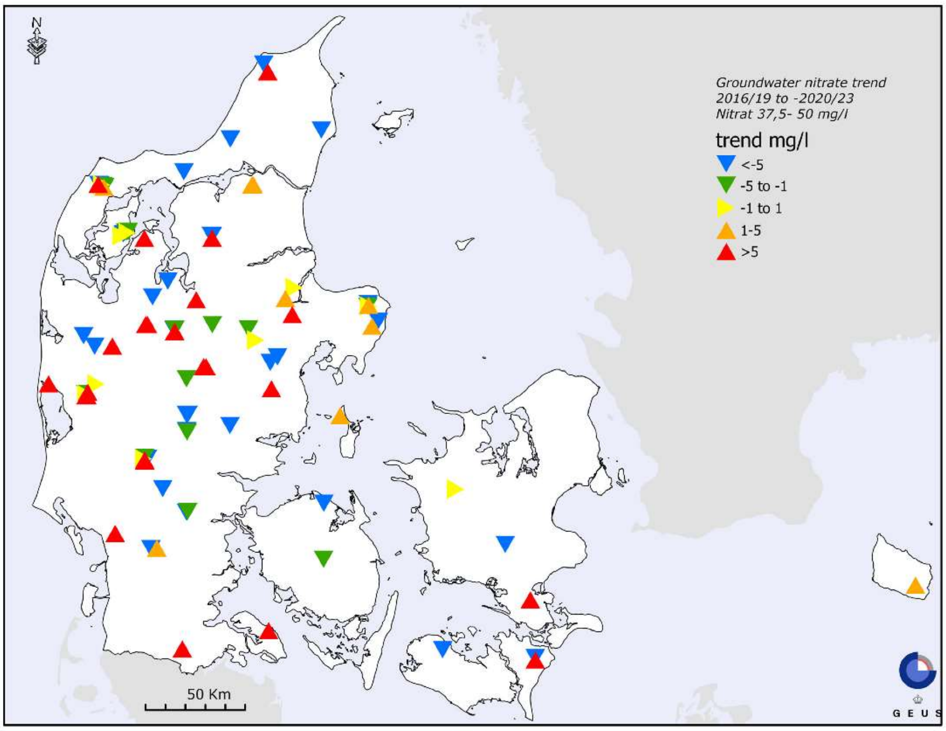



**Figure 3.21. Trend of average nitrate content in 992 common monitoring points from the 7th to the 8th reporting period. (2016-2019 and 2020-2023). Note: On the top map, trends are drawn in ascending order showing the strong increasing trends in the top layer; the bottom map shows trends drawn in descending order - showing the decreasing trends in the top layer.**



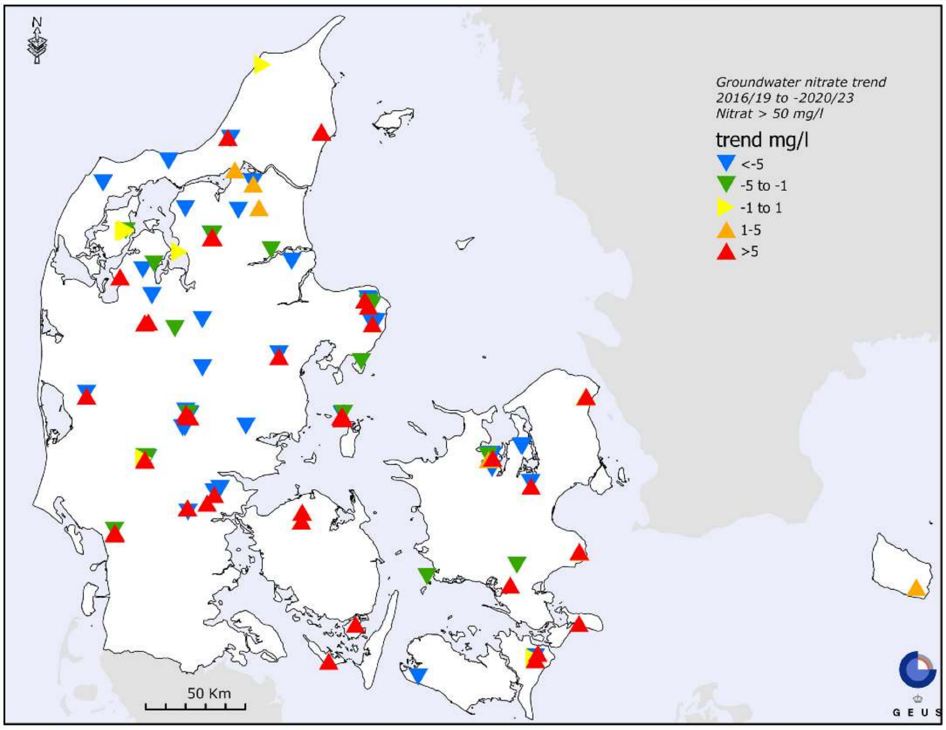




**Figure 3.22. Trend of average nitrate content period for nitrate just below the threshold value (37.5 – 50 mg/l) and nitrate above 50 mg/l in common monitoring points from the 7th to the 8th reporting. (2016-2019 and 2020-2023). Note: In both maps, trends are drawn in ascending, showing the strong increasing trends in the top layer.**

### 3.4.5. Longer trends in nitrate concentrations

This paragraph focusses on the 369 common monitoring point between the first period (1990-1993) and the current (2020-2023) reporting period. Results are also shown for trends between the period (2012-2015) and the current (2020-2023) reporting period.

Table **3.20** shows that despite the relatively week decrease in nitrate between the previous and the current periods, there has overall been a large decrease in nitrate since the first reporting period. It must be noted that only 369 monitoring points can be compared from first to current reporting period, due to the major changes in the monitoring network over time. Taking this into account, around 50% of the monitoring points have a decreasing trend, while only around 15% have an increasing trend.

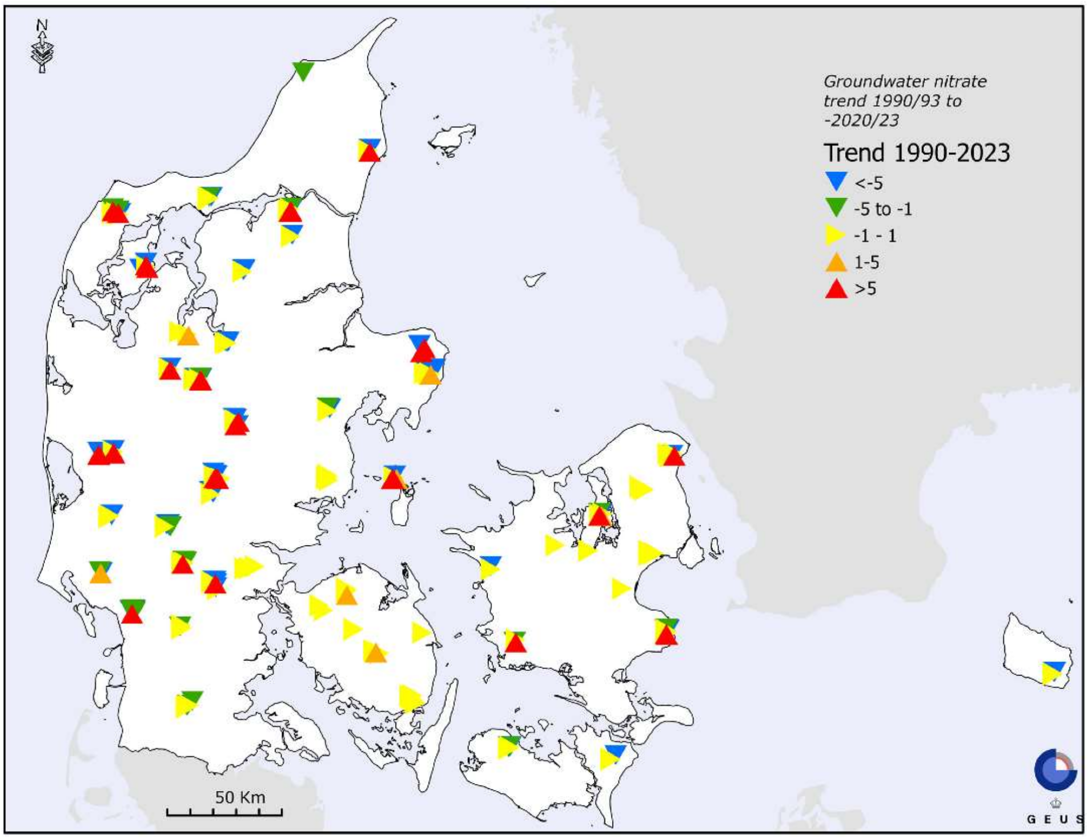
**Table 3.20. Trends in average and maximum nitrate concentrations in 369 common monitoring points between the previous period 1990-1993 and the current reporting period 2020-2023.**

| **Trend first to current reporting period: 1990-1993 and 2020-2023** | | |
|---|---|---|
| **% of common points $NO_3$ > 50 mg/l** | **On max $NO_3$** n=369 | **On average $NO_3$** n=369 |
| **Increasing** | Nitrate mg/l-4years | Nitrate mg/l-4years |
| Strongly >+5 mg/l | 9.8 | 12.5 |
| Weakly >+1 to +5 mg/l | 4.9 | 4.1 |
| **Stable** | | |
| ±1 mg/l | 30.6 | 37.9 |
| **Decreasing** | | |
| Strongly <-5 mg/l | 41.7 | 37.4 |
| Weakly <-1 to -5 mg/l | 13.0 | 8.1 |

**Figure 3.23. Trend of average nitrate content in 369 common monitoring points from the first to the current reporting period (1990-1993 and 2020-2023). Note: On the top map, trends are drawn in ascending order showing the strong increasing trends in the top layer; the bottom map shows trends drawn in descending order- showing the decreasing trends in the top layer.**Figure 3.23 shows a map of trends from the first to the current reporting period (1990-1993 to 2020-2023) and gives an impression of the overall decrease in nitrate concentrations.

Figure 3.24 shows the trends from the first to the current reporting period (1990-1993 to 2020-2023), for average nitrate concentrations just below the threshold value (37.5-50 mg/l) and > 50 mg/l.

Figure 3.25 shows a map of trends from the period (2012-2015 to 2020-2023).



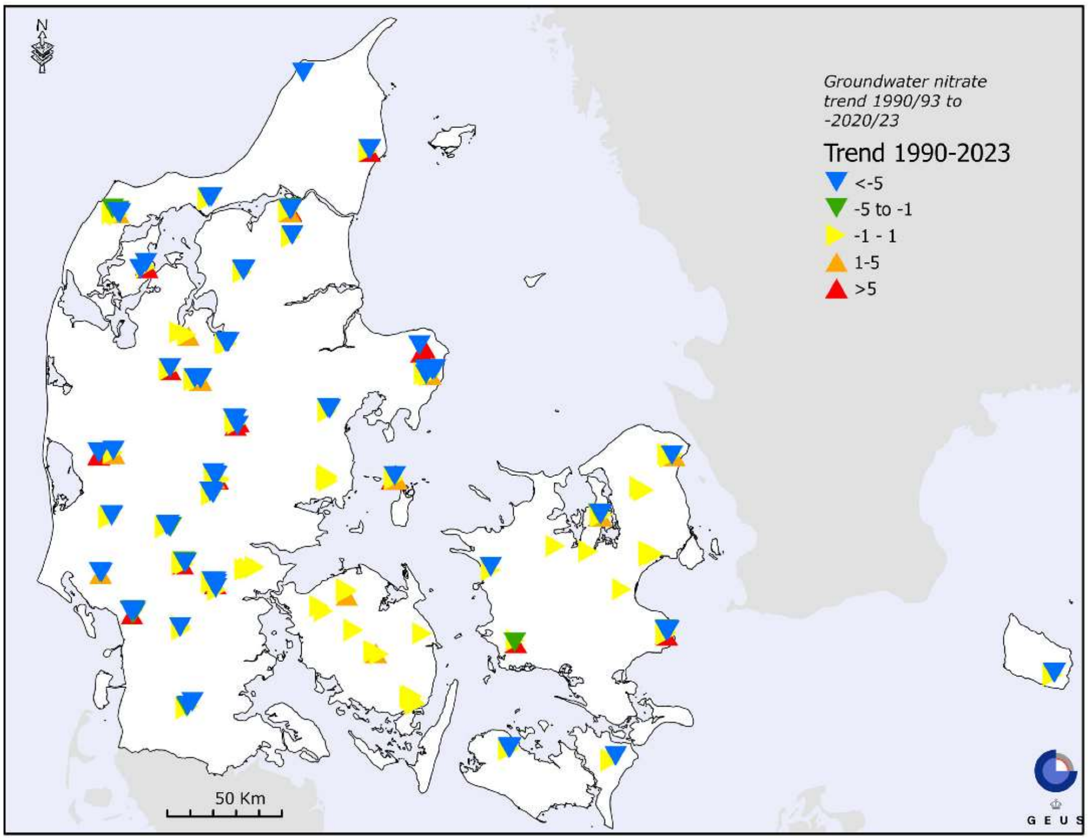
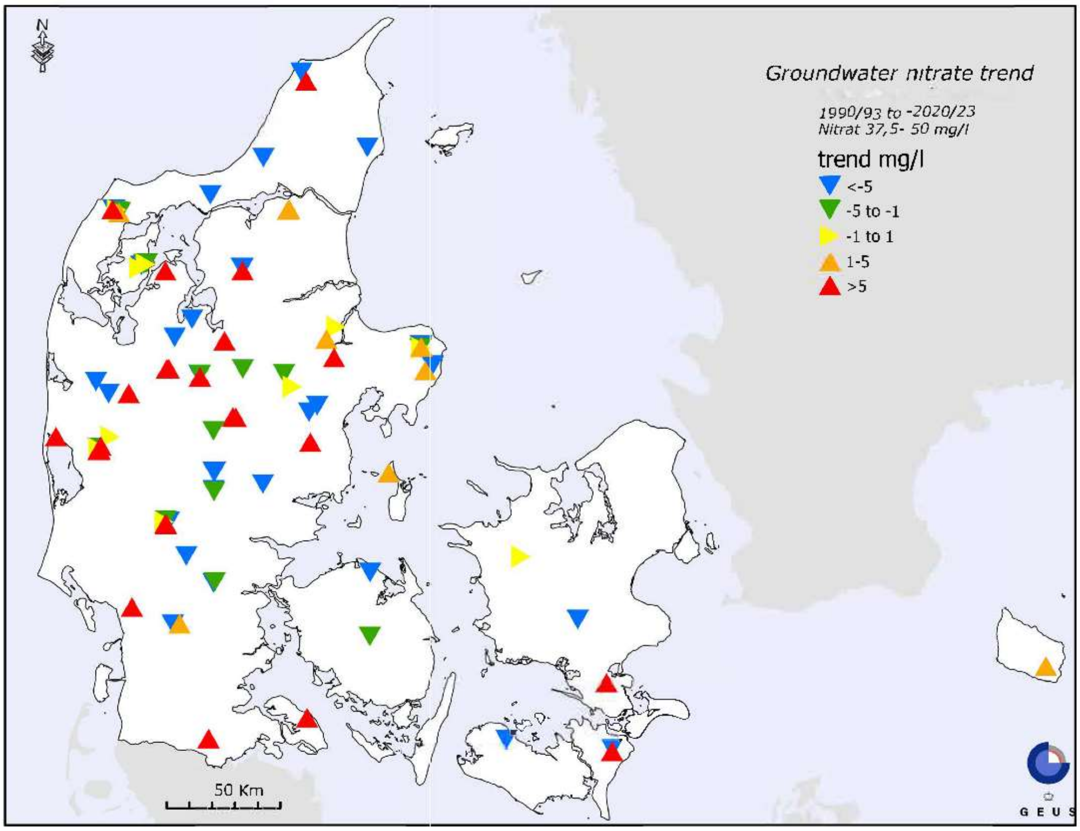




**Figure 3.23. Trend of average nitrate content in 369 common monitoring points from the first to the current reporting period (1990-1993 and 2020-2023). Note: On the top map, trends are drawn in ascending order showing the strong increasing trends in the top layer; the bottom map shows trends drawn in descending order- showing the decreasing trends in the top layer.**



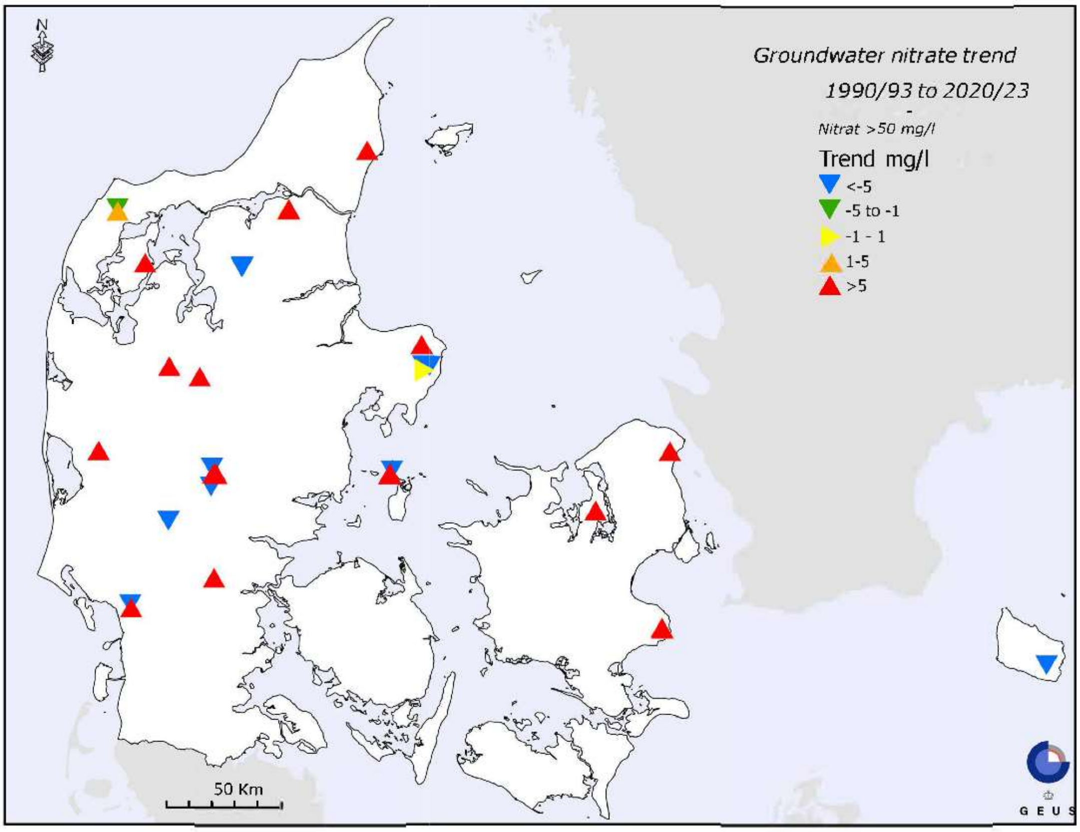
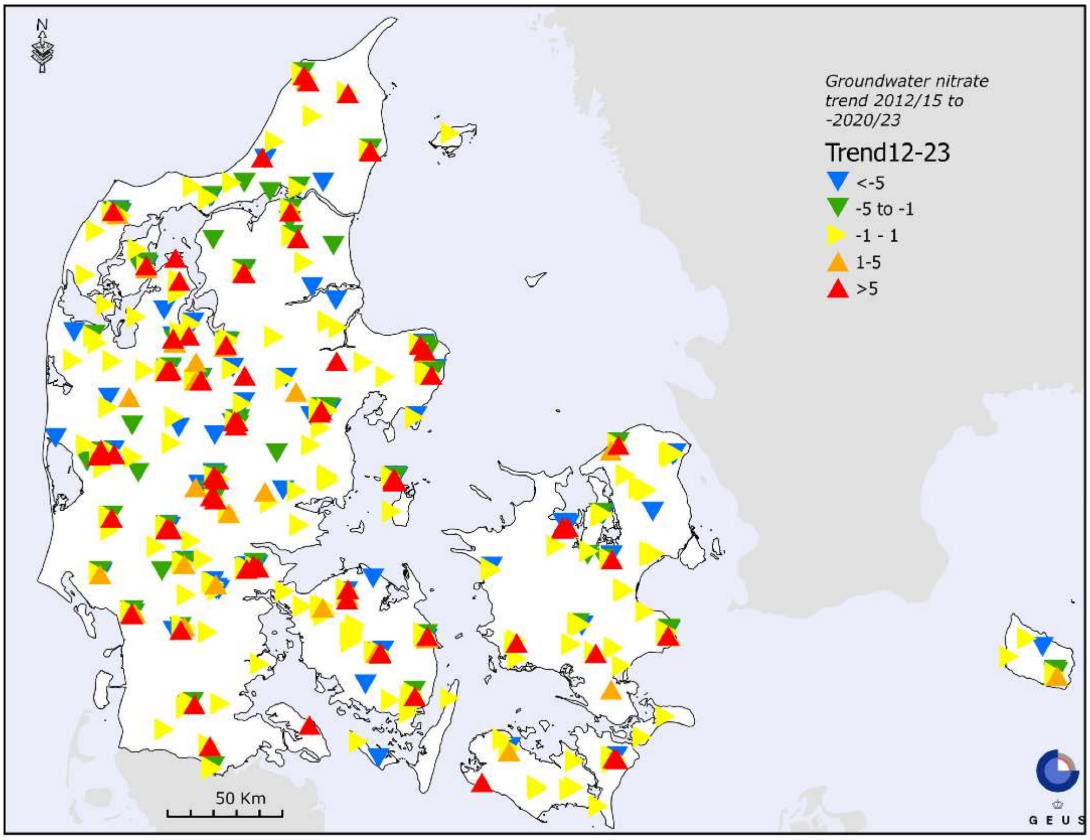




**Figure 3.24. Trend of average nitrate content period for NO3 just below the threshold value (37.5 – 50 mg/l) and NO3 > 50 mg/l in common monitoring points from the first to the current reporting. (1990-1993 and 2020-2023). Note: In both maps, trends are drawn in ascending, showing the strong increasing trends in the top layer.**



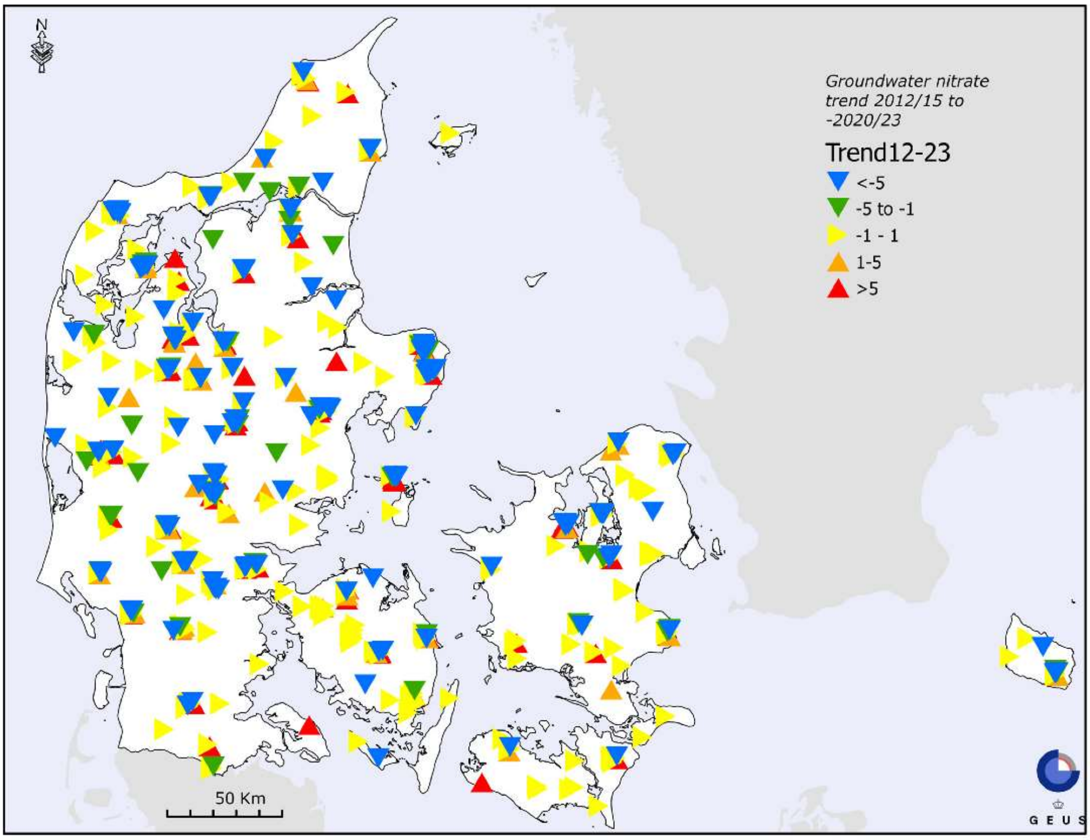




**Figure 3.25. Trend of average nitrate content in 869 common monitoring points from the 6th to the 8th reporting period. (2012-2015 and 2020-2023). Note: On the top map, trends are drawn in ascending order showing the strong increasing trends as the uppermost signature; the bottom map shows trends drawn in descending order - showing the decreasing trends in the uppermost signature.**

### 3.4.6. Improved interpretation of nitrate concentration trends by groundwater dating

Groundwater age determination allows a relationship to concentrations of nitrate with “time of recharge” instead of “time of sampling”. In this way, direct comparison between nitrate in groundwater and N loss from agriculture is possible.

The data analysis in this report only vaguely shows that the nitrate content of Danish groundwater has been improving through the reporting periods. This might be due to the fact that the groundwater age and infiltration time has not been taken into account.

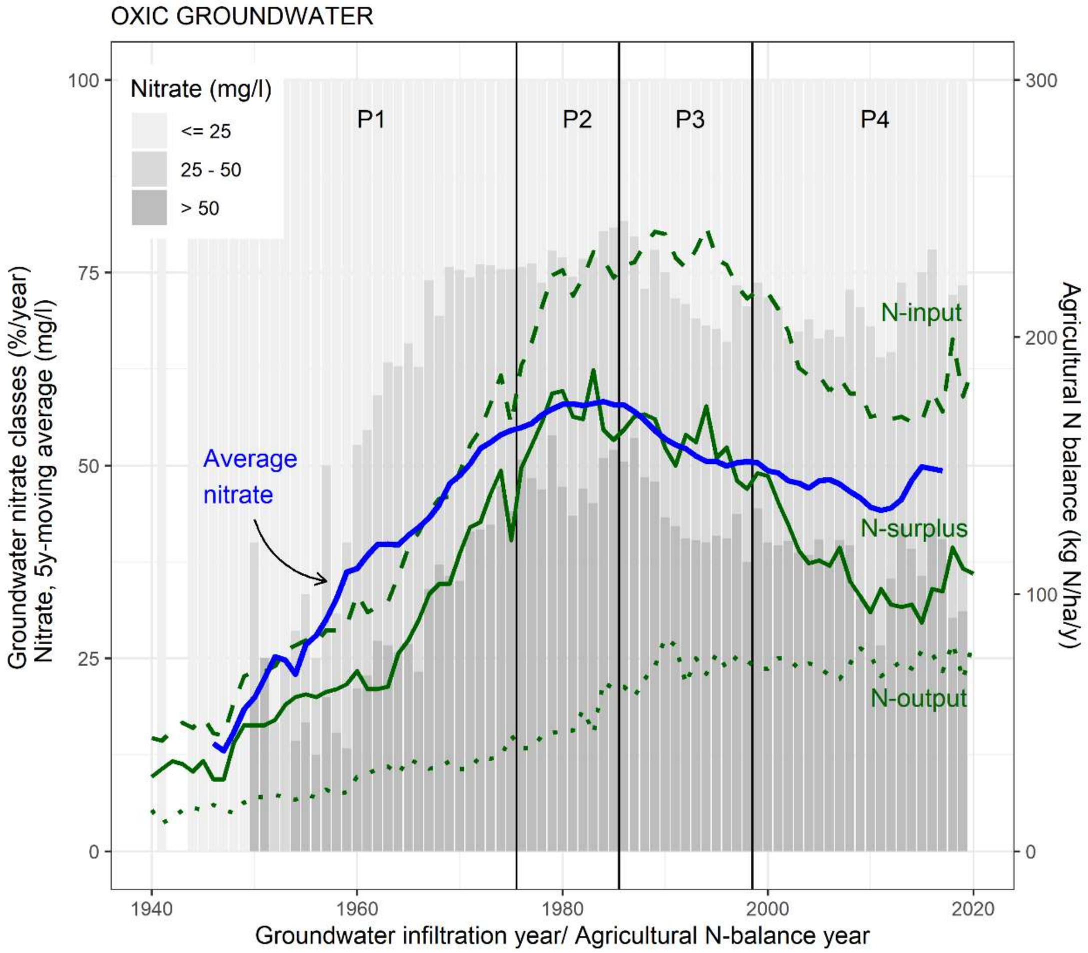



**Figure 3.26. Concentrations of nitrate in oxic groundwater (5-years moving average) as a function of infiltration year for dated groundwater, and nitrogen surplus in agriculture. Nitrate concentration classes are also shown for the intervals: >50 mg/l, 25-50 mg/l, and 1-25 mg/l. A total of 8,371 nitrate samples from 428 oxic monitoring points are shown. For comparison the agricultural nitrogen budget is shown, with the National N input, N output and the resulting N-surplus pr. year, calculated at Foulum, Denmark (Thorling, 2024).**

Statistical nitrate trend analyses at a national level using CFC dating (using CFC gasses dissolved in groundwater as a dating method) gave a strong indication of a trend reversal of nitrate in Danish oxic groundwater in the beginning of the 1980’s due to reduced nitrogen leaching in Danish agriculture (Hansen et al., 2011). A recent assessment by Hansen & Larsen (2016) and Hansen et al. (2017) using both CFC and tritium/helium dating, support these earlier findings showing significant correlation between nitrate in oxic groundwater and nitrogen surplus in agriculture at the overall Danish national level (Figure 3.26). In the last century, nitrate concentrations in groundwater were increasing in wells monitoring groundwater recharged in the period from approximately 1940-1985 due to the development of Danish agriculture with increasing input of N fertilizers and N surplus. A decreasing trend in the nitrate content of oxic groundwater has been observed from 1985 – 2012 (Figure 3.26).

The age of the groundwater in oxic groundwater monitoring points is up to 50 years. Thus, an increase in nitrate concentrations still takes place in many monitoring points due to the high input of nitrogen in agriculture in the period from 1940-1985.

Figure 3.26 also shows that in the last decade or so, the decrease in nitrogen surplus has halted, and instead a minor increase can be detected, probably due to changes in regulatory practices.

To underpin these conclusions, the development in the nitrate concentration in individual monitoring points, i.e. screens, in the national groundwater monitoring network with oxic groundwater has been investigated with a linear regression analysis of nitrate time series from the individual monitoring points, as published in Hansen et al. (2017). The analysis includes a total of 6,193 samples from 364 points, where the time series cover at least eight years in the individual sub-periods. A total of 665 time series are included in the four sub-periods in Figure 3.27 (1940-75, 1975-85, 1985- 1998 and 1998-2020), which means that some of the 364 intakes are repeated in several sub-periods.

The four periods used in this analysis are delineated after the implementation of different programmes of measures to mitigate nitrate pollution of ground and surface water, and the intensification of Danish agriculture.

A nitrate trend is interpreted as increasing if the slope coefficient of the regression line through the monitoring points is positive, and decreasing if it is negative. Figure 3.27 shows the accumulated result of the 665 calculated nitrate trends for the individual monitoring points distributed over the four (infiltration) periods with both statistically significant and non-significant trends at a 95% confidence level.

Figure 3.27 shows a clear trend towards a declining nitrate content in oxic groundwater, both when only the development in the statistically significant trends is considered and when both significant and non-significant trends are examined. It also shows that there has not been any major change in the extent of nitrate trends from the 1986-1996 period to the 1999-2020 period.

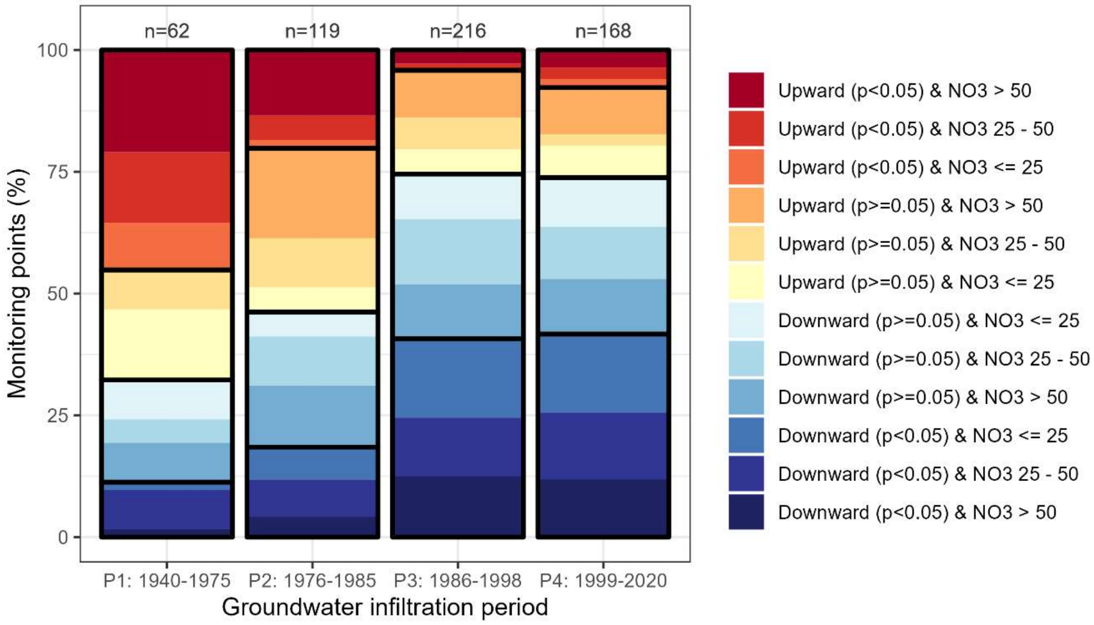



**Figure 3.27. National groundwater monitoring network: Oxic groundwater only: 665 nitrate trends in in oxic groundwater for 4 periods based on the year of groundwater formation. The analysis includes a total of 6,193 samples from 364 screens, where the time series cover at**

**least 8 years. At the top of each column is the number of monitoring points with trends for the period. Both statistically significant and non-significant nitrate trends are shown at 95% confidence levels. The figure is based on data collected from 1988-2012 (Thorling et al., 2024).**

**Literature:**

Hansen, B. & Larsen, F. 2016: Faglig vurdering af nitratpåvirkningen af iltet grundvand ved udfasning af normreduktionen for kvælstof i 2016-18. Danmarks og Grønlands Geologiske Undersøgelse Rapport. 2016/04. GEUS, 22 pp.

Hansen, B., Thorling, L., Dalgaard, T. og Erlandsen, M., 2011: Trend Reversal of Nitrate in Danish Goundwater – a Reflection of Agricultural Practices and Nitrogen Surpluses since 1950. Environmental Science and Technology, vol. 45 nr. 1 pp 228-234.

Hansen, B., Dalgaard, T., Thorling, L., Sørensen, B., Erlandsen, M., 2012: Regional analysis of groundwater nitrate concentrations and trends in Denmark in regard to agricultural influence. Biogeosciendes Disucssion paper, 9, 5321-5346, 2012. http://www.biogeosciences-discuss.net/9/5321/2012/bgd-9-5321-2012.html

Hansen, B., Thorling, L., Schullehner, J., Termansen, M. & Dalgaard, T., 2017: Groundwater nitrate response to sustainable nitrogen management. Scientific Reports, 7, 8566. DOI: 10.1038/s41598-017-07147-2.

Jørgensen, L.F.; Stockmarr, J., 2009: Groundwater monitoring in Denmark: characteristics, perspectives and comparison with other countries. *Hydrogeology Journal* 2009, 17, 827-842

Koch, J., Stisen, S., Refsgaard, J.C., Ernstsen, V., Jakobsen, P.R., Højberg, A.L., 2019: Modelling depth of the redox interface at high resolution at national scale using random forest and residual Gaussian simulation. Water Resources Research, 55, 2, pp1451-1469.

Thorling, L., Albers, C.N., Ditlefsen, D., Hansen, B., Johnsen, A.R., Kazmierczak, J., Mortensen, M.H. & Troldborg, L., 2024: Grundvand. Status og udvikling 1989–2022. Teknisk rapport, GEUS 2024.

# 4. Revision of the Vulnerable Zones

According to Article 3 (5) in the Nitrates Directive (1991/676/EEC), member states shall be exempt from the obligation to identify specific vulnerable zones, if they establish and apply action programmes, referred to in Article 5 in accordance with this Directive throughout their national territory.

Denmark has established and applied action programmes for the whole territory since the first Action Plans in the 1980's.

# 5. Development, promotion and implementation of code of good practice

According to article 3 (5) in the Nitrates Directive the Danish Nitrates Action Programme applies to the whole national territory. The Danish Nitrates Action Programme consists of the measures in annex III and the measures in the code of good agricultural practice in annex II.

Measures according to code of good practice pursuant to the Nitrates Directive, annex II, are included in the Nitrate Action Programme as mandatory measures equivalent to the measures included in the programme pursuant to the directive, annex III. Description of the measures, according to code of good practice, is therefore included in the following chapter.

In the following chapter 6, the principle measures in the Nitrate Action programme are described along with the specific implementation, changes in the regulation effected during the period 2016 to 2019 (both years included) and the promotion of the elements in the programme.

# 6. Principle measures applied in the Action programme

In this chapter, the principle measures in the Nitrate Action programme are described along with the specific implementation, changes in the regulation effected during the programme period and the promotion of the elements in the programme. References of executive orders etc., which may be regularly updated, will be the version of the order that was active on December 31st of 2023.

At present, the Nitrates Directive is implemented in the following legislation as part of the Danish Action programme or as additional measures according to Article 5, paragraph 5:

- Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures with subsequent amendments. "Lov om jordbrugets anvendelse af gødning og om næringsstofreducerende tiltag", jf. lovbekendtgørelse nr. 1053 af 10. juli 2023, see link: https://www.retsinformation.dk/eli/lta/2023/1053

- Act on Livestock Husbandry and Use of Fertilizers with subsequent amendments, "Lov om husdyrbrug og anvendelse af gødning, jf. lovbekendtgørelse nr. 520 af 1. maj 2019, see link https://www.retsinformation.dk/eli/lta/2019/520

- Executive Order no. 1160 of the 26th of July 2023 on Agricultural Use of Fertilisers in the planning period 2023/2024, "Bekendtgørelse om jordbrugets anvendelse af gødning i planperioden 2023/2024". See link: https://www.retsinformation.dk/eli/lta/2023/1060 .The Order is re-issued yearly and the fertilization standards are re-calculated regularly.

- Executive Order no. 1024 of the 30th of July 2023 on Nutrient-Reducing Measures and Cultivation-Related Measures in Agriculture for the planning period 2023/2024, "Bekendtgørelse om næringsstofreducerende tiltag og dyrkningsrelaterede tiltag i jordbruget for planperioden. 2023/2024". See link: https://www.retsinformation.dk/eli/lta/2023/1024 .The Order is re-issued yearly.

- Executive Order no. 1025 of the 30th of June 2023 on Application of Fertilisers, "Bekendtgørelse om Jordbrugsvirksomheders anvendelse af gødning". See link: https://www.retsinformation.dk/eli/lta/2023/1025 . The Order is re-issued yearly.

Other regulation is currently under preparation.

From 2020-2024 the Nitrate Directive was implemented in the following legislation as part of the Danish Action programme or as additional measures according to Article 5, paragraph 5:

- Act on Environmental protection cf. Executive Order no. 928 of the 28th of June 2024, "Bekendtgørelse af lov om miljøbeskyttelse". See link: https://www.retsinformation.dk/eli/lta/2024/928.

- Act on agricultural use of fertilizer and plant cover. "Lov nr. 338 af 2. april 2019 om jordbrugets anvendelse af gødning og om næringsstofreducerende tiltag", see link: https://www.retsinformation.dk/eli/lta/2019/338

- Act no. 256 of the 21st of March 2017 on Livestock Husbandry and Use of Fertilizers with subsequent amendments, "Lov om husdyrbrug og anvendelse af gødning, jf. lovbekendtgørelse nr.520 af 1. Maj 2019, see link https://www.retsinformation.dk/eli/lta/2019/520

- Executive Order no. 1176 of the 23rd of July 2020 on Environmental Regulation of Animal Husbandry and the Storage and Use of Fertilisers,”Bekendtgørelse om miljøregulering af dyrehold og om opbevaring og anvendelse af gødning” See link: https://www.retsinformation.dk/eli/lta/2020/1176

- Executive Order no. 1166 of the 13th of July 2020 on Agricultural Use of Fertilisers in the planning period 2020/2021, “Bekendtgørelse om jordbrugets anvendelse af gødning i planperioden 2020/2021”. See link: https://www.retsinformation.dk/eli/lta/2020/1166. The Order is re-issued yearly and the fertilization standards are re-calculated regularly.

- Executive Order no. 66 of the 28th of January 2020 on Nutrient-Reducing Measures and Cultivation-Related Measures in Agriculture for the planning period 2020/2021, “Bekendtgørelse om næringsstofreducerende tiltag og dyrkningsrelaterede tiltag i jordbruget for planperioden 2020/2021”. See link: https://www.retsinformation.dk/eli/lta/2020/66. The Order is re-issued yearly.

- Act on Water Extraction cf. Executive Order no. 602 of the 10th of May 2022 on Water Extraction, ”Bekendtgørelse af lov om vandforsyning m.v.”. See link: https://www.retsinformation.dk/eli/lta/2022/602.

An overview of the implementation of Annex II and Annex III of the Nitrates Directive as mandatory measures in the Danish Nitrate Action Programme in 2023 is given in Table 6.1. The specific measures are described for each litra in annex II and annex III can be found in text set in bold italic type in Table 6.1.

Note that the overview of the implementation of the programme is given for the legal texts valid by the end of 2023. Changes in the implementation are described for each element in the overview in Table 6.1. Changes in the legal texts in effect in 2024 are not included in the legal references in the overview.

The exact text of the orders, as they were in 2024, can be found in Danish on Legal Information (“Retsinformation”, see respective links given in the list above). Only the paragraphs in the overview in Table 6.1 are legal elements, implementing the Nitrates Directive.

**Table 6.1 Implementation of the Nitrates Directive in national orders during the period 2020-2024 for each litra in the Annex II and III of the Directive and art. 5(5), and changes of the implementation during the same period**

<table>
<tr><th rowspan="2">Nitrates Directive, annex II and III, art. 5(5).</th><th>Implementation in national order by 2024</th></tr>
<tr><th>Indication of changes during the period 2020-2023</th></tr>
<tr><td rowspan="2">Annex II A 1. Periods when the land application of fertilizer is inappropriate.</td><td>§ 9 of Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers.<br><br>In the period from harvest, though no later than the 1st of October to the 1st February, liquid organic fertiliser or chemical nitrogen fertiliser may not be applied – with exemptions.</td></tr>
<tr><td>The rules were until 2021 a part of Executive Order No 1176 of the 23rd of July 2020 on Environmental Regulation of Animal Husbandry and the Storage and Use of Fertilisers.<br><br>Since 2020 greenhouse production has been exempted from the rules.<br><br>During the period the individual exemptions have been updated.</td></tr>
<tr><td rowspan="2">Annex II A 2. The land application of fertilizer to steeply sloping ground</td><td>§ 10 (9 & 10) of Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers.<br><br>Manure and mineral fertilizer must not be applied on steeply sloping areas.</td></tr>
<tr><td>The rules were until 2021 a part of Executive Order No 1176 of the 23rd of July 2020 on Environmental Regulation of Animal Husbandry and the Storage and Use of Fertilisers.</td></tr>
</table>

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| *Annex II A 3. The land application of fertilizer to water-saturated, flooded, frozen or snow-covered ground* | § 10 (8) of Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers.<br><br>***Fertiliser must not be applied in a manner with risk of run-off, including water-saturated, flooded, frozen or snow-covered soil.*** |
| | The rules were until 2021 a part of Executive Order No 1176 of the 23rd of July 2020 on Environmental Regulation of Animal Husbandry and the Storage and Use of Fertilisers. |
| *Annex II A 4. The conditions for land application of fertilizer near water courses* | § 10 (8 & 11) of Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers.<br>***Fertilizer must not be applied 2 m from watercourses.*** |
| | The rules were until 2021 a part of Executive Order No 1176 of the 23rd of July 2020 on Environmental Regulation of Animal Husbandry and the Storage and Use of Fertilisers.<br><br>It was specified in 2020 that manure must not be applied on areas where there is a risk of run-off to water supply facilities. |

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| *Annex II A 5. The capacity and construction of storage vessels for livestock manures, including measures to prevent water pollution by run-off and seepage into the groundwater and surface water of liquids containing livestock manures and effluents from stored plant materials such as silage.* | ***§ 8 (1-7) and (13-14), § 9 (1-2), § 10, § 12, § 13, § 14 (1) and (4), § 15 (1) and (3), § 16, § 17, §19 (1), § 20 (1) and (3-6), § 23, § 24, 27 (1-4), § 28, § 30 (1-6), § 32, § 34 (3) of Order on commercial livestock, livestock manure, silage, etc. no. 2243 of 29/11/2021***<br><br>***Stables, stalls, etc. shall be designed in such a way that groundwater and surface water is not polluted. They shall have floors made of a durable material that is impermeable to moisture. The floors shall be constructed to resist the effects of animals and the tools used in the stalls. A system shall be established for appropriate drainage and collection of all liquid manure and residue water***<br><br>***Capacity of storage facilities for manure must be adequate (specified). Adequate storage capacity may be satisfied by storage on other property or delivery to the biogas plant, manure treatment plant or manure storage facility.***<br><br>***Solid manure storage, manure storage in the field, deep litter, compost and processed manure with a dry matter percentage greater than or equal to 12 must be covered with waterproof material.***<br><br>***Silage must be stored in a silage storage facility or wrapped in waterproof material. Silage effluent must be discharged through purpose-designed drainage.***<br><br>***Containers for liquid livestock manure, silage effluent, and residual water must be constructed of durable materials that are impermeable to moisture. The containers shall be appropriately dimensioned in relation to capacity in such a way that they can resist the impacts of stirring, covering and emptying.. Drains from stables/stalls, manure yards, silage stocks, cesspools, and pump wells shall be run through impermeable closed pipes and shall lead to liquid manure containers.*** |

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| | Since the previous Order on commercial livestock, livestock manure, silage, etc. no. 1318 of /06/2015, there have been transfert rules about the design of stables etc. for carnivorous fur-bearing animals (previous regulated in separate order BEK nr 1428 af 13/12/2006 Bekendtgørelse om pelsdyrfarme m.v.).<br>Furthermore, livestock facilities that are not permanently located (animal shelter) may not be located in the same place, or whithin 25 meters, for a maximum of 12 months at a time.<br><br>There have been made exceptions to the requirement in § 8 (2), and they are all intended to ensure that livestock facilities are arranged in such a way that pollution of groundwater and surface water does not occur.<br><br>There has been a compilation of some of the other rules in the Order, and as a general rule, it is the same legal basis as before. |
| *Annex II A 6. Procedures for the land application, including rate and uniformity of spreading, of both chemical fertilizer and livestock manure that will maintain nutrient losses to water at an acceptable level.* | § 6 (1-4) and § 10 (1-7) of Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers.<br><br>Application of liquid manure may only be carried out by means of trailing hoses, trailing foot/shoe applicators or by injection.<br><br>***Furthermore, fertiliser must be spread evenly. Specific rules are given for various manure types.*** |
| | The rules were until 2021 a part of Executive Order No 1176 of the 23rd of July 2020 on Environmental Regulation of Animal Husbandry and the Storage and Use of Fertilisers. |
| *Annex II B 7. Land use management, including the use of crop rotation systems and the proportion of the land area devoted to permanent crops relative to annual tillage crops;* | § 42 (1), Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures with subsequent amendments.<br><br>§ 11 Executive Order No 1160 of the 26th of July 2023 on Agricultural Use of Fertilisers in the planning period 2023/2024. |

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| | ***Farms subject to registration in the Fertilizer Register pursuant to the Fertilizer Act must report a fertilizer plan in a dedicated template with a field map showing all cultivated and uncultivated areas and the field crops. The farms must do this no later than the 10th of September after the planning period. The farms must submit the plans electronically using a self-service IT facility on the Danish Agricultural Agency website.*** |
| *Annex II B 8. The maintenance of a minimum quantity of vegetation cover during (rainy) periods that will take up the nitrogen from the soil that could otherwise cause nitrate pollution of water;* | § 3 (1)- (4), (6&7) in Executive Order No 1024 of the 30th of July 2023 on Nutrient-Reducing Measures and Cultivation-Related Measures in Agriculture for the planning period 2023/2024.<br><br>§ 38 in Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures with subsequent amendments.<br><br>***General requirement for mandatory catch crops on farms nationwide on a certain percentage of the area on the holding.***<br><br>***Agricultural enterprises with crop or livestock or combinations thereof with a certain annual turnover from crops or livestock, or combinations thereof and a total area of 10 hectares or more, shall establish a minimum amount of catch crops.*** |
| | The rules concerning catch crops are updated annually. Some of the changes concern the plant species approved, the conversion factor between early sown winter crops and catch crops, compatibility with CAP GAECs and consequences in case of late sowing. |
| *Annex II B 9. The establishment of fertilizer plans on a farm-by-farm basis and the keeping of records on fertilizer use* | § 42 (1), Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures with subsequent amendments.<br><br>§ 11 and § 12 Executive Order No 1160 of the 26th of July 2023 |

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| | on Agricultural Use of Fertilisers in the planning period 2023/2024.<br><br>***Requirement to prepare a fertilizer plan and a fertilizer account for each holding.***<br><br>***Farms subject to registration in the Fertilizer Register pursuant to the Fertilizers Act must report a fertilizer plan in a dedicated template showing all cultivated and uncultivated areas, a field map and the field crops. The farms must do this no later than 10 September after the end of the planning period. The farms must submit the plan electronically using a self-service IT facility on the Danish Agricultural Agency website.***<br><br>***By the end of March each year, farmers are obliged to submit their farm fertilization account containing information on the previous cropping season (planning period August-July) to the Danish Agricultural Agency for registration and control.*** |
| | No changes. |
| *Annex II B 10. The prevention of water pollution from run-off and the downward water movement beyond the reach of crop roots in irrigation systems* | §18 and § 22 Consolidated Act on Water extraction no 602 of 10th of May 20122<br><br>***Farmers need permission for water intake for irrigation. Permissions are issued for a limited period.***<br><br>***In addition, the need for irrigation is included when calculating nitrogen fertilizer standards, see Annex III, 1.3.*** |
| | No changes. |

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| *Annex III, 1, 1. Periods when the land application of certain types of fertilizer is prohibited;* | See under Annex II A1<br><br>§ 9 of Executive Order No 1025 of the 30th June 2023 on Application of Fertilisers. |
| *Annex III, 1, 2. The capacity of storage vessels for livestock manure; this capacity must exceed that required for storage throughout the longest period during which land application in the vulnerable zone is prohibited, except where it can be demonstrated to the competent authority that any quantity of manure in excess of the actual storage capacity will be disposed of in a manner which will not cause harm to the environment;* | See Annex II A 5 above. |

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| *Annex III, 1, 3. Limitation of the land application of fertilizers, consistent with good agricultural practice and taking into account the characteristics of the vulnerable zone concerned.* | § 12, § 13, § 42, § 43 (4) Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures with subsequent amendments.<br><br>§ 11-§ 49 Executive Order No 1160 of the 26th of July 2023 on Agricultural Use of Fertilisers in the planning period 2023/2024.<br><br>§ 10 (8, 9) Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers<br><br>***In each plan period, farms subject to registration in the Fertilizer Register pursuant to the Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures must not apply more nitrogen for fertilizer purposes than the fertilizer quota calculated for the farm.***<br><br>***For each plan period, a farm's total fertilizer quota for nitrogen must be calculated as the sum of the quotas for each farm field. For each field the quota must be calculated on basis of the size of the field, the crop, the pre-crop and the nitrogen standard of the crop.***<br><br>***The yearly amount of nitrogen permitted at farm level is calculated taking into account the characteristics of the area and is based on a balance between the foreseeable nitrogen requirement of the crops and the nitrogen supply to the crops from the soil and from fertilization.***<br><br>***The nitrogen standards for each crop are determined and up- dated regularly. The optimal relationship between the nitrogen requirements of the crops and nitrogen supply is set every year on basis of field trials. Due to the varying abilities to retain nutrients, different soil types are divided into four categories with different nitrogen standards for the same crop. Irrigation is taken into consideration by the authorities when the specific standards are set. Yearly variations in temperature and extent of rainfalls in the wintertime are also taken into account.***<br>***In addition, the relationship between prices for nitrogen*** |

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| | ***fertiliser and crops is taken into account, and the economically optimal fertilization level is calculated for each crop.***<br><br>***The fertilizing content of nitrogen in the livestock manure must be calculated using stipulated standards. Standards are set for different types of livestock and with respect to the housing system. If the production deviates from standard, e.g. slaughter weight, the standard figures must be corrected, using standard corrections formulas. A large percentage of the nitrogen contents of applied livestock manure must be included in the accounting of overall application of nitrogen fertilizer on the farm. Minimum application efficiency rates are imposed on each type of manure. Thus, the possibility to use additional mineral fertilizer up to the fertilizer quota is restricted.*** |
| | The specific numbers used for fertiliser accounting are updated regularly. This is the case both for the economically optimal fertiliser levels as well as the amount of nutrients produced by livestock. In addition to the total amount of nitrogen in the manure, it is specified what percentage must be included in the accounting of overall application of nitrogen on the farm (towards the quota described above).<br><br>During the period, the included percentage has been increased for manure, sewage sludge and processed organic fertilisers, and decreased for other organic fertilisers. |

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| *Annex III, 2 These measures will ensure that, for each farm or livestock unit, the amount of livestock manure applied to the land each year, including by the animals themselves, shall not exceed a specified amount per hectare.*<br>*The specified amount per hectare be the amount of manure containing 170 kg N.* | § 14 Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers.<br><br>***A maximum of 170 kg N per hectare per planning period of organic fertiliser may be applied on agricultural holdings.***<br><br>***Derogation (Commission decision of the 17th of July 2020): On agricultural holdings with a yearly production of nitrogen in livestock manure above 300 kg of which at least two thirds are from cattle, can apply livestock manure containing up to 230 kg nitrogen per hectare per planning period when in compliance with certain conditions.*** |
| | The rules were until 2021 a part of Executive Order No 1176 of the 23rd of July 2020 on Environmental Regulation of Animal Husbandry and the Storage and Use of Fertilisers. |
| *Additional measures according to Article 5, paragraph 5* | § 10 (8- 11) and § 14 Executive Order No 1025 of the 30th of June 2023 on Application of Fertilisers.<br><br>***Regulation of land application of fertilizer near watercourses.***<br><br>***Inclusion of other organic fertilisers, in addition to manure, in the limitation of 170 kg N per ha.*** |

# 7. Evaluation of the implementation and impact of the action programme’s measures

## 7.1. Data concerning the territory of Denmark

**Table 7.1. Data concerning the territory of Denmark[1].**

| | Reporting Period | | |
|---|---|---|---|
| | **Previous period average of 2012-2015** | **Previous period average of 2016-2019** | **Current period average of 2020-2023** |
| Total land area[1)] hectare (ha) | | 4,309,800 | |
| Agricultural land, 1000 ha | 2,648 | 2,615[4] | 2,620 |
| Agricultural land available for application of manure, 1000 ha | 2,460 | 2,507[4] | 2,383 |
| Permanent grass, 1000 ha | 211 | 220[5] | 229[5] |
| Perennial crops[2)] (fruit trees, bushes and energy crops), 1000 ha | 14 | 14[5,6] | 13[5,6] |
| Annual use of organic N from livestock manure[3)], 1000 tons | 217 | 220[4] | 220 |
| Annual use of organic N from other sources than livestock manure, 1000 tons | 7 | 8[4] | 8 |
| Annual use of N from fertilizer (mineral N), 1000 tons | 202 | 232[4] | 207 |
| Number of farms | 40,400 | 34,400[4] | 31,194 |
| Number of farms with livestock | 21,800 | 13,400[5] | 11,476 |
| Dairy cattle, 1000 heads | 568 | 573[5] | 559 |
| Cattle, million heads | 1.52 | 1.54[5] | 1.48 |
| Slaughter Pigs, million/year | 20.1 | 17[7] | 16,5[5] |
| Poultry, million heads | 18.6 | 20.8[5] | 22.4 |
| Fur, million heads | 2.78 | 3.14[5] | 0.56 |
| Other (horse, sheep), 1000 heads | 147 | 148[5] | 204 |
| Manure N excretion per livestock category, 1000 tons/year | | | |

| | | | |
|---|---|---|---|
| Cattle | 113 | 117[4] | 116[4] |
| Pigs | 84 | 83[4] | 78[4] |
| Others | 20 | 21[4] | 14[4] |

[1)] Excluding territories not part of the European Union (Greenland and the Faroe Islands)

[2)] Does not include data for Christmas trees

[3)] This figure refers to Nitrogen in livestock manure (excreted Nitrogen minus losses in housing and storages)

Sources: Agency for Green Transition and Aqatic Environment[4], Statistics Denmark[5], Aarhus University[6], Danish Agriculture and Food Council[7]

## 7.2. Nitrogen discharges to the aquatic environment

*Department of Ecoscience, Aarhus University*

The amount of Nitrogen discharged to the sea (load) in the years 2020 to 2022 was in general within a similar range as in the previous three reporting periods (**Table 7.2** and **Figure 7.1**). In 2019, the Nitrogen transport to the sea was high due to a very dry growing season in 2018 which negatively influenced Nitrogen uptake by the crops. The Nitrogen discharges (load) are recalculated for all years with each new annual reporting. Therefore, the loads can be changed compared to previous versions of this reporting.

**Table 7.2. Total nitrogen discharges from the Danish territory to the sea (both diffuse pollution and point sources)** Data represent the values calculated for the first and last year of the periods, and do not capture the total variation within the periods.

| | **4th period (2004-2007)** | | **5th period (2008-2011)** | | **6th period (2012-2015)** | | **7th period (2016-2019)** | | **8th period (2020-2023)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2007 | 2008 | 2011 | 2012 | 2015 | 2016 | 2019 | 2020 | 2022[1] |
| **Total N discharge (tons N)** | 66,000 | 76,000 | 58,000 | 58,000 | 57,000 | 70,000 | 56,000 | 73,000 | 57,000 | 45,000 |
| **Water-discharge-normalized N discharge (tons N)**[2] | 68,000 | 58,000 | 58,000 | 55,000 | 53,000 | 52,000 | 54,000 | 64,000 | 51,000 | 52,000 |

[1)] Data for 2023 not yet available

[2)] For water-discharge normalization, the total N discharge is calculated, corrected by assuming a fixed standard water discharge for each respective year, whereas the actual annual water discharge has varied.

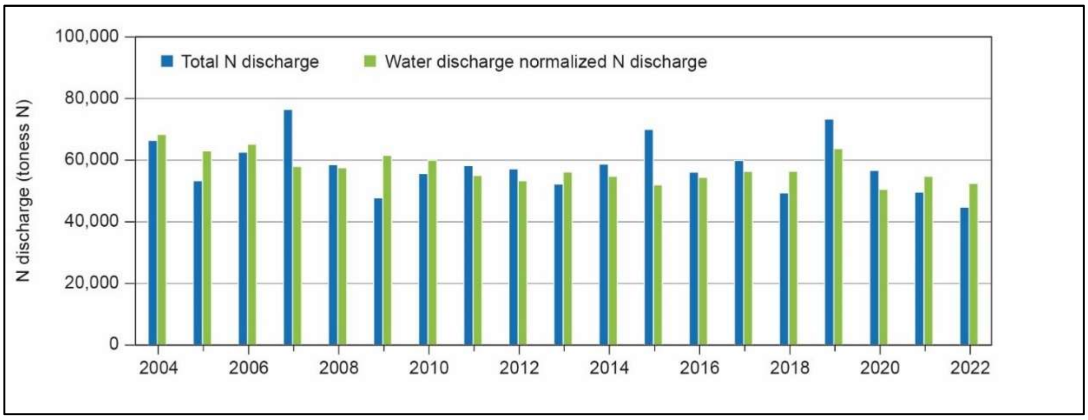


**Figure 7.1 Total nitrogen discharges from the Danish territory to the sea from 2004 to 2022 (both diffuse pollution and point sources).**

Taking the streamflow variations into account, (caused primarily by variation in weather conditions especially precipitation), a decrease in annual nitrogen discharge to the sea from over 100,000 tons N in the early 1990's down to a level ranging from 51,000 to 64,000 tons N/year in all the years 2012 to 2022 (water discharge-normalized, land based N discharge to the sea) has been observed (**Table 7.2**).

The total N discharge to the sea, presented in **Table 7.2**, has been adjusted compared to earlier reports. The estimated land based nutrient load of Danish coastal waters is based on data provided by the national monitoring program NOVANA (Thodsen et al. 2024), which has been in operation since 1989. During this period the methods for this estimation have been stepwise updated with new data input of climate, runoff for ungauged catchments and changes in monitored and unmonitored catchments. These adjustments have resulted in some changed quantifications of the total annual nutrient load, also for the years before 2012.

The watercourse monitoring station network and thus the monitored catchment area (the area upstream of a watercourse monitoring station) has been increased as a result of the political Agreement of Food and Agriculture. Measured N load from 231 stations is included in the estimated load for the total N load in 2022. The measured catchment area (the area upstream of stations) has been expanded from approx. 55% before 2018 to cover approx. 60% of the total area after that year. This expansion of the station network has increased the monitored catchment area in general, and in some coastal waters the proportion of monitored catchment area has increased considerably. At the same time, the uncertainty of the load assessment has decreased, as a larger share of the area is monitored instead of modelled. For the unmonitored catchments, the N load is calculated using an empirical /statistical model for monthly nitrogen concentrations and a national hydrological model for the water discharge, processed through the DK-QNP model_v2 (Thodsen et al. 2019).

Simplified and in rounded values, it can be stated that approximately 10% of the normalized N discharge originates from point sources, e.g. waste water treatment plants. The average diffuse, normalized contribution has been app. 47,000 N/year in the years 2020 to 2022.

In connection with the latest River Basin Management Plans, the natural background contribution to N discharge has been estimated – in rounded numbers – to account for approximately 22% of the N discharge to the sea. Consequently, the share of N discharge to the sea, caused directly by agricultural activities within the country, can be estimated to round about 69% of the total N discharge. However, there are regional differences according to the land use e.g. in the Sound (Øresund) where the contribution from wastewater is higher than the national average due to the urban land use.

In the year 2022, 32 of the largest waste water treatment plants (>50,000 PE) treated 50% of the wastewater in Denmark. **Table 7.3** gives an overview on the amount of N discharge from wastewater.

**Table 7.3. Nitrogen discharges to the aquatic environment with wastewater.**

| Source[1] | 4th period (2004-2007) | | 5th period (2008-2011) | | 6th period (2012-2015) | | 7th period (2016-2019) | | 8th period (2020-2023) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2007 | 2008 | 2011 | 2012 | 2015 | 2016 | 2019 | 2020 | 2022[2] |
| **Urban waste water** | 4,030 | 3,620 | 3,500 | 3,900 | 3,800 | 3,800 | 3,400 | 3,660 | 3,250 | 2,870 |
| **Industrial waste water** | 500 | 500 | 400 | 310 | 220 | 330 | 340 | 240 | 280 | 220 |

1) This is a non-exhaustive list - there are more point sources than urban and industrial wastewater.
2) Data for 2023 not yet available

**Literature**


Thodsen, H., Tornbjerg, H., Troldborg, L., Windolf, J., Ovesen, N.B., Kjeldgård, A. & Højbjerg, A.L. 2019. Udvikling af vanddelen af DK-QNP til havbelastningsberegninger. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 20 s. - Teknisk rapport nr. 145 http://dce2.au.dk/pub/TR145.pdf

Thodsen, H., Kjær, C., Tornbjerg, H., Rolighed, J., Larsen, S.E. & Blicher-Mathiesen, G. 2024. Vandløb 2022. Aarhus University, DCE - Danish Centre for Environment and Energy, 80 s. – Scientific report no. 590. https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Videnskabelige_rapporter_500-599/SR590.pdf


## 7.3. Evaluation of the implementation and impact of the action programmes' measures

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### 7.3.1. Nitrates in water leaving the root zone

This section deals with the general development in nitrate leaching from 1990 to 2022. Data for 2023 is not yet available. Information on agricultural management practise, Nitrate leaching and development in Nitrogen and Phosphorous is based on the annual derogation report to the EU Commission for 2022 (Rolighed et al. 2024) and the annual report from the Agricultural Catchment Monitoring Program (Blicher-Mathiesen et al., 2024).

This Agricultural Catchment Monitoring Programme (Danish abbreviation: LOOP) includes six small agricultural catchments situated in various parts of the country in order to cover the variation in soil type and rainfall and in agricultural practises. The farmers are interviewed every year about agricultural management practice, i.e. livestock, crops and fertilisation and cultivation practises.

### 7.3.2. Development in modelled nitrate leaching in the Agricultural Catchment Monitoring Programme (LOOP), 1990-2022

Nitrate leaching is modelled for every field in the LOOP catchments, based on the information provided by the farmers on agricultural practises and standard percolation values calculated on the basis of the average climate for 1990-2010. The period 1990-2010 covers a period where the Danish precipitation data were measured using the same method. From 2011, there was a change in both the measurement method and the number of stations available, which may influence the modelled water balance, and thereby influence the modelled nitrate leaching. Specifically, it was found that the relation between precipitation and stream runoff in the monitoring catchments was inconsistent before and after 2010, respectively. The precipitation is measured at several rain gauge stations and distributed to cover 10x10 km2 grids by the Danish Meteorological Institute (DMI). The type of rain gauge station was changed from 2011, and also the number of stations decreased significantly. This explains some of the inconsistency related to measured discharge. DMI has delivered new precipitation data for the period after 2010, but all inconsistency in the data has not yet been resolved.

The trend in modelled nitrogen leaching from the agricultural area in the catchments from 1990 to 2022 (representing the hydrological years 1990/91 to 2022/23) is shown in **Figure 7.2** as an average for sandy and loamy catchments, respectively.

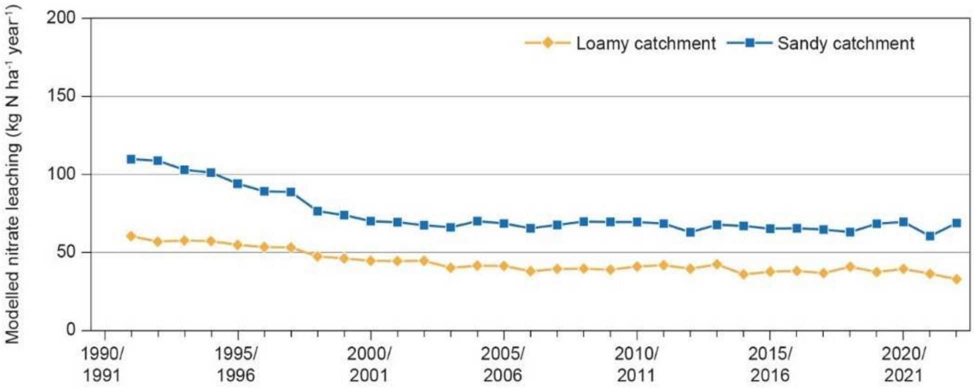


**Figure 7.2 Modelled nitrate leaching in a standard climate for the fields of the Agricultural Catchment Monitoring Programme, 1990/91-2022/2023.**

Modelled Nitrate leaching presented for these five catchments was in the former status report (Miljøministeriet 2021) modelled using the NLES3 and NLES4-models. The model was updated and recalibrated to a new NLES5-model using a larger dataset in 2020 (Børgesen et al., 2020, 2022). Nitrate leaching for the agricultural catchments in the present report is modelled with the NLES5-model. The modelling results are therefore not directly comparable to the results in the former reports.

With the present model calculation with NLES5, a decrease in the modelled nitrate leaching of 43 % has been achieved for the entire period 1991/92 to 2022/23, with each LOOP catchment weighing 1/5. In this way, the average corresponds to loamy soils in Denmark covering 60% and sandy soils 40%. For the period 1991/92 to 2003/04, the decrease in modelled nitrate leaching amounts to 37%. With model calculation of nitrate leaching with NLES3 and NLES4, the corresponding decrease was approx. 43% (Blicher-Mathiesen et al., 2024). The model calculation in LOOP only has data from 1991, while it is expected that nitrate leaching was also reduced before this time. At the final evaluation of Action Plan II for the Aquatic Environment in 2003, it was calculated that Nitrogen leaching at national level had been reduced by 48% from 1985 to 2003 (Grant & Waagepetersen, 2003) with a reduction in leaching from 1985 to 1989 estimated to 12 percentage points.

For the loamy catchments, modelled annual nitrate leaching was relatively stable around 40 kg N $ha^{-1}$ during the period 2003-2014 decreasing to a level below 40 kg N $ha^{-1}$ in the period 2015-2022. For the sandy catchments, the modelled annual nitrate leaching was relatively stable around 67-68 kg N $ha^{-1}$ during the period 2003-2022.

The purpose of the root zone modelling is to show the effects of measures introduced to reduce nutrient losses from agriculture. The modelling is therefore carried out for normalised growth conditions, i.e. averaging the model output for a 20-year period: The model is run for each year in the 20-year period and model outputs are then averaged for the period. The climatic data used cover the period 1990-2010. Actual measurements of nitrate leaching will show higher annual variations than the climatic average of the modelled values as the measurements depend on the actual climate.

### 7.3.3. Measurements of nitrate in water leaving the root zone

In five out of the six Agricultural Monitoring Catchments (LOOP), soil water samples are collected regularly at in total 28 agricultural sites, of which 26 are included in the presented data. The samples represent the root zone water (approx. 1 m depth – 30 samples per year) and the upper oxic groundwater (1.5-5 m depth – 6 samples per year). The measured concentrations are shown as annual average values for loamy and sandy soils, respectively, for the period 1990/91-2021/2022 (**Figure 7.3**). Data are averaged for hydrological years covering the period 31. May – 1. June.

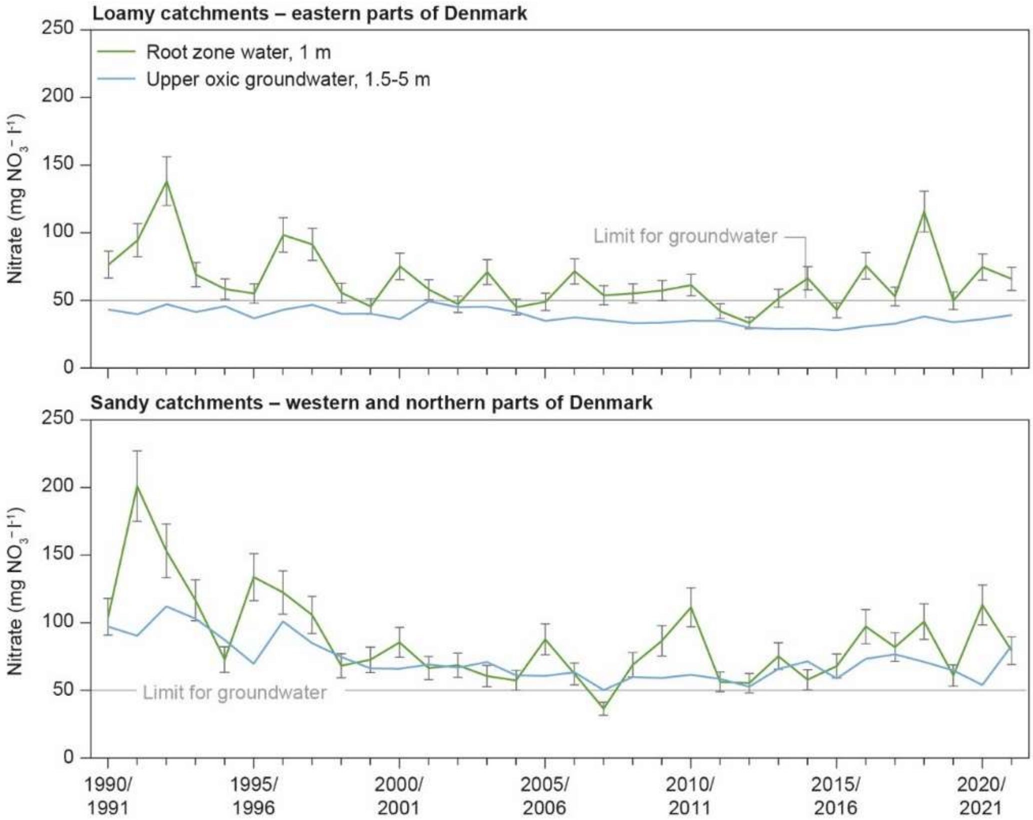


**Figure 7.3 Annual flow-weighted nitrate concentrations measured in root zone water and annual average Nitrate concentrations measured in upper oxic groundwater, the Agricultural Catchment Monitoring Programme (LOOP) 1990/91-2021/22. The standard error bars on the flow-weighted nitrate concentrations represent the uncertainty from variation in monitored precipitation caused by changed monitoring method and number of monitoring gauges before and after 2010.**

There is a strong inter-annual variation in the measured nitrate concentrations due to differences in rainfall and temperature. Therefore, long time series and a large number of measuring points is necessary to detect any statistically significant trend. Such data series are available from the Danish Monitoring Programme.

In 2018, statistical trend analysis (Mann-Kendall tests) were performed on the average percolation-weighted Nitrate concentration for the sand and clay soil catchments for the measurement period 1990/91-2015/16 and for the sub-periods 1990/91-2003/04 and 2004/05-2015/16 (

**Table 7.5**).

**Table 7.4 Trends in flow-weighted Nitrate concentrations in soil water for stations on clay and sandy soil catchments for two periods, 1990/91-2003/04 and 2004/05-2015/16, respectively, and for the entire period 1990/91 - 2015/16. The 95 % confidence interval for the trend is given in brackets. The last six hydrological years 2016/17 - 2021/22 are not yet included in the trend analysis.**

For the measurement period 1990/91-2015/16, a significant decrease in Nitrate concentrations was

| Catchment | Number of stations | Measured N-conc. (flow-weighted) (mg Nitrate-N $l^{-1}$) | | Calculated annual change in N-conc. v. statistical analysis (mg Nitrate-N $l^{-1}$ year$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | | 1990/91-93/94 | 2004/05-2015/16 | 1990/91-2015/16 | 1990/91-2003/04 | 2004/05-2015/16 |
| Clay soils | 14 | 22 | 12 | -0,27 (-0,52 to -0,12) | -0,37 (-1,02 to 0,32) | No significant trend |
| Sandy soils | 13 | 33 | 16 | -0,58 (-1,01 to -0,25) | -1,67 (-2,80 to -0,41) | No significant trend |

observed on both loamy and sandy dominated catchments of 0.27 and 0.58 mg N $l^{-1}$ $yr^{-1}$, respectively. For the period 1990/91-2003/04, the statistical test showed a decrease in concentrations of 0.37 ($p=0.27$, not significant) and 1.67 ($p=0.003$, significant) mg nitrate-N $l^{-1}$ per year for the loamy soil and sandy dominated catchments, respectively. Based on the period before the start of the Action Plan for Sustainable Agriculture in 1994, this corresponds to a decrease of 27 and 70 %, respectively, for the two catchment types. However, the standard deviation is very large, and with a 95 % probability, the reduction in nitrate concentration is between 0 and 66 % for loamy soils and between 17 and 117 % for sandy soils. For the period 2004/05-2015/16, there is no statistically significant decrease in the annual percolation-weighted nitrate concentrations in soil water in the two soil types.

The statistical trend analysis has not yet been performed with inclusion of the period after implementation of the Food and Agricultural Agreement in December 2015. The reason is that the large annual variations means that a longer period with data after the change of regulation is required to perform a statistically sound trend analysis.

In loamy catchments, the measured nitrate concentrations in root zone water decreased from 61-155 mg NO3 $l^{-1}$ in the 5-year period 1990/91-1994/95 to 37-66 mg NO3 $l^{-1}$ in the 5-year period 2011/12-2015/16. In the latest 5-year period 2017/18-2021/22 the concentrations have varied from 50 to 116 mg NO3 $l^{-1}$. High Nitrate concentrations are seen in years with low percolation as observed on loamy soils in 2004/05, in 2010/11, in 2016/17, in 2018/19 and in 2020/21.

In the sandy catchments, the Nitrate concentration decreased from 73-192 mg NO3 $l^{-1}$ in the 5-year period 1990/91-1994/95 to 54-73 mg NO3 $l^{-1}$ in the 5-year period 2011/12-2015/16. High nitrate concentrations were measured in the hydrological year 2018/19 after the dry growing season in 2018 with drought and low yield as well as low percolation in the winter period. In contrast, low nitrate concentrations were measured in 2019/20 due very high percolation diluting the nitrate leaving the root zone.

It should be noted that the measurements of nitrate leaching originate from a small number of sampling stations (26-27 stations). Furthermore, the measurements are affected by variation in crop yields and effects of crop rotations, especially the appearance of perennial grass in rotation. These conditions induce higher inter-annual variations at field scale than seen in the modelled nitrate leaching, which covers a larger area including approx. 121 farms. In the upper oxic groundwater (1.5-5.0 m below ground level), Nitrate concentrations were lower than in the root zone water, especially on loamy catchments, indicating nitrate reduction in the aquifer between the bottom of the root zone and the uppermost groundwater (**Figure 7.3**).

In the loamy catchments, measured annual mean of Nitrate concentrations in the upper oxic groundwater decreased from a range covering 40-47- mg NO3 $l^{-1}$ in the 5-year period 1990/91-1994/95 to a range covering 33-39 mg NO3 $l^{-1}$ in the 5-year period 2017/18-2021/2022. In sandy catchments, the Nitrate concentration decreased from 87-112 (±27-65) mg NO3 $l^{-1}$ in the 5-year period 1990/91-1994/95 to 54-83 (±24-46) mg NO3 $l^{-1}$ in the 5-year period 2017/18-2021/22. This large variation in the nitrate content of upper oxic groundwater is also seen in the latest year. In 2022, oxic upper groundwater in the sandy and loamy catchments, respectively had more than 50 mg/l on average in approx. 70% (14 out of 20) and approx. 36% (8 out of 22) of the monitoring points.

#### 7.3.4. Difference between input and output of nitrogen

In the annual reports of the national monitoring programme for the aquatic environment and nature (NOVANA) the annual Nitrogen balances for the agricultural area is published. The N-balance illustrate the loss potential for Nitrogen in connection with agricultural production and is calculated as "added minus removed Nitrogen" from agricultural fields. Applied Nitrogen in this context consists of Nitrogen allocated with commercial mineral fertilizers and livestock manure, including Nitrogen from grazing cows, Nitrogen fixation, Nitrogen applied with seeds and atmospheric N deposition (the calculation methods for field balances are described further in Blicher-Mathiesen et al. 2024, appendix 3). Nitrogen removed comprises Nitrogen removed with harvested crops. Overall, the Nitrogen surplus for the cultivated area has decreased by 204,700 tons (approx. 51%) in the period 1990-2022. The first years after adoption of the Food and Agriculture Package in 2015 showed a temporary increase in surpluses of N due to increased use of inorganic fertilizers. After 2020 the use of mineral fertilizers decreased again which led to lower N surpluses. In 2022 the lowest Nitrogen surplus since 1990 was calculated (199,700 tons N) (**Figure 7.4** and

**Table 7.6**).

The weather's influence on yields is showed in the N-balances of for example 1992 and 2018, where the N-surplus were higher than normal because of a drought in the growing season causing low yields.

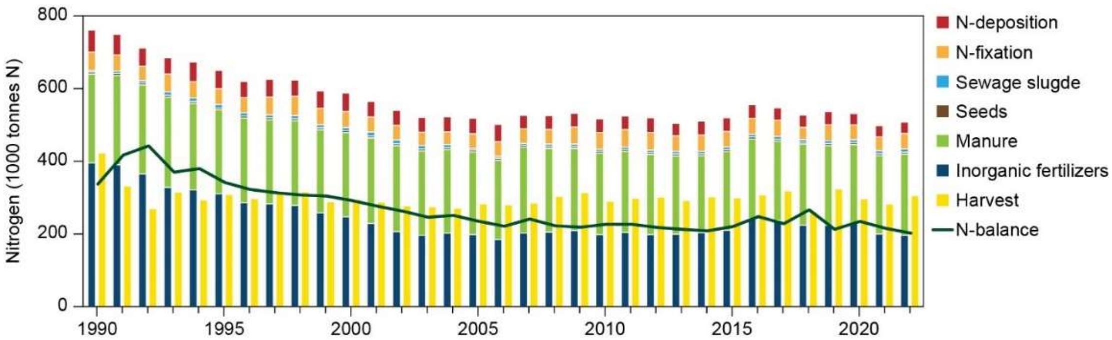


**Figure 7.4. Development in applied and harvested Nitrogen for the entire agricultural area in Denmark from 1990 to 2022.**

Since 1990, the utilization of Nitrogen in animal manure has improved significantly. This can be regarded as a result of the regulatory measures such as binding N-norms, increased slurry storage capacity, increased requirements for utilization of Nitrogen in animal manure, higher proportion of slurry being spread during spring and summer and the investment in and use of advanced slurry application techniques (

**Table 7.5**).

Broadspreading of animal slurry has been banned since 2003. Since 2011, farmers are obliged to inject slurry on grass or bare soil.

**Table 7.5. Overview of development in key parameters concerning the use of livestock manure within the LOOP-monitoring programme in 1990 and during the reporting period (2020-2022, data for 2023 not yet available).**

| Parameter | 1990 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| Storage capacity for liquid animal manure, corresponding to 9 months' production (% of LU) | 38 | 96 | 100 | 100 | 100 |
| Spreading of manure during spring & summer (% of LU) | | | | | |
| Liquid manure | 55 | 93 | 96 | 97 | 95 |
| Solid manure | 40 | 76 | 82 | 76 | 77 |
| Slurry application with trail hose or injection (% of total N in liquid animal slurry applied) | 8 | 98 | 98 | 98 | 97 |
| Percentage applied by trail hose (%) | | 41 | 44 | 42 | 47 |
| Percentage injected (%) | | 57 | 54 | 56 | 53 |

Increased utilization requirement for Nitrogen in livestock manure has led to a gradually displacement of commercial fertilizers in the crops' total N quota (N-norm) (**Figure 7.5**). This development has especially taken place in the period 1990-2003 but has also been increased in 2022 following increased requirements for increased utilization of livestock manure from 2021. The utilization requirement was increased with 5-15 % for the majority of manure types, e.g. from 75% to 80% for pig slurry and from 70 % to 80 % cattle slurry.

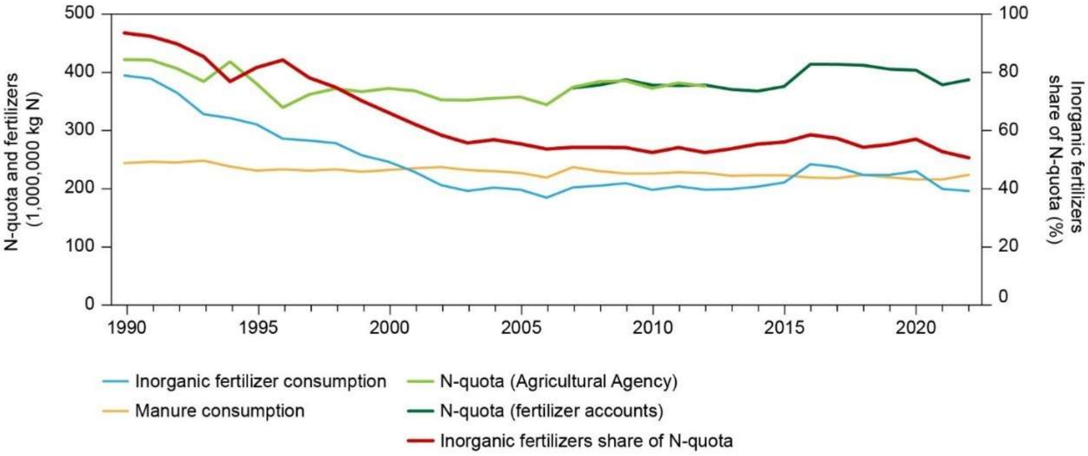


**Figure 7.5. The development in the agricultural Nitrogen quota (N-norm), consumption of N in livestock manure and N in commercial fertilizer for the whole country in the period 1990 to 2022. In addition, the commercial fertilizer's share of the N quota in per cent.**

While keeping the amount of harvested N relatively constant since the late 1990's, the N balance has decreased due to increased utilization of applied fertilizers.

More detailed field balances, given in kg N per hectare, can be found in

**Table 7.6** and in the annual report from the Agricultural Catchment Monitoring Program (LOOP 2022).

**Table 7.6. Data on field balances for whole territory (kg N/ha) cultivated area until 2022.**

| Year | 1990[1] | 1998[1] | 2007[2] | 2011[2] | 2015[2] | 2019[2] | 2020[2] | 2021[2] | 2022 |
|---|---|---|---|---|---|---|---|---|---|
| Inorganic fertilizer | 141,8 | 104,1 | 72,5 | 75,7 | 78,9 | 86,0 | 88,4 | 76,8 | 75,3 |
| Livestock manure[3] | 87,5 | 87,2 | 86,7 | 84,7 | 84,7 | 84,4 | 83,0 | 83,0 | 86,1 |
| Other organic fertilizer | 1,6 | 3,3 | 1,9 | 2,2 | 2,6 | 3,2 | 3,1 | 3,1 | 3,5 |
| Seeds | 2,0 | 2,0 | 2,0 | 2,0 | 2,0 | 2,0 | 2,0 | 2,0 | 2,0 |
| N-fixation | 17,9 | 20,0 | 14,8 | 18,1 | 16,0 | 16,8 | 15,6 | 14,6 | 16,5 |
| N-deposition[4] | 22 | 17 | 14 | 14 | 14 | 14 | 12 | 12 | 12 |
| Applied[5] | 273 | 233 | 195 | 197 | 196 | 206 | 204 | 192 | 195 |
| Harvested | 128 | 118 | 107 | 113 | 114 | 125 | 114 | 109 | 118 |
| **N balance** | **145,0** | **114,9** | **87,5** | **83,8** | **82,2** | **82** | **90** | **83** | **77** |
| Cultivated area (1000 ha) | 2788 | 2672 | 2744 | 2693 | 2663 | 2599 | 2599 | 2596 | 2588 |

[1] data for mineral fertiliser based on information from "Statistics Denmark"
[2] data for mineral fertiliser based on information from the Fertilizer Accounting System (since 2005)
[3] data for livestock manure based on the Fertilizer Accounting System (2015-2018), earlier data on livestock from Aarhus University (LOOP, 2018)
[4] data for other organic fertilizers contains e.g. sewage sludge and industrial waste.
[5] since 2005 based on data from Fertilizer Accounting System

### 7.3.5. Difference between input and output of Phosphorous (P- Balance)

In the annual reports of the national monitoring program for the aquatic environment and nature (NOVANA) the annual Phosphorous balance for the Danish agricultural area is published. The development in applied and harvested Phosphorus for the entire agricultural area in Denmark from 1990 to 2022 is shown in **Figure 7.6**.

The use of phosphorus in livestock manure is indirectly regulated through the maximum allowed Nitrogen application in organic fertilizers. From 2005-2019, mineral phosphorus in feed was regulated through a tax of DKK 4 per kg P. This law was repealed as of 1 July 2019, and the tax is no longer payable on mineral phosphorus in feed. As a result of the 2015 Food and Agriculture Package, a new Animal Husbandry Act entered into force on 1 August 2017. Based on the farms' type of use, the new law introduces a limit on the field application of Phosphorus from both commercial and livestock manure.

The consumption of Phosphorus in mineral fertilizers has generally decreased since 1990 and is about 65 % lower in the period 2018-2022 than in 1990 (**Figure 7.6**). The Phosphorus applied with livestock manure has been reduced from approx. 55,000 tons P in 1990 to approx. 40-45,000 tons of P in the period after 2005, corresponding to a reduction of approx. 20 %.

The net input (also referred to as the field surplus) was reduced from approx. 40,000 tons P in 1990 to approx. 13,000 tons P in the period 2018-2022, corresponding to a reduction of almost 70 % (**Figure 7.6**).

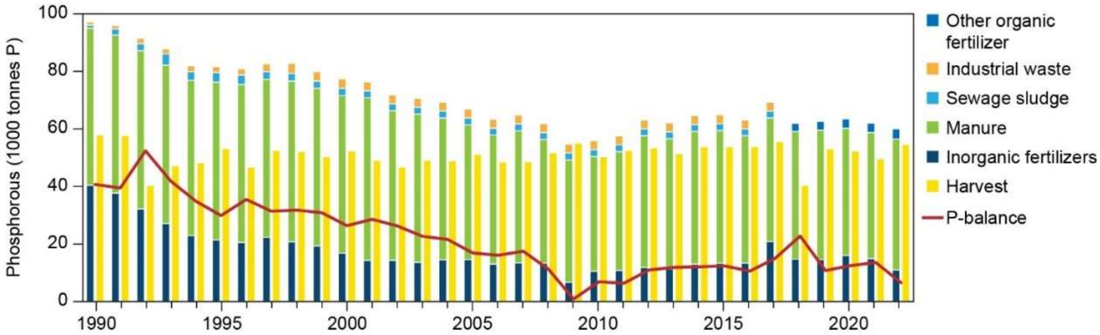


**Figure 7.6. Development in applied and harvested Phosphorus for the entire agricultural area in Denmark from 1990 to 2022.**

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## 7.4. Percentage of farmers visited by the supervising authorities or their delegates

*Agency for Green Transition and Aquatic Environment, The Ministry for Green Transition*

Provisions on crop rotation, fertilizer planning and catch crops as well as provisions on rational fertilization use taking into account physical, climatic conditions and irrigation among other parameters are implemented in the Danish Act on Agricultural Use of Fertilizer and Nutrient-Reducing Measures, including the annually revised “Statutory Order on Nutrient-reducing Actions and Cultivation-related measures in the planning period”, “Statutory Order on agricultural use of fertilizer in the planning period” and “Statutory Order on Nitrogen Prognosis”.

Administrative staff of the Agency for Green Transition and Aquatic Environment (formerly: Danish Agricultural Agency) controls the provisions in the mentioned acts and orders. Besides the administrative control, they also inspect farm compliance of the rules on the spot.

Inspection on the spot combined with administrative control covers control of crop rotation planning, including plant cover and catch crops, fertilizer planning, fertilizer account, but also the provisions regarding application of the amount of livestock manure to land each year (harmony rules) laid down in the Statutory Order on Application of Fertilizer.

In the planning period 2020/2021, the Agency for Green Transition and Aquatic Environment carried out 683 controls. 69 inspections on the spot combined with administrative control of submitted fertilizer accounts and 614 administrative control of submitted fertilizer accounts, regarding the orders mentioned above, corresponding to approx. 2.3 % of all agricultural holdings obliged to submit a fertilizer account.

The on-spot inspections regarding fertilizer accounts support the administrative control carried out on basis of the annually submitted data in the fertilizer accounting system. During the on-site inspections combined with the administrative control of submitted fertilizer accounts, compliance with the requirements of fertilizer accounts and requirements regarding use of fertilizers are controlled. In the planning period 2020/2021, 69 inspections and administrative controls of fertilizer accounts were carried out, and of which 68 (98.6 %) have been completed and one (1.4 %) are still under investigation. For the completed investigations 11 farms (16.2 %) exceeded the farms’ nitrogen quota by up to 6 kg nitrogen per hectare and they received a notification and recommendation (minor violation). None of the 68 farms in the completed controls were reported to the police or received an administrative fine for severe violations, according to the nitrogen quota. The same 69 inspected farms were also controlled regarding the amount of organic manure applied to land each year (harmony rules). For the completed investigations three of these farmers (4.4 %) were reported to the police for severe violations of the harmony rules.

The vast majority of all Danish farmers must submit data to the Fertilizer Accounting system each year, which is administrated by the Agency for Green Transition and Aquatic Environment. For the planning period 2020/2021, 29,436 farmers were obliged to submit a fertilizer account. All submitted fertilizer accounts were automatically checked at submission by the IT-system, according to a set of previously defined risk criteria. In the planning period 2020/2021, 614 administrative controls of fertilizer accounts were carried out, and of which 567 (92.3 %) have been completed and 47 (7.7 %) are still under investigation. The administrative control of these 567 fertilization accounts showed that 98 farms (17.3 %) exceeded the farms’ nitrogen quota by up to 6 kg nitrogen per hectare and they received a notification and recommendation (minor violation). 48 farms (8.5 %) exceeded the farms nitrogen quota from 6 kg nitrogen and up to 9 kg nitrogen per hectare and they received a warning (minor violation). 59 farms (10.4 %) exceeded the farms nitrogen quota by 9 kg nitrogen or more per hectare and they received an administrative fine. Four farms (0.7 %) exceeded the farms nitrogen quota by 9 kg nitrogen or more per hectare and they were reported to the police. The same 567 farms were also controlled regarding the amount of livestock manure applied to agricultural land each year (harmony rules). The administrative control showed that 29 farms (4.6 %) applied more than 170 kg nitrogen from organic manure per hectare agricultural land per planning period. Four farms (0.7 %) applied nitrogen from organic manure in amounts equivalent to an area of agricultural land, that exceeded the farms agricultural land by up to 1.5 hectare and they received a notification and recommendation (minor violation). 10 farms (1.8 %) applied nitrogen from organic manure in amounts equivalent to an area of agricultural land, that exceeded the farms agricultural land from 1.5 hectare and up to 3 hectare and they received a warning (minor violation). Eight farms (1.4 %) applied nitrogen from organic manure in amounts equivalent to an area of agricultural land, that exceeded the farms agricultural land by 3 hectare or more and they received an administrative fine. Finally, four farms (0.7 %) applied nitrogen from organic manure in amounts equivalent to an area of agricultural land, that exceeded the farms agricultural land by 3 hectare or more and they were reported to the police for severe violations of the harmony rules.

In 2017 a new scheme on livestock catch crops was introduced. The individual requirement to establish catch crops for holdings using organic manure such as livestock manure was aimed at ensuring the sufficient protection towards nitrogen leaching to sensitive Natura 2000-areas in catchment areas, where the amount of applied organic manure has increased since 2007 and at contributing to the reduction of nitrogen leaching to coastal water bodies, where a reduction of nitrate leaching is necessary in order to obtain the environmental objective according to the River Basin Management Plans (RBMP).

As part of the political agreement on the Food and Agricultural Package of December 2015, the reduction of the nitrogen application standards was removed. It was also agreed to develop a new nitrogen regulation, the “targeted nitrogen regulation”, which was to be implemented in 2019. The Danish government introduced an intermediate initiative, the “targeted catch crops scheme”, to reduce N-losses through promoting the establishment of additional catch crops in 2017 and 2018. The scheme was designed to protect both groundwater bodies and coastal waters. The scheme was designed as a de minimis aid scheme for voluntary establishment of additional catch crops. The targeted regulation of nitrogen has contributed to the Danish implementation of the Nitrate Directive in the period 2017 to 2019. From 2020, the regulation has contributed to the implementation of the Water Framework Directive and hence no longer part of this reporting.

In 2023, the Agency for Green Transition and Aquatic Environment carried out a total of 93 on-site inspections on catch crops involving two national schemes on catch crops: Mandatory catch crops and livestock catch crops. The mandatory catch crops have a requirement on 10.7 % or 14.7%, respectively of the area to be covered with catch crops. In 2023 livestock catch crops included in total around 34,000 ha.

The farmer may use alternative measures instead of catch crops in order to minimize the leaching of nutrients e.g. fallow, establishing energy crops, early sowing of winter crops, precision farming, and reduction of the farms’ nitrogen quota. Conversion factors are used to secure that the alternatives have the same nitrogen reduction effect as catch crop.

In the non-compensated national schemes of mandatory and livestock catch crops 7 of the 93 inspections (7.5 %) were reported to the police and 12 farmers (12,9 %) received an enforcement notice for non-compliance with the requirements for the establishment of catch crops.

This share on the national scheme illustrates an overall decrease in farms with violations, compared to the previous data from 2019 (12.8 % and 7.4 %, respectively) not least in the light of a significant decline in the number of inspections reported to the police and a decline in the number of requested inspections. Enforcement notice is issued for non-compliance of areas under 0.9, although the number has increased the total area remains small. It is important to highlight that in 2019 the rules for e.g. reporting, calculation, establishment and control of catch crops have been changed and the rules of sanctioning has been further tightened. The lower infringement rates reflect that farmers are adjusting to the new rules.

The Agency for Green Transition and Aquatic Environment continuously focuses on how to improve and streamline the control of catch crops. For the non-compensated national schemes of mandatory and livestock catch crops farmers are not required to report the use of catch crops or alternative measures at field level, but the required area has to be present on the farm. As mentioned earlier the targeted nitrogen regulation now contributes to the implementation of the Water Framework Directive. Hence, to ensure a representative measurement on the compliance with the rules, the random sample size was increased from 1 to 2 per cent in 2024, and in recent years a significant proportion of the inspections of the targeted catch crops are designated using satellite-based screening (e.g. including analysis of specific risk factors), which is very effective compared to other methods of designating farms to control. In 2022 there were 1,014 inspections of the targeted catch crops, of which 328 were designated randomly and 686 were designated based on a risk analysis. Approximately 65 % of the farms designated using risk analysis were sanctioned, however, a large proportion of these were minor offences.

For the targeted catch crops, non-compliance is sanctioned with both a reduction in the subsidy and a reduction of the fertilizer nitrogen quota for the farm corresponding to the non-compliance.

# 8. Economic analysis with respect to nitrogen reduction in Denmark 2020-2023

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## Introduction

This section concerns the measures, the costs and the cost-efficiency of the different measures to improve water quality through reductions of nitrogen losses from 2020 to 2023.

One of the first changes in this period was the increase in the required utilization of nitrogen in animal manure. In 2020, an increase in requirement regarding animal manure of 5% from 2020/2021 was decided (Retsinformation, 2020). The required utilization of nitrogen in manure in Denmark was already one of the highest in Europe and it is controlled via the fertilizer accounting, which is not the case in other EU countries (Webb et al., 2013). Analyses have shown that, since the last adjustment in 2003, it is now possible to increase utilisation of N in manure for selected types of manure with limited costs (Eriksen et al., 2020). The required utilisation of nitrogen from biogas plants is lower than the average for the output from biogas plants (SEGES, 2020). So higher than expected utilisation of manure can be achieved when the manure comes via a biogas plant, but the increased use of straw in biogas plants might reduce the utilization of nitrogen compared to five years ago (Toft et al., 2022). It is assumed that around 30% of all manure in Denmark has been sent to a biogas plant in this period (Blicher-Mathiesen et al., 2023).

Higher utilisation of nitrogen in manure has led to a reduction in the use of mineral fertiliser by around 15,000 ton N (from 2019/2020) compared to the two following years (see also **table 8.1**) (Blicher-Mathiesen et al., 2024). Furthermore, the increase in area with spring barley has also lowered the use of mineral fertiliser as this crop has a lower nitrogen norm per ha. Together, this has meant that the use of mineral fertiliser in the fertiliser accounts in 2021 and 2022 are now down to the level of around 200,000 tons N per year used in fertiliser accounts before the Agricultural Package in 2012-2014 (Blicher-Mathiesen et al., 2024). The nitrogen surplus in the field in 2022 is down to around 80 kg N/ha which is around the same level as before the Agricultural Package from 2015 (Blicher-Mathiesen et al., 2024).

A key decision in the analysed report period was the political agreement regarding a Green Transition of Danish Agriculture from October 2021 (Anonymous, 2021). In the agreement the parties stated that the nitrogen losses to the sea should be reduced by 13,100 tons N by 2027. It was decided that the CAP should be actively used to reduce both nitrogen losses and greenhouse gas emissions. The direct measures are aimed at a reduction of 10,800 tons N in the agreement and this was based on a technical adjustment later reduced to 10,400 tons N in the River Basin Management Plans. A revisit in 2024 will determine how the remaining reduction requirements should be dealt with. It is stated that the targeted regulation will provide a reduction of up to 6,500 tons N and that collective measures through voluntary measures (wetlands, mini wetlands, forest and set-aside) would provide a reduction of 1,500 ton N. In case more has been achieved through voluntary measures the required reduction from targeted regulation can be reduced.

The Green transition Agreement also suggests a more targeted regulation in the coming planning period. Following this, the first draft of the 3rd River Basin management Plan was issued in 2022 and the final version entered into force in June 2023.

Another key issue in this period has been the high fluctuation in fertiliser and crop prices. The development has meant that prices on fertiliser have been more than twice the level from 2015-2020 in 2021-2023. The crop prices also increased, but not as much (+40-70%) (Danish Statistics, 2023). This might have reduced the fertiliser consumption somewhat compared to the norms for the year, but must farms have applied the nitrogen they could based on the nitrogen norms per crop. The use of phosphorus and potassium was reduced in 2021/22 by around 30% compared to previous years (see **Table 8.1**). Whether this still is the case in 2022/23 is too early to say.

With respect to the utilization of the nitrogen quota in 2021/22 at the farm level a recent analysis has shown that around 30% of the area does not receive the full quota (10 kg N/ha or more under quota) (Blicher-Mathiesen, 2024). As organic farms typically apply less than the quota it is relevant to focus only on the conventional farms. The analysis shows that on 142,000 ha, the N applied is 50-100 kg N/ha under the quota (Blicher-Mathiesen, 2024). The total national quota is around 386,000 ton N and this would indicate that the total unused quota of nitrogen for all farms (organic and conventional) is around

30,400 tons N or 8% (Blicher-Mathiesen, 2024). This level is a little higher than found in previous years where the level of unused quota was 4-6%. One reason could be the price aspect as described above. The use of mineral fertiliser is around 200,000 ton N in fertiliser accounts in 2020-22 and this is lower than the amount of mineral fertiliser sold of 229-239,000 tons N in 2020-22 (see **Table 8.1**). One reason for this could be changes in stocks of nitrogen over time at the farm level.

**Table 8.1 Nitrogen, Phosphorus and Potassium sold in mineral fertiliser in 2019-2022**

| | 2019/2020 | 2020/2021 | 2021/2022 |
|---|---|---|---|
| Nitrogen (N) | 251,876 | 228,623 | 238,846 |
| Phosphorus (P) | 16,905 | 17,557 | 11,897 |
| Potassium (K) | 60,548 | 63,000 | 44,047 |

Source : Landbrugsstyrelsen (2023c).

The River Basin Management Plan (RBMP) from 2016 covered the period from 2016-2021 and the current plan covers the period from 2021-2027, although the final version was ready only in June 2023 (Miljøministeriet, 2023). The national reduction target for the annual marine N input from land-based sources in 2027 is estimated to 12,955 t N compared to the average normalized marine N input of 56,300 t N for the period 2016-2018. An effort regarding part of the remaining reduction amounting to 3,000 t N is to be decided in 2023/2024 and other measures covering 2,500 ton N will be implemented after 2025, so that the total reduction will reach 13,000 t N for coastal waters in 2027 (Miljøministeriet, 2023). As part of the revisit in 2023/24 a decision regarding a new and more cost effective field regulation model will be made.

The following economic analysis covers the collective measures, including the effort to take areas with soils rich in organic carbon out of production and the implementing off targeted regulation to reduce nitrogen losses.

## 8.1. Collective measures

The collective measures include wetlands, mini-wetlands, afforestation and set-a-side of areas with soils rich in organic carbon .Wetlands often include several farmers, whereas the mini wetlands are decided and created by one farmer. The measures are perceived as collective measures in that farmers are implementing this on their own farm for the benefit of the catchment, but there is no direct reward such as lower requirements regarding targeted regulation on this farm, which could offer an incentive for participation.

For wetlands, the target from 2015-2021 was close to 14,500 ha for five years which was an ambitious level compared to the around 5,000 ha which has been achieved for the previous five years. It is expected to get gradually more difficult to establish these sites as wetlands have been a part of the planning for 20 years. Mini wetlands were a new measure at the time and a very ambitious target of 100,000 ha catchment linked to the mini wetlands was set as the target in the Plan from 2016 (Graversgaard et al., 2021). The actual mini wetland is around 1% of the catchment for that lake, so a mini wetland of 1 ha will be based on a catchment of 100 ha (Eriksen et al., 2020).

It was, in 2021, assumed that the expected level of collective measures was as described in **table 8.2**. The original target was 2,500 tons N, but the likely effect was by the Ministry of Environment estimated to be around 1,500 tons N by the end of 2021. The reductions still to be achieved were moved to the next RBMP for 2021-27.

**Table 8.2. Expected collective measures towards 2021**

| | **Adjusted effect (kg N/ha)** | **Adjusted total effect (tons N)** | **Adjusted area (ha)** | **Fulfilment (%)** |
|---|---|---|---|---|
| Wetlands | 130 | 977 | 7,513 | 78 |
| Mini wetlands | 6.5 | 332 | 51,031 | 37 |
| Afforestation | 30 | 81 | 2,688 | 54 |
| Set a side (low areas) | 40 | 128 | 3,197 | 85 |
| **Total** | | **1,517** | | **62** |
| **Reductions still to be achieved** | | **936** | | |

Source: Miljøministeriet, 2020.

The assessment of this target by the end of 2022 is shown in **Figure 8.1**. Due to the delay of the RBMP report for 2021-27, it was possible to apply for projects also in 2022. As shown in **Figure 8.1**, this new target from Table 2 has almost been achieved at the end of 2022 as 1,363 ton N is either implemented or has been accepted (black and green part of the bars) (Miljøstyrelsen, 2023a).

With the Agreement regarding a Green Transition of Danish Agriculture it was decided that reductions from collective measures should reduce nitrogen losses by 1,500 tons N in 2022-2027 (Anonymous, 2021). In the first round in 2023 projects with an effect of 154 tons N per year (10%) were applied for (Miljøstyrelsen, 2023a).

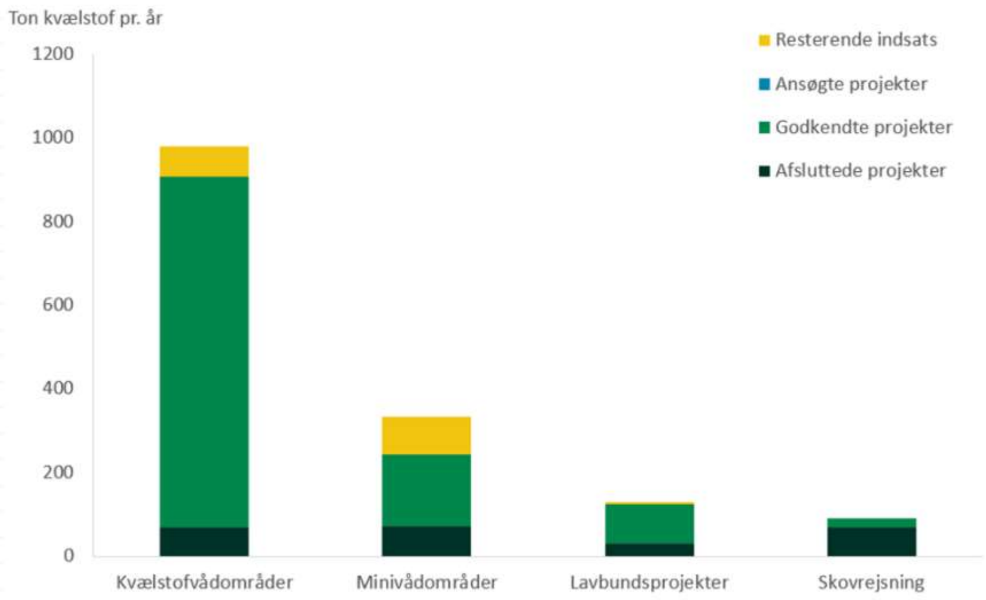


**Fig. 8.1. Collective measures (nitrogen wetlands, Mini wetlands, organic rich soils projects and afforestration) in RBMP II (2015-2022)**

Note: The figure shows finished projects (black), accepted projects (green), applied projects (blue) and remaining effort (yellow) with respect to collective measures (wetland, mini wetlands, organic rich soils and afforestration).
Source: Miljøstyrelsen (2023a)

There is no official assessment of the costs used for collective measures in 2020-23 as it is difficult to use the total cost stated in overviews from the Ministry of Agriculture as they also include administrative costs (Folketinget, 2023). So only the costs for wetlands and set-a-side have been assessed based on the Political Agreement regarding Green Transition (Anonymous, 2021) prior to the implementation. The costs for mini wetlands follow the standard cost approach and so applicants should be given the expected standard cost, which was also used in the nitrogen catalogue from 2020 (Eriksen et al., 2020). The costs of wetlands have increased compared to the calculation in the nitrogen catalogue and the effect has been reduced to 90 kg N per ha (see **Table 8.3**). The focus in measures is on private forests as the state forest is more expensive with a cost of around 160-210,000 kr. per hectare.

The total cost for the measures for 2015-22 is based on the information from the Agricultural Agency and the Environmental Agency and amounts to 967 million kr. for measures with an agreement (Folketinget, 2023).

**Table 8.3. Costs per ha and per kg N for collective measures**

| | Efficiency (kg N/ha) | Yearly cost pr ha based on 20 years (DKK pr. ha) | Cost efficiency (based on 20 years) (DKK/kg N) |
|---|---|---|---|
| Wetlands | 90 | 14,718 | 163 |
| Mini wetlands (0.2-0.5 ha) | 4.7 | 1,323-786 | 280-142 |
| Private afforestation | 50 | 2,073 | 39 |
| Set a side (low lying fields) | 40 | 9,789 | 245 |

Source: Anonymous (2021), Blicher-Matthiesen, et al., 2023 and Eriksen (2020)

Notes:

| | |
|---|---|
| Wetlands: | 200,000 DKK per ha (4% and 20 years) |
| Carbon rich soils: | 133,000 DKK per ha (4% and 20 years) |
| Afforestation : | 35,000 DKK per ha as support. The cost is roughly the income foregone and the support of 35,000 DKK per ha is not included. The State forest has a higher costs of around 160-210,000 DKK pr. ha. |

On top of the collective measures it is expected that the Common Agricultural Policies (CAP) will also give an effect around 1,500 tons N. This is based on the effects from GLM8 (4% set aside) and Eco-schemes on environment and biodiversity (Jacobsen, 2022). Other types of extensification should reduce the Nitrogen losses by 492 ton N (Miljøministeriet, 2023).

There have also been measures focusing on taking soils rich on carbon out of production. In the Agricultural agreement the target was 100,000 hectares of carbon rich soils. This has since been changed to 50,000 ha carbon rich soils, 38,000 ha with extensification and other areas 12,000 ha. (Miljøstyrelsen, 2023b)

With respect to soils rich in organic carbon, analyses show that by the end of 2023 around 40,000 ha were applied for. This is expected to give an effect of 1,600 tons N based on 40 kg N per ha. However, it does take some time to create these areas and get them through the application process (Landbrugsstyrelsen, 2023b). This measure is primarily implemented to reduce the greenhouse gas emission from Danish Agriculture. The total effect of measures in the Green Deal Agreement is estimated to be around 0.3 million ton $CO_2e$ in 2025 and 0.6 million ton $CO_2e$ in 2030 (Anonymous, 2021).

## 8.2. Targeted regulation

Targeted regulation was first mentioned in the political agreement about Agriculture from 2015 and was introduced in 2019 with the aim of reducing N-losses further. The implementation was intended to happen over three years where 1/3 of the final target would be reached in 2019, 2/3 in 2020 and full implementation in 2021. It was later changed so full implementation was implemented already in 2020. In 2019, the requirement was 1,167 tonnes N or approximately 120,000 ha catch crops and the compensation was 529 kr. pr. ha (Ørum et al., 2018). The full additional requirement was around 380,000 ha of catch crops in 2020 (Miljø- og Fødevareministeriet, 2019).

The basic concept is a flexible implementation at the farm level so that farmers can choose the measures which fit their farm the best. The measures are shown in table 4. There is a nationally fixed exchange rate using the area with catch crops as the requirement. Using the same exchange rate across the country meant that the variation in effects of the measures was not as targeted as it could have been. As an example, the effect of catch crops on sandy soils and clay soils are very different (approx. 12 vs. 45 kg N/ha in the root zone), but an average of 33 kg N/ha was used. However, it allowed for an implementation that was understandable and yet flexible. With more detailed levels, the data requirements would have been even greater. The compensation covers the costs for the average farmer linked to the Rural Development Program, but pig farmers especially might have higher costs as they need the high yields from winter wheat, and so there is limited room for catch crops. Farmers can use alternatives like early sowing or in between crops if this is a better alternative for their farm. However, some farms have included more spring crops in the crop rotation which makes the implementation more expensive. The exchange rate in catch crops between the different measures is shown in Table 4. This shows that 4 ha of early sowing or 2 ha of in between crops replace one 1 ha of catch crop based on the conversion used in 2022-23.

Some new measures have been introduced (precision farming), but the choice of measures over the years has been roughly the same. Looking at the 2023 implementation in Table 4 we can see that most of the 600,000 ha catch crops units have been achieved using catch crops (around 80% of the voluntary measures). A new popular measure is precision farming which now covers almost 100,000 ha. The effect of precision farming is around 1-3 kg N/ha as stated in the nitrogen catalogue and it is based on different approaches (Eriksen et al., 2020). In some cases, the yield potential is used to adjust the N-level application in other cases the auto steering can reduce the amount of overlap with respect to fertilizer application.

N-quota reductions have been used only limited, but it might be used if the crop rotation or weather conditions does not allow for so many catch crops as expected. The increased requirement regarding N-utilization in manure, mentioned above, might have decreased the wish to use reduced N-application, in case the required utilization is not met. There will be some variation in the use of early sowing between the years as this varies with the weather conditions. Many of the other options have not been selected in more than 5% of the cases and it can be concluded that riparian zones are still not a popular measure.

**Table 8.4. Targeted regulation assessment regarding implementation in 2023 including both livestock catch crops, voluntary catch crops and obligatory catch crops**

| | Area (ha) | Conversion factor | Units of catch crops (ha) |
|---|---|---|---|
| Catch crops | 475,115 | 1 | 475,115 |
| Catch crops with N-fixation | 1,840 | 1 | 1,840 |
| Reduction of N-quota (average)<br>Under 80 kg N/ha<br>Over 80 kg N/ha | 203 | 122 kg N<br>93 kg N<br>150 kg N | 24,791 |
| Riparian zones | 101 | 4 | 403 |
| Set a side | 329 | 1 | 329 |
| Early sowing | 254,016 | 0.25 | 63,504 |
| Precision farming | 96,305 | 0.2 | 19,261 |
| In between crops | 23,508 | 0.5 | 11,754 |
| Energy crops | 3,582 | 1.25 | 4,478 |
| **Sum** | | | **601,475** |
| **Environmental effect (ton N) (10 kg N/ha)** | | | **6,015** |

Source: Landbrugsstyrelsen, 2023a and own calculations
Note: Some of the catch crop requirement is linked to old catch crops and livestock catch crops.

Overall the actual use of measures follow the expectations from SEGES (the Danish Advisory Service) (Krogh and Nielsen, 2023). The focus in their recommendation is also on catch crops and early sowing. The Advisory service suggest more set aside near streams, in between crops and reduced nitrogen norms than was actually implemented in practice (Krogh and Nielsen, 2023). With the current measures, the level of required catch crops in 2023 was around 30% of the total agricultural area in large parts of Jutland, but under 25% in some parts of Zealand (Landbrugsstyrelsen, 2022).

The catch crop requirement is for each catchment area, not per farm, which has meant that some farmers could implement more catch crops than required, especially if the compensation was higher than their cost. This flexibility allowed farmers with more room in their crop rotation to implement more and so farmers with less options could implement less. In total, this reduced the overall costs for the farmers. The voluntary round is followed by an assessment where the total required area is compared with the area which farmers have committed them to implement. In case the target is not reached an obligatory level of catch crops has to be implemented in the catchments. In 2023 a further 12,320 ha catch crops needed to be established which is equivalent to 3% of the total requirement (Landbrugsavisen, 2023). The level of obligatory catch crops is the same for all farms in a given catchment, but the level varies between catchments.

The basic concept of the regulation is a flexible implementation at the farm level so that farmers can chose the measures which fit their farm the best. The compensation has, in later years, been 500 DKK per ha which has been financed through the Rural Development program (2020-2023). There is no compensation for areas with obligatory catch crops so there is an incentive to participate in the first voluntary round. The targeted regulation has provided the expected effect in terms of the area with catch crops and the expected nitrogen effect partly due to the obligatory catch crops which ensures that the target has been reached.

## 8.3. Conclusion

Further reductions in nitrogen losses were planned for the period 2020-2023. The original targets regarding collective measures have been too ambitious and so they have not been achieved, but the new targets for 2027 are more likely to be reached. There has been a large effort from the farm advisory service to get farmers on board with collective measures such as mini wetlands. It again shows that it often takes several years from planning to implementation for some of these collective measures as there are often also administrative challenges.

The period from 2020 to 2023 followed the transition established in earlier periods towards more targeted measures. The increased flexibility was a process that was already started before 2016 allowing farmers to replace catch crops with other measures if the measures had the same environmental effect. For the targeted regulation, the key measure is still catch crops and early sowing, but the new precision farming has also been popular. Set-aside and lower N application are still rarely used measures. With the current approach to targeted regulation the expected area with catch crops (or equivalent) is achieved to a very high degree due to the implementation approach adopted.

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# 9. Forecast of the future evolution of the water body quality

## 9.1 Nitrogen pressure on coastal Waters

An assessment of the 3rd River Basin Management Plan (RBMP)[9] for 2021-2027 regarding the status for the marine coastal waters has shown that only 5 coastal water bodies of the total 109 coastal waters bodies are in good ecological status. The number of marine waterbodies has changed since the 2nd RBMP because of changed delineations of some water bodies. The coastal waters are affected by a number of pressures. However, the primary reason for not meeting the environmental objectives is a too high nitrogen load. Therefore, the efforts in the 3rd RBMP focus on a significant reduction of the nitrogen loads to coastal waters. The all-important anthropogenic source to the nitrogen load to coastal waters is the loss of nitrogen from agricultural land.

In the 3rd RBMPs for 2021-2027 it was estimated that land-based Danish nitrogen losses to Danish coastal waters should be reduced to approximately 38,300 tons N/year (target load) to support the coastal waters to meet good ecological status. In the model calculations it is assumed that other member states reduce their load according to international agreements (especially The Baltic Sea Action Plan (BSAP)) and to their decided 3rd RBMPs. An effort from the Danish side alone cannot bring the more open parts of Danish coastal waters in good ecological status. For the 3rd RBMP for 2021-2027, the model calculations have been expanded, compared to the previous RBMPs and updated with the most resent monitoring data.

For approximately 60% of the catchment areas in Denmark, the nitrogen load to the marine waters are monitored (in watercourses). Loads are estimated based on model calculations for the remaining 40% of the catchment where there are no monitoring data. More monitoring stations have been installed in watercourses in 2017 and 2018, reducing the area of catchment areas to be modelled,

In the 3rd RBMP it is estimated an average load to coastal waters for the years 2016-2018 of approx. 56,300 tons N/year. A forecast from 2019-2027 (baseline load 2027) of the load in 2027 has been made. This baseline effect includes effect of measures from 2nd RBMP that had been planned, but still need to be established during 3rd RBMP and also a forecast of reduction in agricultural area for urban purpose, roads etc. The baseline effect for 2019-2027 can be added up to 4.900 tons N/year. The load in 2027 is hence estimated to be 51.300 tons N/year. The gap between the estimated 2027 load and the target load (to support achieving good ecological status) is calculated for each catchment to the 109 marine water bodies for the 3rd RBMP and amounts to approx. 13.000 tons N/year at national scale.

Target loads for each coastal water body are "Danish targets loads" and generally based on the premise that measures are implemented until 2027 and nitrogen loads are reduced to a level, which support achieving good ecological status in the adjacent Danish water bodies in the coming years. Moreover, it is presupposed that international measures against waterborne as well as airborne nitrogen emissions towards 2027 are also implemented according to international agreements (e.g. NEC-directive) and other countries RBMPs.

In October 2021, a political Agreement on the green transition of Danish agriculture was reached by the government and supporting parties. With the agreement measures with a reduction effect of 10,400 tonnes of nitrogen in the coastal waters were decided out of the total need for reduction of 13,000 tonnes of nitrogen to support achieving good environmental status in Danish coastal waters. The decision on the remaining 2,600 tonnes of nitrogen reduction need was postponed until a revisit of the above mentioned agricultural agreement in autumn 2024.

[9] The 3rd RBMP was published 15th of June 2023.

According to the agricultural agreement a so-called *Second Opinion* of the scientific basis of the total need for reduction of 13,000 tons Nitrogen/year should also be carried out. The results of the second opinion will be reported to the political parties behind the political agreement prior to the revisit in 2024. The second opinion also includes an update of both the status load for nutrients and the baseline forecast to 2027.

The second opinion (draft report from august 2024) has shown a need for reduction of 12.900-14.100 tons Nitrogen/year to Danish coastal waters. The interval is depending on whether the good/moderate target for phytoplankton is re-adjusted in open coastal waters, according to the previously intercalibrated targets with Sweden and Germany.

Efforts to achieve good ecological status, but also efforts to achieve targets for $CO_2$ reductions will have major consequences for society, including for agricultural operations. Therefore in 2023 a “Green Tripartite” was set up with participation of the Danish government and main stakeholders, i.e. the Danish Agriculture & Food Council, the Danish Society for Nature Conservation and the unions for workers in the Food and Metal Industries, Federation of Danish Industry (DI), and the association of municipalities, Local Government Denmark. The objective of the “Green Tripartite” was to find broad-based and long-term solutions to the agricultural sector's climate and nature challenges and to come up with recommendations for how we in Denmark best manage our land, nature and drinking water resources.

On 24th of June 2024, the “Agreement on a Green Denmark” was reached by the “Green Tripartite”, need for reduction was consolidated to 13,800 tons with the political “Agreement on the Implementation of a Green Denmark” from November 2024.

The agreement will form the long-term basis for a historic reorganization and restructuring of the Danish landscape as well as the food and agricultural production in Denmark. The agreement provides concrete answers to agriculture's climate and nature challenges and at the same time paves the way for a historic land reform. Danish agriculture has always been in a state of constant change, and with this agreement the path is paved for the major changes in the coming years.

In general, the Green Tripartite has agreed to a paradigm shift in the nitrogen effort, where a land reform is the main driving force to achieve the goals of the Water Framework Directive. A comprehensive land reform will create much more nature, while regulation on the remaining agricultural land will be tightened further, where needed, Better water quality and an even more efficient agricultural production are expected as outcomes of the extensive efforts.

The Green Tripartite acknowledges that the Danish water environment is in a very serious state, and that the Danish coastal waters are massively challenged. Hence, it was agreed, that there is a need for a comprehensive restoration of nature under the surface of the sea, so that life can return and have good conditions. In the agreement, discharge of nitrogen is identified as the primary reason why the coastal waters are in poor conditions.

The Green Tripartite thus agreed that an ambitious nitrogen effort must be implemented on the basis of the following principles:

- Denmark must meet the targets in the Water Framework Directive and thereby ensure prerequisites for life to return to the Danish water environment.
- A comprehensive effort is being launched with targeted land reform, supported conversion of agricultural land and modern land management as the supporting pillars.
- The best possible framework is created to carry out the necessary efforts. The key elements are:
- Establishment of Denmark's Green Area Fund and including financial prerequisites for the land reform:
    - New local organization, which must ensure efficient and locally anchored planning and implementation, at the same time that efforts are continued and started up
    - Strengthened “environmental guarantee” for all coastal waters (a guarantee for meeting the objectives for realizing measures)
    - Tightened targeted agricultural regulation (where needed) and extensification of agricultural as bridge building for a new land use

- “Rapid Action Plans” in the most challenged coastal waters
- Minimization of all relevant loads from point sources, including waste water in particular

As a central framework for the land reform, Denmark's Green Area Fund is being established, which will act as an umbrella for a number of significant efforts:

- Support for the establishment of 250,000 hectares of new forest until 2045 (on previously farmed land)
- Support for set a side of 140,000 hectares of carbon-rich lowland soils (incl. peripheral areas) towards 2030
- Support for other land redevelopment, including wetlands and extensification of agricultural land
- Strategic land acquisition, including with a view to on nitrogen load reduction needs

A historically high amount of approximately DKK 40 billion (approx. 5.3 billion €) is set aside for the efforts in Danish Green Area Fund.

The Green Tripartite agreement will form the background for a revisit of the nitrogen effort in the agricultural agreement from 2021 and for an update of the 3rd RBMP, which is planned to be submitted for public consultation before the end of 2024.

## 9.2 Expected achievement of environmental objectives in coastal waters by 2027

According to the 3rd RBMP there are 5 of the 109 water areas that have been assessed as being in good ecological status. For 104 water bodies, good status is only expected to be achieved after 2027 because of natural conditions.

Coastal waters, where there is expected to be a delay from the time the effort is implemented during the planning period until the target is reached, are covered by an extended deadline to after 2027 due to natural conditions. Improvements in the status of the water bodies as a result of the efforts will often only occur sometime after the measures have been implemented, as it takes time for the ecological systems to adjust to a new state of equilibrium. For example, the prerequisite for eelgrass to spread to the required depth is that the basic physical and chemical conditions (e.g. light conditions) have been restored. Next, expansion ofeelgrass meadows by natural dispersal mechanisms will take several years.

To ensure the obligation for measures under the WFD for coastal waters the 3rd RBMP is planned to be updated in 2024-2025 due to follow up on the Green Tripartite Agreement from June 2024 and on the revisit of the Agreement on the green transformation of Danish agriculture from October 2021.

The Green Tripartite acknowledges in the agreement that it will not be possible to implement all measures, which currently are assessed to be needed in order to facilitate achieving good ecological status in all 109 coastal water bodies by 2027. For a number of coastal waters, where the most comprehensive measures have to be taken, it is expected that implementation will take place until 2030, which eventually might include expropriation of farms, if needed.

Achievement of environmental objectives in groundwater

In the river basin management plans for the period 2021-2027, the assessment of chemical status for groundwater bodies is based on groundwater quality standards and threshold values for pollutants. Currently, 1604 (out of 2043) groundwater bodies are in good chemical status in relation to nitrate, 45 groundwater bodies are in poor chemical status in relation to nitrate, and 394 bodies have unknown chemical status in relation to nitrate. Poor chemical status in relation to nitrate is attributed to a ground water body when one monitoring point or more is assessed to have a nitrate concentration exceeding 50 mg/liter and a conceptual model and expert assessment concludes that 20% or more of the groundwater body exceeds the groundwater quality standard of 50 mg/liter. The assessment of significant and sustained upward trend in the concentrations of pollutants has yet to be completed.

It was presupposed in the 3rd RBMP that on a long term basis, the new targeted regulation along with the new baseline 2027 and the existing general regulation will meet the need of measures for groundwater bodies as proposed in the river basin management plans 2021-2027. Thus, groundwater bodies in poor chemical status in general are expected to reach good chemical status after 2027. For the revisit of the 3rd RBMP, this assessment will be reevaluated. It should be noted that in general, the chemical status of groundwater bodies develops slowly.

Environmental objectives for watercourses and lakes and relevant pressures

Danish watercourses and streams are relatively short compared to major rivers in Europe. The national monitoring program and the scientific studies indicate that the ecological water quality in Danish rivers and streams is not significantly affected by emissions of nitrogen. Quality elements such as phytobenthos and to some extent macrophytes may be affected by the phosphorus concentration in watercourses. However, it has not yet been possible to determine how phosphorus affects these quality elements in watercourses and streams.

Emissions/discharges of phosphorus are the most important pressures preventing the fulfilment of good ecological status in lakes. New measures such as improved wastewater treatment and constructed wetland. can reduce the discharges of phosphorus in the catchment areas to lakes.

The revisit of the 3rd RBMP (cf. 9.1) will also encompass a decision on how to handle remaining contingent reduction needs for other water bodies than coastal waters. For example, for lakes the revisit of the 3rd RBMP proposes to implement new measures e.g. planting of trees along streams and further measures for waste water treatment. In addition, it is also considered how to achieve synergy to the already agreed nitrogen measures. For watercourses the revisit is primarily focused on physical restoration and handling physical barriers, however nitrogen measures can have a positive effect on watercourses and vice versa.

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