STUDY

Requested by the PETI committee

Monitoring of nitrogen in water in the EU

Legal framework, effects of nitrate, design principles, effectiveness and future developments

Policy Department for Citizens' Rights and Constitutional Affairs
Directorate-General for Internal Policies
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Abstract

This study, commissioned by the Policy Department for Citizens' Rights and Constitutional Affairs for the Committee on Petitions (PETI) of the European Parliament, provides an overview of the legal and environmental context in which nitrogen emissions to water are measured in the EU, and how the European Commission makes sure that monitoring systems and their results are comparable throughout the EU. The study explores the development of nitrate concentrations in the EU in view of the European Green Deal and provides (policy) recommendations for EU institutions and Member States, taking into account their respective remits.

This document was requested by the European Parliament's Committee on Petitions.

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CONTENTS

LIST OF ABBREVIATIONS

BWD	Bathing Water Directive (2006/7/EC)
CAP	Common Agricultural Policy
DWD	Drinking Water Directive (EU/2020/2184)
EC	European Commission
EU	European Union
GWD	Groundwater Directive (2006/118/EC)
IPPC	Integrated Pollution Prevention Control Directive (96/61/EC)
ND	Nitrates Directive (91/676/EEC)
PETI	The European Parliament's Committee on Petitions
RDR	Rural Development Regulation (1305/2013/EU)
UWWD	Urban Waste Water Directive (98/15/EC)
WFD	Water Framework Directive (2000/60/EC)

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EXECUTIVE SUMMARY

Over the last decades, emissions of nutrients and pesticides have proved to be a major source of pollution for both drinking water resources and (aquatic) ecosystems in Europe. Agriculture is a major emission source of nutrients and pesticides, but there are other sources as well, such as emissions of human and industrial waste water effluent. This study focuses on nutrient emissions by agriculture. Extensive legislation has been developed by the EC during this time, to protect its waters for future generations, as 'water is not a commercial product like any other, but rather a heritage that must be protected, defended and treated as such' (Water Framework Directive (WFD, 2000/60/EC), consideration 1).

However, despite this acknowledgement of the importance of water resources, the protection and remediation of both surface water and groundwater from agricultural pollution is still an ongoing challenge throughout Europe.

Scope and objective

This study aims to give an overview of the legal and environmental context in which nitrate emissions to water are measured in the different Member States of the EU, and how the European Commission makes sure that monitoring systems and their results are comparable throughout the EU. The primary focus of this study is on the Nitrates Directive, but placed in the wider context of water legislation such as the WFD.

The Nitrates Directive includes both health-based objectives related to resources for drinking water (both groundwater and surface water) and ecologically based objectives related to eutrophication of surface waters like rivers, lakes and coastal waters. For this reason, this study addresses both these objectives and describes monitoring requirements in groundwater and in surface water. These questions are placed in the wider context of legislation and policy development regarding agriculture and water quality management.

The study is based on existing available data, studies and analyses from various sources and documents from national and international institutions and has used concrete quantitative and qualitative evidence.

Nutrients (N&P), nitrogen and nitrate

Nitrogen (N) and phosphorous (P) are nutrients from manure, chemical fertilisers and compost that are released to air, soil and water in various chemical forms. Depending on the environmental compartment and function to be protected (e.g. drinking water, groundwater, air quality, surface water ecology) a specific nutrient or its chemical form is relevant for the evaluation. For the protection of drinking water resources levels of nitrate and nitrite (chemical forms of nitrogen) are relevant as they may give rise to health risks. To avoid eutrophication from surface water and thus protect ecological water quality, levels of nitrogen (N) and phosphorous (P) need to be assessed. Regarding emissions to air, nitrogen oxides and ammonia (gaseous chemical forms of nitrogen) need to be taken into account.

This distinction between the different nutrients and chemical forms is important when discussing challenges in agricultural policy and practices and deciding on intervention strategies that are adequate for what they are aimed for.

Legal framework

The EU has developed an extensive regulatory and policy framework to protect the environment from agricultural pressures. Focusing on the emissions to soil and water, the most relevant directives are the Water Framework Directive, the Nitrates Directive, the Groundwater Directive and the Drinking Water Directive. Policies like the Common Agricultural Policy and the European Green Deal offer provisions to achieve sustainable agricultural practices while ensuring a level playing field for farmers and preserving food security. Despite this extensive framework, countries face significant challenges to meet the nutrient objectives set. Recent studies show that national implementation often takes place sectorally, within policy domains such as the water domain or the agricultural domain. As a result, multiple cross-sectoral objectives need to be realised simultaneously at the regional to local level. And although efforts have been made to create linkages between directives, requirements such as monitoring and reporting may be different. Implementation would therefore benefit from more advanced cross-referencing.

A good example for this advanced cross-referencing can be found in the recent revision of the Drinking Water Directive by including objectives for the protection of drinking water resources that are linked to the objectives of the WFD.

Effects of nitrate on health and environment

Excess amounts of nitrogen compounds in groundwater and surface waters can affect both human health and natural ecosystems. Nitrate exposure to humans comes from air, food (vegetables, cured meat, and dairy products to a lesser extent) and drinking water consumption. Excess nitrate consumption can lead to cyanosis, a blueish skin hue due to the lack of oxygen, and consequent health effects. Infants (especially bottle-fed infants) and pregnant women are most at risk for these effects. Some studies report on possible adverse health effects of nitrate, related to colorectal cancer and reproductive outcomes, but the results of these studies are mixed. Finally, bathing in eutrophic water can also cause health effects from nitrogen. Eutrophic waters are susceptible to the formation of harmful algae blooms. Some blue algae produce toxins with adverse health effects for bathers.

Eutrophication and the enhanced production of (harmful) algal blooms in turn might have an indirect impact on physical-chemical water quality characteristics (e.g. transparency, oxygenation conditions), with reduced biodiversity as a result. Standards for nitrogen in surface waters to prevent eutrophication are dependent on the characteristics of the water body and are much more stringent (4-5 times) than the standard set for drinking water.

Monitoring networks for groundwater and surface water

From 2008 to 2019, the number of monitoring stations for nitrogen monitoring of groundwater and surface waters has increased steadily in the EU, although there is a large variation in station density between countries and frequency by which these stations are sampled.

The European Commission does not require Member States (MS) to have the same monitoring systems but aims to ensure full compliance with the Nitrates Directive and related directives by each MS. The differences in monitoring systems do not mean that the reliability of the information provided by the MS differs, but rather that the comparability of the datasets is not straightforward. Differences in current concentration levels, total agricultural area, variation in type of agriculture, and variation in natural soil, aquifer and surface water characteristics can be regarded as design criteria, and as such contribute to differences in the setup of the monitoring networks between MS. Due to these differences, the current data set at the EU level is less suitable for the production of figures and maps on water quality status and trends at the EU level.

To obtain a data set that meets the requirements for such analyses at the EU level, would require a coordinated formulation of the monitoring goals, using a selection of national monitoring stations with the help of national experts.

Development of nutrient emissions

Since the introduction of the Nitrates Directive, nutrient emissions from agriculture have been reduced substantially, although emissions seem to have stabilised in the last decade. Groundwater quality has improved as well but seems to have stagnated since 2012. Trends in the development of eutrophication cannot be provided at EU level as not all MS provided this information in their last progress reports. Moreover, MS use a wide variety of parameters in the assessment of eutrophication of surface waters, which complicates comparison.

The Biodiversity and the Farm to Fork Strategies within the European Green Deal aim to reduce nutrient losses to the environment by at least 50% by 2030. Recent European studies show that, on average, this level of ambition is also necessary to comply with the objectives of the Nitrates Directive. To achieve such a reduction requires more structural policy choices. Economic pressure in agricultural practice severely limits local room to manoeuvre to further improve water quality. Improved nutrient management and other innovative solutions could limit production losses. EU support for both research and innovation and sustainable practices is therefore indispensable. This support is envisaged in the Farm to Fork Strategy, but a further revision of the CAP would also be required.

Implementation of EU policy

The legislative EU framework related to nitrate in the environment is extensive and complex. Based on information from various EU projects and international expert exchanges (H2020 WaterProtect, H2020 Fairway, EIP Water, EIP Agri, joint DWD and WFD expert meeting), several recommendations have been derived that are of relevance to monitoring of nutrients.

<u>Coherence and consistency: Improve (policy) effectiveness through increased cross-referencing</u>

Policy effectiveness and cost-effectiveness will improve through increased cross-referencing across different directives and policies and further harmonisation of monitoring and reporting requirements.

More focus on the interdependence between the Water Framework Directive (WFD), the Groundwater Directive (GWD), the Drinking Water Directive (DWD), the Nitrates Directive (ND) and the Common Agricultural Policy (CAP) will contribute to a more effective nutrient policy. At present, their connectedness is not formalised. Requirements from the DWD and GWD that relate to institutional frameworks could be included in the WFD as an additional component to consider. As such, the programmes of measures developed and implemented under the WFD, would be better harmonised with the thresholds and relevant requirements in the DWD and GWD, including time frames and monitoring.

<u>Coherence and consistency: cross-sectoral approach</u>

Complexities and inconsistencies of European legislation become most explicit at the local level, where different sectoral policy objectives must be implemented simultaneously, integrated measures must be taken, and their effects must be monitored. The cascading of all relevant governance arrangements down from the EU level to farm scale often results in a plethora of policy and legal instruments to control nutrient emissions from agriculture and to protect water quality. The perception of stakeholders of the actual local governance has often diverged from the intention of the original directives. At local level, a lack of knowledge of the overall legislative framework, the complexity of water systems' responses, and the role of different, often competing interests will obstruct cross-sectoral approaches. Well-designed feedback mechanisms could support connections between local/regional challenges.

The complexity of nutrient policy demands sufficient capacity (knowledge and means) to support a transdisciplinary and cross-sectoral approach, also across scales. A combination of top-down and bottom-up approaches will give extra impetus and improvement. The EU could support local capacity building by facilitating international and intersectoral learning.

Trade-offs funding mechanism under the Common Agricultural Policy

Existing funding incentives may lead to competition between initiatives aimed at stimulating farming communities to become more economically sustainable and sacrificing sustainable practices to engage competitively in markets. It is necessary to introduce guidelines or additional peripheral requirements for the CAP and RDR to uphold the underlying principles of other directives, including the ND, such as Article 4.1 related to a code of conduct, to improve the effectiveness of the overall framework.

INTRODUCTION

1.1. Background

Over the last decades, emissions of nutrients and pesticides have proved to be a major source of pollution of both drinking water resources and (aquatic) ecosystems in Europe. Agriculture is a major emission source of nutrients and pesticides, but there are other sources as well, such as emissions of human and industrial waste water effluent. This study focuses on nutrient emissions by agriculture. During this time, extensive legislation has been developed by the EC, to protect its waters for future generations. In fact, 'water is not a commercial product like any other but, rather, a heritage that must be protected, defended and treated as such' (Water Framework Directive (2000/60/EC), consideration1).

However, despite the importance acknowledged to water resources, the protection and remediation of both surface water and groundwater from agricultural pollution, is still an ongoing challenge throughout Europe.

Over the years, the European Parliament's Committee on Petitions (PETI Committee) has received several petitions from EU citizens who are concerned about the effects of nitrate on the environment.

Considering the petitions received (see also Annex II of this report) and the importance of the consequences of nitrate pollution in the EU, the PETI Committee decided that it would be appropriate and useful that its Members be provided with expert information on the environmental impacts of nitrate and in particular on how nitrate levels are measured in the different Member States in the context of the relevant EU legislation.

1.2. Scope and objective of this study

The scope of this study is to give a clear overview of the legal and environmental context in which nitrate emissions to water are measured in the different Member States of the EU, and how the European Commission makes sure that measuring systems and their results are comparable throughout the EU.

The petitions (see Annex I) demonstrate citizens' concerns on monitoring related to the objectives and requirements of the Nitrates Directive (ND, 91/676/EEC). The Nitrates Directive includes both health-based objectives related to resources for drinking water (both groundwater and surface water) and ecologically based objectives related to eutrophication of surface waters like rivers, lakes and coastal waters. For this reason, this study addresses both these objectives and describes monitoring requirements in groundwater and in surface water. The primary focus of this study is on the Nitrates Directive, but it is placed in the wider context of water legislation such as the WFD.

The study is based on existing available data, studies and analyses from various sources and documents from national and international institutions, and concrete quantitative and qualitative evidence has been used.

The study provides:

- an introduction and a brief overview of the most important relevant EU legislation and a short assessment of implementation and compliance by Member States;
- data on the effects of nitrogen on human health and the environment;
- data on the number and distribution of nitrogen measuring stations in the EU;

- information on and an explanation of the tools and technologies used for measurements;
- information on the factors that influence measurements (e.g. the composition of soils, climatic conditions and geological diversity);
- a description of what an exemplary nitrogen measuring system could look like;
- a discussion on the problems with nutrient emissions to water in light of the European Green Deal;
- policy recommendations for the most relevant actors who could help to improve the existing EU policy and legislation on nitrogen.

Nutrients (N&P), Nitrogen, Nitrate

Nutrients, nitrogen (N) and phosphorous (P), from manure, chemical fertilisers and compost are released to air, soil and water in various forms. Depending on the environmental compartment and function to be protected (e.g. drinking water, groundwater, air quality, surface water ecology) a specific nutrient or its chemical form is relevant for the evaluation. For the protection of drinking water resources, levels of nitrate and nitrite (chemical forms of nitrogen) are relevant as they may impose health risks (see Section 3.1 of this report). To avoid eutrophication from surface water and thus protect ecological water quality, levels of nitrogen (N) and phosphorous (P) need to be assessed. Regarding emissions into the air, nitrogen oxides and ammonium (as gas) need to be taken into account. Figure 3 in Chapter 3 provides an infographic of the different emission routes for nitrogen.

This distinction between the different nutrients and chemical forms is important when discussing challenges in agricultural policy and practices and deciding on intervention strategies that are tailored to their goal.

1.3. Reading guide

This study has been structured into six chapters. After this introduction (Chapter 1), Chapter 2 provides an overview of the EU legislation that is most relevant to this study. Chapter 3 describes the exposure routes and effects of nitrogen components on human health and the environment. Chapter 4 provides information on monitoring in Europe for the Nitrates Directive. Chapter 5 explores possible developments in nutrient emissions, also in light of the European Green Deal. Table 1 shows in which chapters the questions of the PETI Committee are addressed.

Table 1: Questions by the PETI Committee and the chapters in which they are addressed

Question	Chapter
Provide a brief overview of the most important relevant EU legislation and, where possible, a short assessment of implementation and compliance by Member States.	2
Describe and provide data on the effects of nitrogen.	3
Provide data on number and distribution of nitrogen measuring stations in the EU.	4.1
Provide, where possible, policy recommendations/suggestions that could help improve the existing EU policy/legislation with regard to nitrate.	4.2

Provide information and explanation of the tools and technologies used for measurements.	4.3
Discuss how the EU guarantees the comparability of nitrogen measuring systems in the different Member States.	4.4
Describe what an exemplary nitrogen measuring system could/should look like.	4.5
Discuss nutrient emissions, if possible, in the light of the European Green Deal.	5
Provide, where possible, policy recommendations/suggestions that could help improve the existing EU policy/legislation with regard to nitrogen.	6

2. LEGISLATIVE FRAMEWORK

KEY FINDINGS

- The EU has developed an extensive regulatory and policy framework to protect the environment from agricultural pressures. Focusing on the emissions to soil and water, the most relevant directives are the Water Framework Directive, the Nitrates Directive, the Groundwater Directive and the Drinking Water Directive.
- Policies like the Common Agricultural Policy and the European Green Deal offer provisions to achieve sustainable agricultural practices while ensuring a level playing field for farmers and preserving food security. Despite this extensive framework, countries face significant challenges in meeting the nutrient objectives set.
- Recent studies show that national implementation often takes place sectorally, within policy domains such as the water domain or the agricultural domain. As a result, cross-sectoral objectives need to be realised at the regional to local level.
- Although efforts have been made to create connections between directives, requirements regarding monitoring and reporting may be different.
- Implementation would benefit from more advanced cross-referencing. A good example can be found in the recent revision of the Drinking Water Directive by including objectives for the protection of drinking water resources that are linked to the objectives of the WFD.

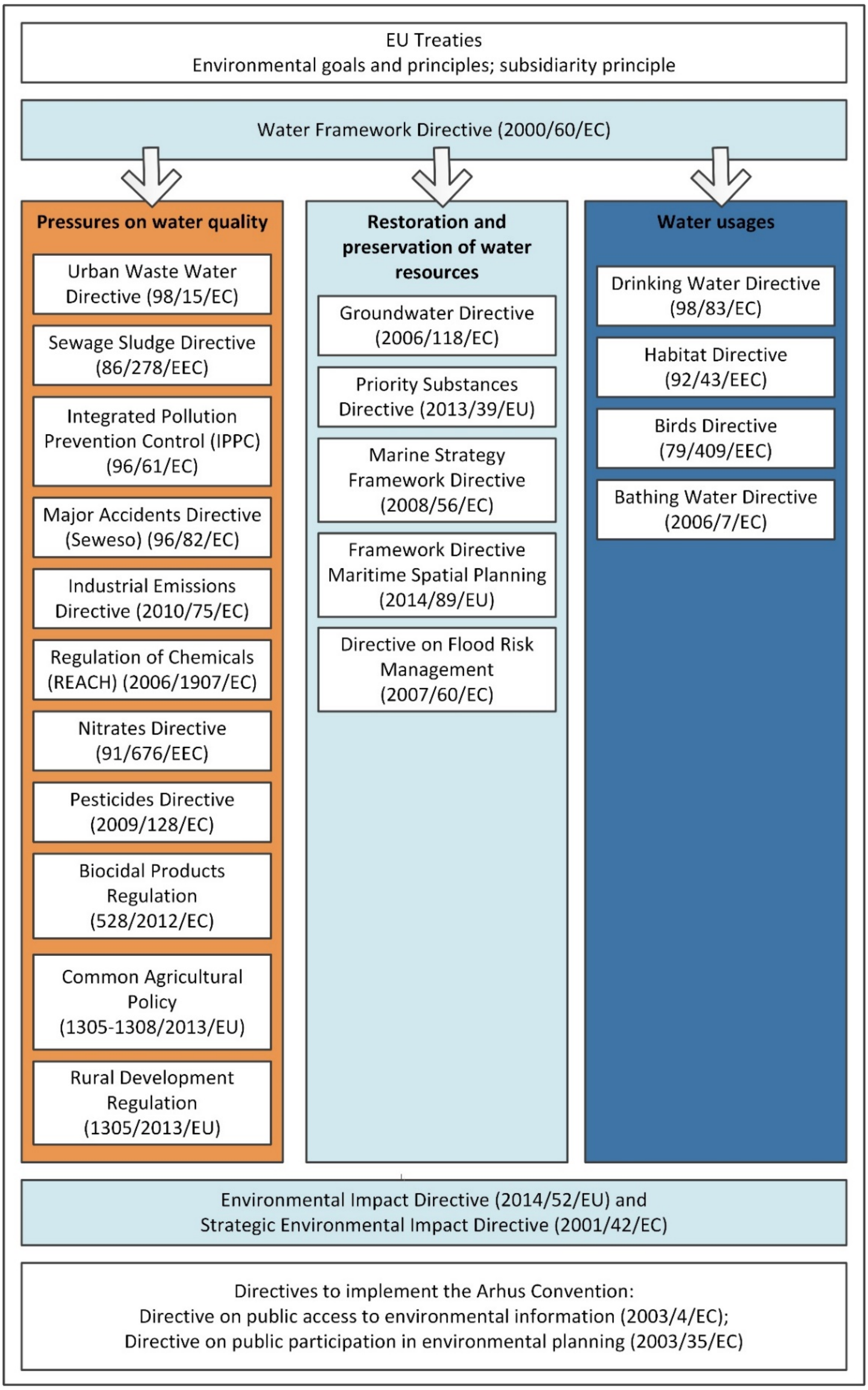
Over the last decades, the EU has developed an extensive regulatory and policy framework that addresses both water and agricultural sectors, environmental pollution, and land use, in order to reduce and mitigate emissions from agriculture to water and protect the environment (see Figure 1 and Platjouw, Moore et al. (2019)). In this study, we will focus on the directives directly related to nitrates in surface water and groundwater. The Nitrates Directive will be explained in its relation to other relevant directives (Water Framework Directive, Groundwater Directive, Drinking Water Directive and Urban Waste Water Directive) and policies (Green Deal, Farm to Fork, CAP). In this study, we focus on the objectives, monitoring, and reporting requirements.

2.1. EU water quality law

In general, three stages can be identified in the development of European environmental law. At first, directives focused on the protection and restoration of water quality for specific water functions like drinking water (80/778/EEC; 75/440/EEC), bathing water (76/160/EEC), shellfish waters (79/923/EEC), fish waters (78/659/EEC), and groundwater (80/68/EEC).

During the second stage, directives were introduced that focused on the reduction of emissions, such as the Nitrates Directive (ND, 91/676/EEC), the Urban Wastewater Directive (UWWD, 98/15/EC) and the Integrated Pollution Prevention Control Directive (IPPC, 96/61/EC). In this stage, legislation addressed water quality issues from a sectoral point of view (reduction of emissions) and less attention was paid to stakeholder involvement (Van Rijswick and Havekes 2012).

Figure 1: EU landscape of water quality law and related directives regarding agricultural pressures, categorised by pressures on water quality, water usages and the restoration and preservation of water resources.



Source: An elaboration of (Van Rijswick & Keessen, 2017; Wuijts, 2020)

A third stage in the development of European water quality law can be identified with the introduction of the Water Framework Directive (WFD, 2000/60/EC). The WFD, with its river basin approach, offers an almost all-inclusive overarching framework to achieve ecological, chemical and quantitative objectives, and tackle other water usage objectives to improve the quality of, for example, drinking water or bathing water. The WFD explicitly links to other directives such as the Nitrates Directive and the Drinking Water Directive. The Groundwater Directive (GWD, 2006/118/EC) further elaborates the requirements for groundwater that are set in the WFD.

2.2. Nitrogen objectives under the different European directives

The Water Framework Directive (2000/60/EC) sets objectives to achieve a good ecological and chemical status of surface water and groundwater, freshwater, and coastal waters. To achieve a good ecological status, the levels of nutrients need to be low enough to avoid eutrophication (see Chapter 3). Member States determine the levels of nutrients required for this objective themselves, since they also depend on regional characteristics of the water body and its feeds. The levels of nutrients reported back by MS are part of the ecological status of a water body and not part of the chemical status of a water body. The chemical status of a water body is set by the substances listed in the Priority Substances Directive (2013/39/EU) and an additional set of substances identified as relevant at river basin or national scale. Nitrates and components of nitrogen are not part of the Priority Substances Directive.

The Groundwater Directive (2006/118/EC, revision of 80/66/EEC), as a daughter directive of the WFD, sets objectives for a good chemical and quantitative status of groundwater. The Groundwater Directive establishes water quality standards for nitrate and pesticides and requires MS to set threshold values for groundwater bodies for all pollutants and indicators of pollution that may cause a groundwater body to be at risk of failing to achieve good groundwater chemical status. In this requirement, a connection has been made to the objectives of the WFD (achieving a good ecological and chemical status for all waters). The threshold values take into account the hydrogeological characteristics of the groundwater body as well as background concentrations and interactions between groundwater and associated aquatic and dependent terrestrial ecosystems. The water quality standards set for nitrate and pesticides apply to all groundwater bodies in Europe. The standards set for nitrate in the Groundwater Directive follow the Drinking Water Directive and the Nitrates Directive. Dependent on regional circumstances, such as the interactions with aquatic and dependent terrestrial ecosystems, Member States may derive stricter standards for nitrate at the regional level to protect these receptors.

The Drinking Water Directive (DWD, EU/2020/2184, revision of 98/83/EC and 80/778/EEC) sets water quality standards for water intended for human consumption (also referred to as 'water quality at the drinking water tap'), including standards for nitrate (50 mg NO_3/l) and nitrite (0.5 mg NO_2/l) (DWD, Annex I, Part B). With the recent revision, a risk-based approach has been introduced. The approach follows the Water Safety Plan methodology as developed by the World Health Organisation (Howard and Schmoll, 2006), and requires MS to identify, manage and control (potential) hazards from source to tap.

In water abstraction areas, MS should monitor pollutants that they have identified as relevant due to the presence of certain activities or emissions. This characterisation and monitoring is directly related to the requirements set by the WFD and aims to overcome a disconnect identified during the evaluation of the DWD (Platjouw et al., 2019). Based on the risk assessment of the catchment areas for abstraction points, management measures to prevent or control the risks identified should be taken to safeguard the quality of the water intended for human consumption, for example reducing abstractions from wells that are polluted or introducing advanced water treatment.

The Nitrates Directive (91/676/EC) aims to prevent and limit water pollution by nutrients from agricultural sources. The standard set for nitrate in groundwater is 50 mg NO_3/l. This value is based on the protection of drinking water resources. For surface water, objectives have been included for resources for drinking water production and for eutrophication. The standard set for drinking water production from surface water is the same as for groundwater resources.

Regarding surface water for drinking water production, the Nitrates Directive refers to the directive 'concerning the quality required of surface water intended for the abstraction of drinking water in the Member States' (75/440/EEC). Directive 75/440/EEC sets standards for nitrate, nitrogen and ammonium. For surface water resources for drinking water in general, concentrations of nitrogen and ammonium rarely pose a risk for drinking water supply. This could explain why the link in the Nitrates Directive for drinking water has been limited to the standard set for nitrate.

Directive 75/440/EEC was repealed in 2007, seven years after the introduction of the WFD (WFD, Article 22) and its obligations have been taken over by the WFD in order to maintain a similar level of protection (WFD, Consideration 51).

Eutrophication can be characterised by the level of nutrients (total-N and total-P) and the presence of algae growth (represented by indicator parameter chlorophyll-α). Although the Nitrates Directive does not include specifications regarding the objective to prevent and limit eutrophication (ND, Annex I), the Urban Wastewater Directive (UWWD, 91/271/EEC amended by 98/15/EC) does provide requirements to discharges from urban wastewater treatment plants to areas that are sensitive to eutrophication for total phosphorus and total nitrogen (Amendment UWWD, Annex I, Table 2). Freshwaters and coastal waters should be regarded as sensitive areas when they are eutrophic or potential eutrophic or when a resource for drinking water could be non-compliant due to nitrate concentrations as laid down in Directive 75/440/EC (UWWD, Annex II). Similar criteria for eutrophication are being used by MS to report on progress towards the objectives of the Nitrates Directives (EC, 2020a). Objectives regarding N-total are set at the level of a water body (regional scale) as the characteristics of a water system determine what maximum level of nutrients it can cope with (based on the WFD-objectives). These levels are generally 3-4 times lower than the drinking water-based standard for nitrate (see also Chapter 3).

2.3. EC policies on nutrients: Green Deal, Farm to Fork, CAP

With the Farm to Fork Strategy and the Common Agricultural Policy, the European Commission has developed ambitions and means to work towards sustainable and healthy food systems in Europe, while ensuring a fair economic return in food production.

The Farm to Fork Strategy as part of the European Green Deal (https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en, last viewed on 2 March 2022) aims to reduce nutrient losses from agriculture by at least 50% by 2030, while ensuring no deterioration of soil fertility. To enable this transition, the EC has provided funds for Research and Innovation by the Horizon 2020 and Horizon Europe programmes and is strengthening partnerships to speed up innovation and knowledge transfer, for example with the European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI) and the European Regional Development Fund (EC, 2020b). Knowledge and tailored advice are key conditions to facilitate the transition of the whole food chain towards sustainability. The EC believes that MS need to scale up support for Agricultural Knowledge and Innovation Systems (AKIS) in their CAP Strategic Plans. For this reason, the EC will propose legislation to convert its Farm Accountancy Data Network into the Farm Sustainability Data Network. This conversion will enable the collection of data on the Farm to Fork and Biodiversity Strategies' targets and other sustainability indicators (EC, 2020b). This allows progress towards the ambitions set for nutrient losses and a sustainable environmental quality to be monitored.

With the Common Agricultural Policy, the EU provides financial support to farmers in MS. It is one of the founding policies of the original Common Market and brings together national intervention programmes into one scheme to allow farmers to compete on a level playing field while protecting against volatility in agricultural prices (and hence incomes), and to provide food security. In 2018, the EC proposed a reform of the CAP to modernise and simplify it and align it with the ambitions set in the Farm to Fork Strategy. In 2021, an agreement was reached and the new CAP was formally adopted on 2 December 2021. MS need to implement the new CAP by formulating a National Strategic Plan at national level by 1 January 2023 (factsheet-newcap-environment-fairness_en.pdf (europa.eu), last viewed on 2 March 2022). Digital platforms such as the FAST tool can support the transition towards more sustainable practices (https://fastplatform.eu/about), last viewed on 25 May 2022).

2.4. Monitoring and reporting requirements

To monitor progress towards achieving the water quality ambitions set in the directives described in section 2.2, MS must establish adequate monitoring programmes and report to the EC at intervals on the results of these monitoring programmes. Each of the directives described here contains requirements, each of them tailored to the aim of the directive. This means that, although efforts have been made to connect directives, requirements may be different (Platjouw et al., 2019). In practice, MS aim to create synergies between these monitoring programmes in order to increase efficiency and to develop a coherent view on progress towards water quality ambitions. For this reason, the description of monitoring networks in Chapter 4 of this study, focuses on the monitoring requirements for the ND with links made to the WFD when this is relevant.

The ND aims to reduce, prevent and limit water pollution by nutrients from agricultural sources. Monitoring and reporting focus on the progress towards these goals. The designation of nitrates vulnerable zones and action programmes must be reviewed at least every four years. Member States are also obliged to submit a progress report on the implementation of the Directive every four years with information on codes of good agricultural practice, nitrate vulnerable zones, water monitoring results, and relevant aspects of action programmes.

The WFD, with its more overarching objective of realising and preserving the good ecological and chemical status of water systems, requires MS to establish programmes for water status monitoring which provide a coherent and comprehensive overview of water status within each river basin district (WFD, Art. 8.1). The WFD thus has a wider scope than the ND, including aspects related to water quantity and hydromorphology and a wider scope of substances that have to be monitored, depending on the regional circumstances. Sampling points, parameters and sampling frequency must be such that they provide a coherent and comprehensive overview of the status of a water body and the development of trends. MS must report on progress every six years.

Regarding groundwater, the monitoring requirements set by the GWD are strongly determined by the nature of groundwater flows: once groundwater bodies are polluted, it is extremely costly and time-consuming to remediate this pollution. For this reason, programmes of measures focus on the prevention and limitation of sources of anthropogenic pollution. With their monitoring programmes MS must be able to identify any significant and sustained upward trends in levels of anthropogenic pollutants found in bodies of groundwater. To do so, they must establish a monitoring programme in conformity with Annex V WFD and Annex IV GWD. Reports on progress of the GWD are included in the WFD-reports.

The DWD focuses on water quality at the drinking water tap. MS are required to regularly monitor the quality of water intended for human consumption, including the resource quality, and to ensure that any failure to meet the water quality standards is investigated and corrected through remedial action as soon as possible. Reporting is required every six years on risks assessment and risk management from resource to drinking water tap with an annual update on incidents, exceedances of water quality standards and remedial actions taken.

2.5. Implementation and compliance

Following the principle of subsidiarity (Article 5(3) of the Treaty on European Union [2012/C 326/01]), which aims to safeguard the ability of Member States to take decisions and actions adjusted to their needs, culture and governance frameworks, the legal obligations arising from EU directives such as the Nitrates Directive (ND, 91/676/EEC) and related directives must be implemented (transposed) into national legislation to come into force. Because of this principle of subsidiarity, the mode of implementation (transposition) can differ between MS.

To achieve water quality objectives, different sectors (e.g. water management, agriculture, urban planning and industry) must work together. The WFD with an overall objective and the linkages to other relevant directives, provides a legal basis for such an integrated approach, whilst the ND focuses on reduction of water pollution caused by agriculture. Several scientific studies have demonstrated that the mode of implementation (transposition) is quite often set by existing regulatory frameworks (Keessen et al., 2010; Voulvoulis, Arpon and Giakoumis, 2017; Giakoumis and Voulvoulis, 2018). As a result, implementation is often guided by existing sectoral institutional structures. This means that programmes and measures in practice may not be fully supported by an integrated national legal framework.

The H2020-funded research project FAIRWAY demonstrated the challenges that arose from this sectoral implementation. In this project, governance arrangements for 13 case studies in 11 European countries (9 MS, Norway and the UK) were studied. These arrangements aim to prevent or limit pollution of drinking water resources by agricultural activities. Part of this analysis was an expert consultation on the mode of implementation of the Water Framework Directive, the Groundwater Directive, the Drinking Water Directive, the Nitrates Directive, the Pesticides Directive and the Common Agricultural Policy. For all countries participating, full implementation of the relevant directives was reported back (Wuijts et al., 2021).

However, there were substantial differences between the countries studied in how the sectoral directives had been implemented into national law and how coherence and interaction between these directives had been ensured to achieve water quality objectives. Quite often, sectoral legislation has to be realised at the local level. This imposes a challenge to achieving objectives that require multidisciplinary capacity and instruments. For instance, the mechanisms under the CAP require farmers to maximise the land area classed as "actively farmed" and eligible for area-based payments. This area is also important for determining the permitted stocking rate for a farmer (based on the limit value of 170 kg manure N/ha from the Nitrates Directive).

One of the cases in the FAIRWAY project showed that for areas not in use by active grazing, pesticides are being used for weed suppression and to keep the land arable, with adverse effects on water quality. The CAP mechanism then counteracts resolving water quality issues (Wuijts et al., 2021). In the

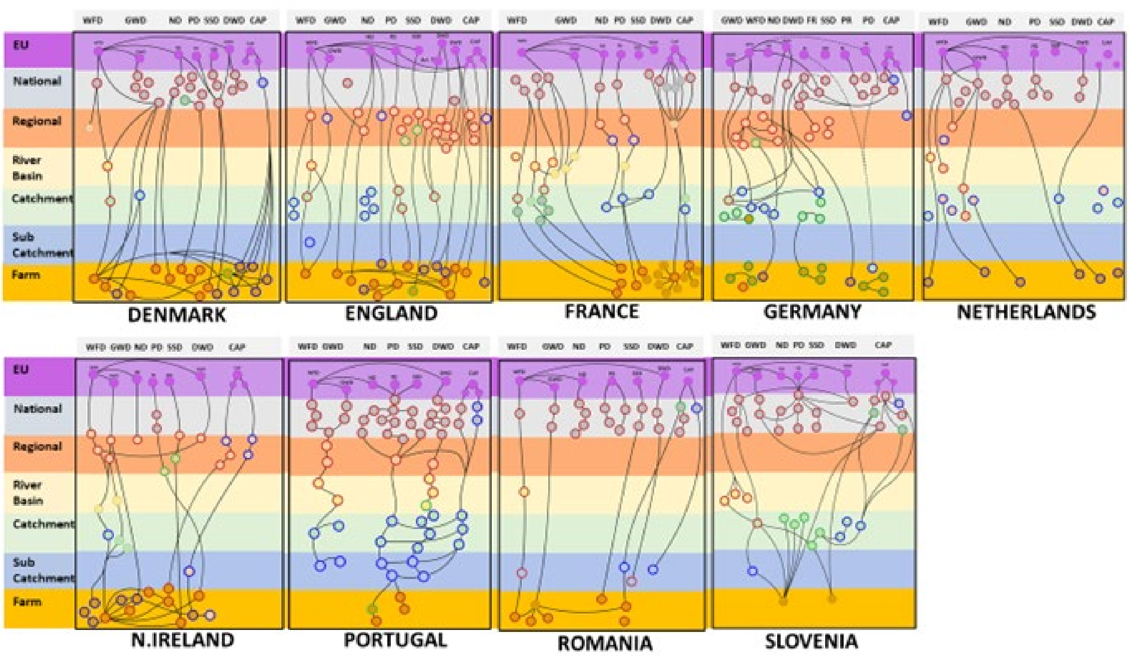
FAIRWAY project, visualisations ('impressions') were created for each participating EU country, showing the cascade of governance from EU directive to farm level. The impressions were based on input from informed stakeholders working at the local level, reflecting their perceptions (see Figure 2).

The impressions demonstrated the diversity in the mode of implementation (transposition) of water quality and nutrient-related EU directives in the nine selected MS across different scales (Rowbottom et al., 2022). These differences between countries also illustrate the complexity of governance in Member States and explains, at least partly, the differences in the nutrient monitoring systems of MS.

The EC-report on the implementation of the Nitrates Directive for the period 2016-2019, describes the progress towards the objectives set by the ND (EC, 2021b). All MS plus the UK have reported on their progress and monitoring results. During the reporting period (2016–2019), 14% of the groundwater stations exceeded the annual concentration of 50 mg nitrates/litre. This situation is similar to the previous reporting period (2012-2015), during which 13% of the groundwater stations exceeded the annual average concentration of nitrates.

For surface waters, the levels of nitrogen, phosphorous and eutrophication are being reported. For the MS plus the UK, 36% of the rivers, 32% of the lakes, 31% of the coastal waters, 32% of the transitional waters, and 81% of marine waters were reported as eutrophic. The parameters used for the assessment of the level of eutrophication varied widely among Member States, despite the availability of a guidance document (EC, 2012). This makes it difficult to compare progress between MS towards the reduction of the level of eutrophication. Furthermore, no trends on progress are available at EU level for the state of eutrophication, because of the lack of data and the differences in the methodologies applied by Member States (EC, 2021a). Chapter 5 of this study further explores the development of nutrient emissions.

Figure 2: Impressions: A visual representation of the cascades showing water and nutrient governance arrangements of nine MS from directive to farm level



GWD Groundwater Directive, SSD Sewage Sludge Directive, WFD Water Framework Directive, DWD Drinking Water Directive, ND Nitrate Directive, PD Pesticide Directive. GERMANY only: FR Fertiliser Regulation, PR Pesticide Regulation.

Source: H2020 FAIRWAY.

3. EFFECTS OF NITRATE ON HEALTH AND THE ENVIRONMENT

KEY FINDINGS

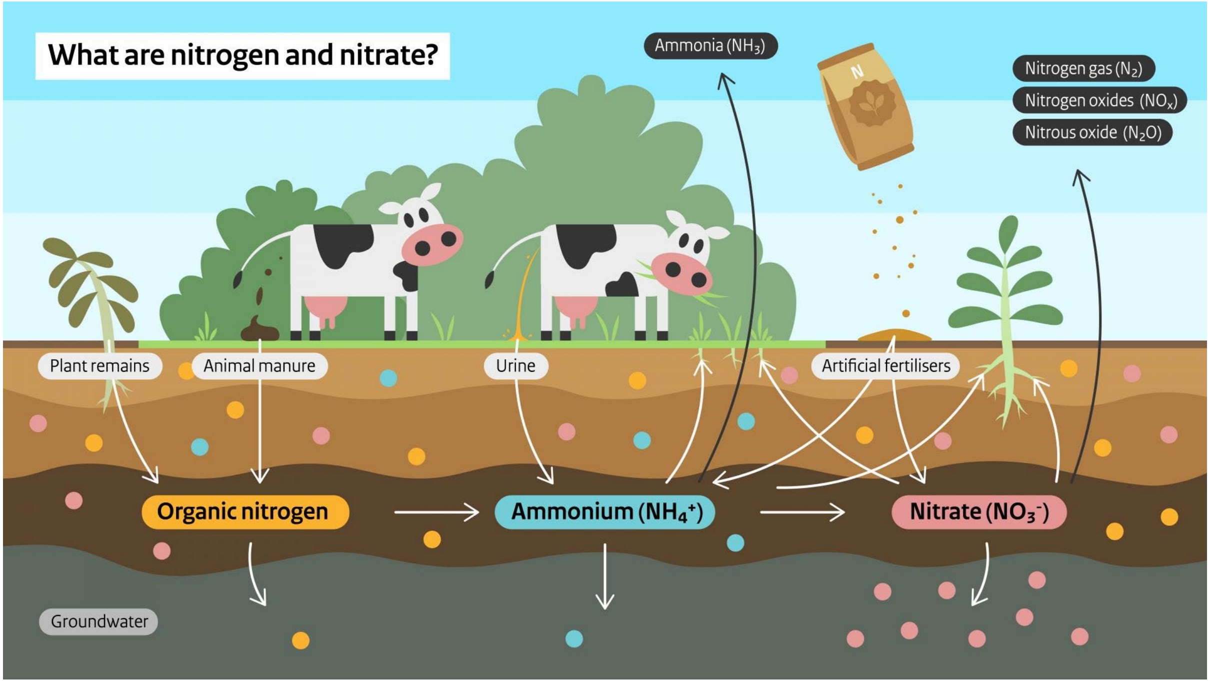
- Excess amounts of nitrogen compounds, such as nitrate and nitrite, in groundwater and surface waters can affect both human health and natural ecosystems.
- Human exposure to nitrate comes from both the air, food (vegetables, cured meat, and dairy products to a lesser extent) and drinking water consumption. Excess nitrate consumption can lead to cyanosis, a blueish skin hue due to the lack of oxygen, and consequent health effects. Infants (especially bottle-fed infants) and pregnant women are most at risk for these effects.
- Some studies report on possible adverse health effects of nitrate, related to colorectal cancer and reproductive outcomes, but the results of these studies, are mixed. Other health effects of nitrogen may come from bathing in eutrophic water.
- Eutrophic waters are susceptible to the formation of harmful algae blooms. Some blue algae produce toxins with adverse health effects for bathers.
- Eutrophication and enhanced production of (harmful) algal blooms in turn might indirectly affect physical-chemical quality elements (e.g. transparency, oxygenation conditions), with reduced biodiversity as a result.
- Standards for nitrogen in surface waters to prevent eutrophication are dependent on the characteristics of the water body and are much more stringent (4-5 times) than the standard set for drinking water.

Nitrogen is one of the most important nutrients necessary for crop production. The use of artificial nitrogen fertilisation in the 20th century led to an enormous increase in crop production, but also led to excess nitrogen application (both by manure and artificial fertiliser), resulting in emissions into the environment. Other sources of nitrogen in surface water and groundwater originate from (untreated) sewage water and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks (WHO, 2011). Excess amounts of nitrogen compounds, such as nitrate (NO_3), nitrite (NO_2) and ammonium (NH_4), in ground and surface waters may affect both human health as well as natural ecosystems.

When applied to the soil, manure containing organic nitrogen first decomposes to produce ammonium, which can then be oxidised to nitrite and nitrate (see Figure 3). Artificial fertilisers usually come in the form of inorganic nitrogen compounds, such as ammonium and nitrate. Inorganic nitrogen (ammonium and nitrate) is absorbed by plants during their growth and used in the synthesis of organic nitrogenous compounds. Surplus nitrate leaches to the groundwater and surface water but can also be lost to the air in the form of ammonia, nitrogen gas, nitrogen oxides or nitrous oxide.

Nitrate and nitrite can be a risk for the production and supply of healthy drinking water. The standard of 50 mg/l NO_3 in the Nitrates Directive is a derived value that protects the quality of drinking water. However, nitrogen occurs in the soil and water bodies in various other forms too, notably ammonium and organically bound nitrogen. For the ecological quality, it is the sum of all forms in which nutrients, such as nitrogen and phosphorus, are present that matters. Standards for nitrogen in water bodies are of the magnitude of 2.5 mg/l of nitrogen in order to prevent eutrophication of the water body. These values are dependent on the characteristics of the waterbody and are much lower than the standard set for drinking water. For comparison, 50 mg/l NO_3 (nitrate) is equivalent to 11.3 mg/l N (nitrogen). The value of 50 mg/l for nitrate is therefore not a yardstick of good ecological quality. That is why the eutrophication status of water bodies in Europe is based on the parameters total N, total P and chlorophyll-α (e.g. Fraters et al., 2020) and other parameters, depending on regional circumstances.

Figure 3: Infographic showing nitrogen input into the soil, various forms and transformations of nitrogen compounds, and losses to the groundwater and air



Source: Infographic by RIVM and published in Fraters et al. (2020)

3.1. Human health

3.1.1. Exposure routes

Nitrate exposure to humans comes from the air, food (vegetables, cured meat, and dairy products to a lesser extent) and drinking water consumption. In this list, air pollution is only a minor source of nitrate exposure. If nitrate levels in drinking water are low (below 10 mg NO_3/l), food will be the main source of nitrate intake (Van den Brand et al., 2020; EFSA, 2017).

When nitrate is consumed, it can be chemically reduced to nitrite in the gastrointestinal tract. In the blood stream, nitrite is involved in the oxidation of haemoglobin to methaemoglobin, which has no capacity to carry oxygen. This in turn can lead to cyanosis, a blueish skin hue due to the lack of oxygen, and consequent health effects. Infants (especially bottle-fed infants) and pregnant women are most at risk for these effects (WHO, 2011).

Other studies report on possible other adverse health effects of nitrate, related to colorectal cancer and reproductive outcomes (e.g. McElroy et al., 2008; Brender and Weyer, 2016; Espejo-Herrera et al., 2016; Schullehner et al., 2018). The results of these studies, however, are mixed. This means that some studies show a correlation between nitrate concentrations in drinking water and/or diet and health effects related to colorectal cancer (based on limited epidemiological studies) and reproductive outcomes (indicated by a single study or single research group), whereas others do not or only show a negligible link (e.g. De Roos et al., 2003; Manassaram et al., 2007; Houthuijs et al., 2022).

It is difficult to distinguish between the contribution of different exposure routes (water, diet, other risk factors) in epidemiological studies. Other (unknown) factors could be of influence on the possible correlation. As a result, the scientific debate on the risk of other possible adverse health effects is still ongoing.

3.1.2. Guideline value

When nitrate levels in drinking water exceed the level of 50 mg NO_3/l, drinking water will be the major source of total nitrate intake, especially for bottle-fed infants. The WHO has set guideline values for both nitrate and nitrite (WHO, 2011). The guideline value for nitrate of 50 mg NO_3/l is based on epidemiological evidence for methaemoglobinaemia in infants. This guideline value is based on the risks related to short-term exposure of humans to these levels. This value is protective for bottle-fed infants and, consequently, other, less vulnerable population groups. Microbial contamination of drinking water and possible gastrointestinal infections as a result could increase the health effects of nitrate exposure for bottle-fed children significantly (WHO, 2011).

In the European context, this guideline value of 50 mg NO_3/l has been incorporated as a water quality standard in the legal framework of the Drinking Water Directive, the Nitrates Directive, Urban Wastewater Directive, the Water Framework Directive and the Groundwater Directive (see Chapter 2). To date, MS report exceedances of this water quality standard in 18% of the ground water bodies within 24 MS (EEA, 2018) (also see Chapter 5).

3.1.3. Health risks related to eutrophication of bathing water

Nitrate emissions to surface water could lead to eutrophication. Eutrophic waters are susceptible to the formation of harmful algae blooms. Blue algae produce toxins with adverse health effects for bathers. For example, WHO (2018) and Camargo and Alonso (2006) describe health effects from these algal toxins, causing nausea, vomiting, diarrhoea, pneumonia, gastroenteritis, hepatoenteritis and muscular cramps, and several poisoning syndromes due to shellfish consumption (paralytic shellfish poisoning, neurotoxic shellfish poisoning, amnesic shellfish poisoning). Animals that drink eutrophic water may also show symptoms of toxicity (e.g. Trevino-Garrison, 2015).

3.2. Effects on natural ecosystems

The Urban Wastewater Directive (91/271/EEC amended by 98/15/EC) defines eutrophication as "the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned". Eutrophication and the enhanced production of (harmful) algal blooms in turn might cause indirect effects on physical-chemical quality elements (e.g. transparency, oxygenation conditions), and other biota (e.g. macro-invertebrates) (EC, 2009b), with reduced biodiversity as a result.

Eutrophication has been widely recognised as a problem in freshwater systems for many years. Concerns regarding the increase of eutrophication in transitional and coastal waters arose in the last decades. The contribution of nitrogen and phosphorous to eutrophication appears to be different for freshwater systems compared to transitional and coastal waters (EC, 2009b). Research shows that fresh waters and lake systems are the most susceptible to eutrophication due to an increase in phosphorus concentrations. However, nitrogen can also lead to eutrophication, especially in coastal and transitional waters (Howarth and Marino, 2006). Sometimes, these systems are susceptible to both an increase in nitrogen and phosphorus, as phosphorus limits primary production. Thus, although phosphorus is usually the limiting factor in fresh water systems, the transport of nitrogen compounds downstream to coastal systems can impact the eutrophication status of these waters (Conley et al., 2009).

4. MONITORING NETWORKS

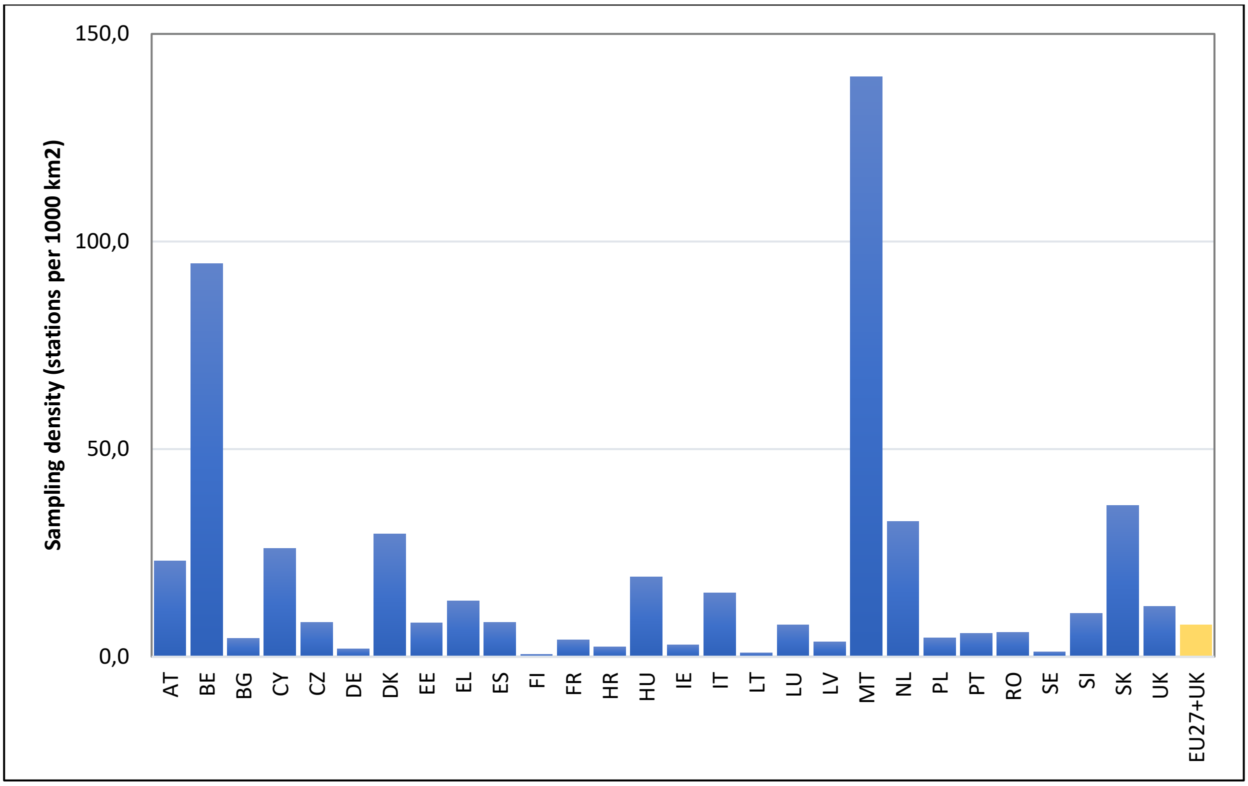
KEY FINDINGS

- The European Commission does not require MS to have the same measuring systems but aims to ensure full compliance with the Nitrates Directive by MS.
- There are significant differences between EU MS in the density of groundwater and surface water monitoring stations as well as the frequency by which these stations are sampled. These differences in measuring systems do not mean that the reliability of the information provided by the MS differs.
- Differences in current concentration levels, total agricultural area, variation in type of agriculture, and variation in natural soil, aquifer and surface water characteristics can be regarded as design criteria and as such contribute to differences in the setup of the monitoring networks between MS.
- Due to these differences, the current data set at the EU level is less suitable for the production of figures and maps on water quality status and trends at the EU level.
- Obtaining a data set that meets the requirements for such analyses at the EU level would require a coordinated formulation of the monitoring goals, using a selection of national monitoring stations with the help of national experts.

4.1. Monitoring networks in EU Member States

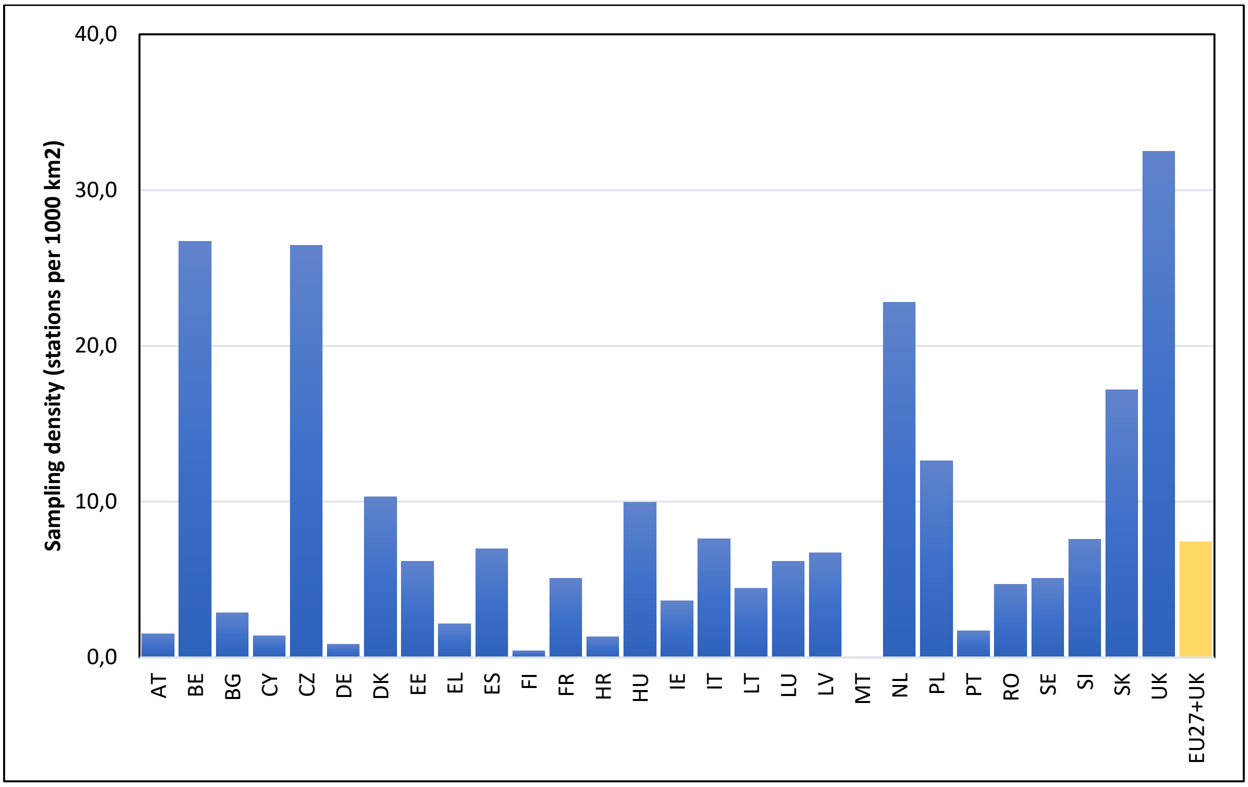
MS report a steady increase in the number of stations used for nutrient monitoring of ground and surface waters at the EU level in the 2008-2019 period (EC, 2021a; see Annex II, Table 2-4). During that period, the number of groundwater stations increased from 7.3 to 7.7 stations per 1,000 km^2, and the number of fresh surface water stations from 6.0 to 7.4 per 1,000 km^2. There is a large variation in station density between countries, varying from less than 1 up to almost 140 stations per 1,000 km^2 for groundwater (see Figure 4), and varying from less than 1 up to 32 stations per 1,000 km^2 for fresh surface waters (see Figure 5).

Figure 4: Groundwater station density (stations per 1,000 km2 of land) for the Nitrate Directive in reporting period 2016-2019. Stations with data of average annual nitrate measurements



Source: EC, 2021a

Figure 5: Fresh surface water station density (stations per 1,000 km2 of land) for the Nitrate Directive in reporting period 2016-2019. Stations with data of average annual nitrate measurements



Source: EC, 2021a

4.2. Criteria for monitoring design

The design of a monitoring network primarily depends on the objective of the network. If more than one objective must be met, it should be clear which is the main objective, as financial and capacity constraints often make it impossible to fully meet all objectives. The objectives should make clear at what spatial and temporal scale the network must provide relevant and reliable information on status and trends.

Even before the EU environmental directives came into force, MS had well-established monitoring networks, which were set up to provide data for the evaluation and improvement of national or regional policies. It is efficient to use the existing network infrastructure and data produced as much as possible to comply with new EU monitoring obligations.

The EU environmental directives require MS to monitor and report monitoring data to show compliance with the directives' goals and obligations. This, however, does not ensure that the reported data are suitable for comparison of status and trends between MS.

There are several natural factors that determine the nitrate concentration in groundwater and surface water as well as the eutrophication of surface water. There may be significant differences between nitrate concentrations even if agricultural practices are the same, due to differences in soil type, groundwater level, hydro-geological and climatic conditions, depth of surface water, and velocity of water flow.

The number of monitoring stations needed to assess status and trends (see also Section 4.3) depends on several factors. Key factors are the differences between the current concentration levels and the environmental quality standards, the acceptable level of uncertainty, the ability to identify changes in concentrations due to policy interventions, the size of the area under consideration, and the spatial variations in concentrations. Variations in concentrations are also determined by the extent of natural heterogeneity in soil and its hydro-geochemical characteristics. Differences in these factors between countries and differences in existing infrastructure have contributed to different station densities as shown in Figure 4 and 5, but also complicate comparisons of monitoring results between MS.

4.3. Tools and technologies used for monitoring

There are several types of monitoring. One way of distinguishing between types of monitoring is to differentiate between (a) status and trend monitoring, (b) quick response monitoring, (c) investigative monitoring and (d) compliance checking surveys (e.g. Fraters et al., 2011).

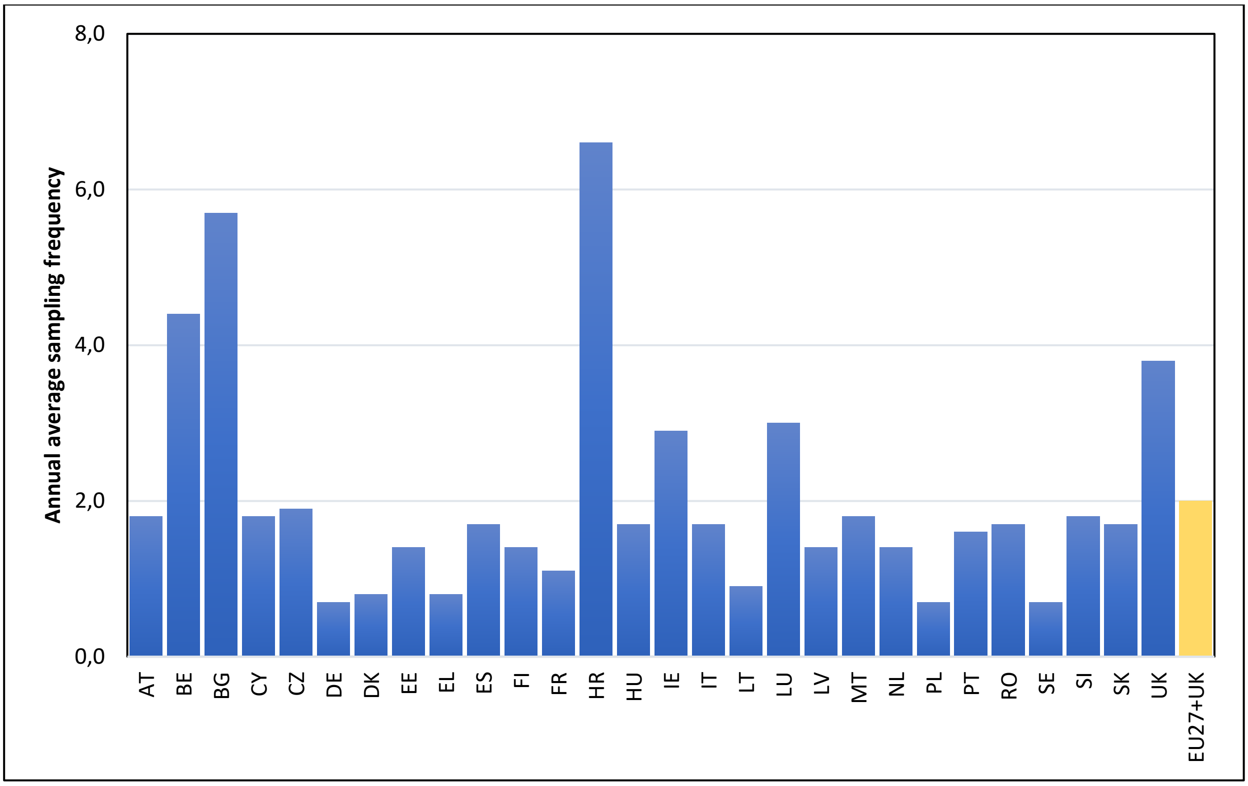
<u>Status and trend monitoring</u> of groundwater and surface water is carried out by all MS in order to provide a general overview of the water quality and its development. This is both an obligation of the ND and one of the obligations set by the Water Framework Directive (see also Chapter 2). There are differences in the procedures used for trend analysis for the ND and the WFD (EC, 2011).

For groundwater monitoring either dedicated monitoring wells are used or existing wells, for example drinking water production wells, and/or natural springs. Wells are sampled at various frequencies from every few years up to a few times per year, depending on, for instance, sampling depth (see Figure 6).

For surface waters, grab samples are often taken at fixed locations in streams, rivers, lakes, and coastal and marine waters. Surface water locations are often sampled once a month or every two months (see Figure 7) as water quality changes during the year with different concentrations between summer and winter. This is, among other reasons, due to a difference in biological activity in summer and in winter.

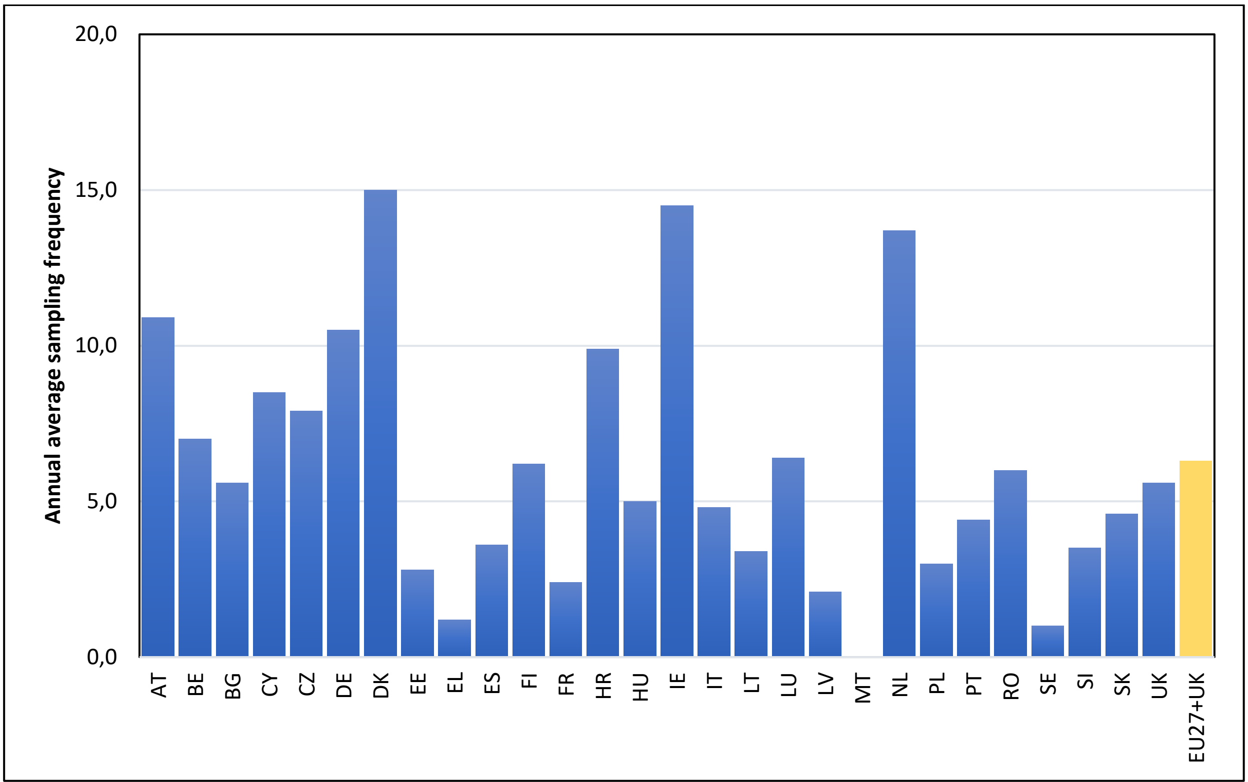
Improvements due to actions taken within the Nitrates Directive Action Programmes often take a long time (multiple years to decades) before they result in improvements in the water quality monitored in these networks (Kim et al., 2020). This is due to several factors, such as long travel times – the time it takes for precipitation to infiltrate soil and to flow with nitrate to the points of monitoring in groundwater or surface water, bio-geochemical processes – for example denitrification and mixing of water from other land use types – and, for example, whether it is a nature or urban area.

Figure 6: Average annual groundwater sampling frequency for the Nitrate Directive in reporting period 2016-2019. Stations with data of average annual nitrate measurements



Source: EC, 2021a

Figure 7: Annual average fresh surface water sampling frequency for the Nitrate Directive in reporting period 2016- 2019. Stations with data of average annual nitrate measurements



Source: EC, 2021a

Quick response monitoring aims to show the effect of the Nitrates Action Programmes on water quality within a relatively short time frame (four to six years), which is relevant for policymakers. For this quick response monitoring, some MS use selected monitoring stations of their status and trend monitoring networks, sometimes combined with investigative monitoring and/or compliance checking surveys. Other MS have dedicated and specially designed quick response monitoring networks, such as Denmark, Ireland, the Netherlands, and Sweden. Monitoring points are within agricultural fields to measure the concentrations in water leaching from the root zone or in ditches or head waters along these fields. Sampling of water is carried out in most cases in a few representative catchments, but at a higher density and more frequently compared with status and trend monitoring networks. Monitoring is combined with process modelling to address weather variability and to upscale monitoring results to the national level (e.g. Denmark). The Netherlands uses a different approach for quick response monitoring. Sampling is carried out at many locations, but at a lower density and frequency at each location. Statistical models are used to address weather variability and to interpolate results.

Investigative monitoring uses a similar approach as quick response monitoring but aims to investigate the effect of specific measures or agricultural practices on water quality. The results can be used to improve models that evaluated action programmes. In some countries these models are used in combination with data from agricultural surveys to assess the effect of the action programme on water quality.

Compliance checking surveys of farming practices are carried out in all MS. In some countries, measurements of soil mineral nitrogen in fields after harvest are part of the compliance checking, for example in Austria, Belgium, Czech Republic, and parts of Germany.

4.4. Comparability of monitoring networks between Member States

As described in the previous sections, monitoring networks differ between MS (Fraters et al., 2011, 2005). These networks were already operational before the Nitrates Directive came into force. They were set up to enable the answering of questions of national interest and they were adapted to the local conditions. Further developments occurred organically as new questions came up or new scientific developments or techniques were incorporated. The monitoring requirements set by the Nitrates Directive (EC, 1991) and later the Water Framework Directive (EC, 2000a) and (new) Groundwater Directive (EC, 2006) resulted in intensification of monitoring, and led to some adaptations to the networks to meet their objectives, i.e. to fulfil the obligations of the directives and/or to comply with the non-obligatory guidelines as developed within the Common Implementation Strategy of the Water Framework Directive (see, for example, EC, 2019).

The Nitrates Directive obliges Member States to (EC, 1991, Article 6):

- draw up and implement suitable monitoring programmes to assess the effectiveness of action programmes established;
- monitor the nitrate concentration in surface waters at least monthly and more frequently during flood periods;
- monitor the nitrate concentration in groundwater at regular intervals and consider the provisions of Directive 80/778/EE;
- repeat the monitoring programme at least every four years, except for those sampling stations where the nitrate concentration in all previous samples has been below 25 mg/L and no new factor likely to increase the nitrate content has appeared, in which case the monitoring programme only needs to be repeated every eight years;
- review the eutrophic state of their fresh surface waters, estuarial and coastal waters every four years.

The method for measuring the nitrate concentration is laid down in Annex IV of the Nitrates Directive. This annex refers to a Council decision from 1977 (EC, 1977) about monitoring fresh surface waters.

In 2002 (EC, 2002), the European Commission stated that synergy must be developed in the future work for common implementation of these water directives, on items such as: *"harmonisation of water sampling points, networks, parameters and frequencies for water quality monitoring in order to meet, with minimum work at field level, the needs linked with EU Directives, OECD-Eurostat Questionnaires, EEA 'Eurowaternet', Marine and River Conventions, and local/regional needs"*.

The European Commission published guidelines for monitoring required under the WFD (EC, 2003, 2004, 2007, 2009a) and under the Nitrates Directive (EC, 2004). These monitoring and reporting guidelines do not confer any statutory obligations on MS. They have been developed, among other reasons, to facilitate cross comparison among MS' monitoring procedures. The WFD guidelines explicitly urge for the selection of monitoring sites based on the potential for integrated multi-purpose monitoring, e.g. combining requirements for Nitrates Directive monitoring, monitoring of Drinking Water Protected Areas and monitoring of WFD and Groundwater Directive compliance where appropriate (EC, 2007). The EC also recommends using monitoring data that have to be reported according to other European directives and international river and sea conventions for the purpose of surveillance monitoring, e.g. the Nitrates Directive (EC, 2009a).

The ND monitoring guidelines (EC, 2004) identify several objectives of monitoring:

- the identification of waters affected by agricultural nitrate pollution,
- to review the trophic status of surface waters (eutrophication),
- for country-wide action programmes,
- to assess action programme effectiveness on receiving water,
- the effect of action programmes on nitrate sources.

In addition, the European Commission published reporting guidelines in 2000 (EC, 2000b), with updates in 2011 (EC, 2011) and 2020 (EC, 2020). The objective of these guidelines is "to receive data in a well-structured standardised way, which should allow assessing agricultural pressure on the quality of the waters, analysing trends, evaluating the impact of the Nitrate Action Programmes and estimating the future evolution of the water quality" (EC, 2020). Therefore, the reporting guidelines may contribute to the harmonisation of the monitoring systems in different MS. For example, the 2020 ND reporting guidelines recommended assessing eutrophication according to or in line with the WFD guidance document that was developed within the Common Implementation Strategy of the WFD (EC, 2009b). This document includes guidelines on the selection of monitoring sites, the selection of quality elements or parameters to be measured, and the frequency of monitoring.

The EC does not require MS to have the same monitoring systems but aims to ensure full compliance with the ND. The EC reported being in constant dialogue with MS for, among other things, reinforced water quality monitoring (EC, 2021b). During the reporting period (2016-2019), two infringement cases were ongoing against MS on water quality monitoring and the stability of the monitoring network (EC, 2021b).

4.5. Options for harmonisation of monitoring networks

The differences between monitoring networks among MS can be explained from both local characteristics and historical reasons. These differences are not a problem if MS comply with the monitoring and reporting requirements of the ND and other directives. A forced change of monitoring networks to harmonise may be expensive and counterproductive, as it might introduce a discontinuity in observed series (Fraters et al., 2011).

However, if the goal of the monitoring network is the production of figures and maps on water quality status and trends at the EU level, the current data set is sub-optimal. The current sets of data do not provide information on 'representativeness' and sampling (e.g. frequency, spatial distribution, sampling depth) and analytical methods differ between MS. For example, for national purposes, data of some regions or water types may be overrepresented in the database. It is well known that different laboratories that use the same analytical method may report different concentrations. To obtain a data set that meets the requirements for the analyses at the EU level, an EU-wide monitoring network must be set up.

Setting up an EU-wide monitoring network does not mean the installation of new monitoring stations for groundwater and surface waters all over the EU. What it does mean, is a coordinated formulation of the network goals. Based on these goals, EU expert groups should define frameworks for the monitoring of groundwater and surface waters. Together with national experts, a selection of monitoring stations can be made in each MS and interlaboratory comparisons and comparisons between the organisations that take the water samples have to be organised. Such a network has been developed in the USA for groundwater monitoring (USGS, 2013) and for surface waters monitoring

(USGS, 2021). There are also experiences with such an approach within MS to develop monitoring networks at a national level, e.g. in Germany for groundwater and surface waters (LAWA, 2022) and in the Netherlands for surface waters (Klein et al., 2012).

5. DEVELOPMENT OF NUTRIENT EMISSIONS

KEY FINDINGS

- Since the introduction of the Nitrates Directive, nutrient emissions from agriculture have been reduced substantially, although the emissions seem to have stabilised in the last decade.
- Groundwater quality has also improved, but seems to have stagnated since 2012.
- Trends in the development of eutrophication cannot be provided at the EU level, as not all MS provided this information in their last progress reports. Moreover, MS use a wide variety of parameters in the assessment of eutrophication of surface waters, which complicates comparison.
- The Biodiversity and the Farm to Fork Strategies within the European Green Deal aim to reduce nutrient losses to the environment by at least 50% by 2030. Recent European studies show that, on average, this level of ambition is also necessary to comply with the objectives of the Nitrates Directive. To achieve such a reduction requires more structural policy choices.
- Economic pressure in agricultural practice severely limits local room to manoeuvre to further improve water quality. Improved nutrient management and other innovative solutions could limit production losses.
- EU support for both research and innovation and sustainable practices are indispensable. This support is foreseen in the Farm to Fork Strategy, but a further revision of the CAP would also be required.

The Biodiversity and the Farm to Fork Strategies within the European Green Deal, set a common objective of reducing nutrient losses to the environment by at least 50% by 2030. Both Strategies were issued in 2020, after the last reporting period of the ND (2016-2019) (EC, 2021b). One of the questions raised by the PETI Committee was to reflect on the development of nutrient emissions in light of the Green Deal. To this end, we reflect on what has been achieved so far in terms of reduction of nitrogen and phosphorous surplus and the development of water quality since the introduction of the Nitrates Directive. This information is used to reflect on possible implications of the objectives set by the Biodiversity and the Farm to Fork Strategies for nutrient emissions and their impact on water quality.

It should be noted that the ambitions formulated in both Strategies for nutrients seem to lack a comparison to a base-line year or reporting period in contrast to the pesticide targets that have been set. The Farm to Fork pesticide targets are evaluated by comparing reported data with the average of the years 2015 to 2017 (Farm to Fork targets - Progress (europa.eu), last accessed 7 April 2022). In this Chapter, we will use the results from the reporting period 2016-2019 as the baseline for our observations.

In its progress report, the EC regards compliance towards the objectives set in the ND as the first step towards achieving the ambitions set in the Biodiversity and Farm to Fork Strategies (EC, 2021b). This argument, however, could also be turned around: achieving the ambitions set in these Strategies would initiate a major step towards the objectives set in the ND.

An important provision of the ND is that in areas in which action programmes apply (the Nitrate Vulnerable Zones), farmers may not spread more than 170 kg nitrogen per hectare per year derived from manure on their fields (EC, 2021b). This limit applies all over the EU, irrespective of the climatic and soil conditions and the crops grown. In addition, MS must set a limit for the application of fertilisers on land, consistent with good agricultural practice and taking into account the characteristics of the vulnerable zone concerned (Annex III of ND, EC, 1991)

However, as growing conditions may be different across climate zones, the ND also provides for the possibility to apply a higher amount of manure nitrogen per hectare per year. Such a derogation can only be given if these amounts do not interfere with the water quality objectives of the ND. A derogation request should be supported by scientific evidence and is granted under strict conditions. During the reporting period 2016-2019, derogations were granted to Belgium (Flanders), Denmark, Ireland, Italy (Lombardia and Piemonte (expired in December 2019 and not renewed)), the Netherlands and the UK (derogation for England, Scotland and Wales expired in 2016, only Northern Ireland was granted a new derogation) (EC, 2021b).

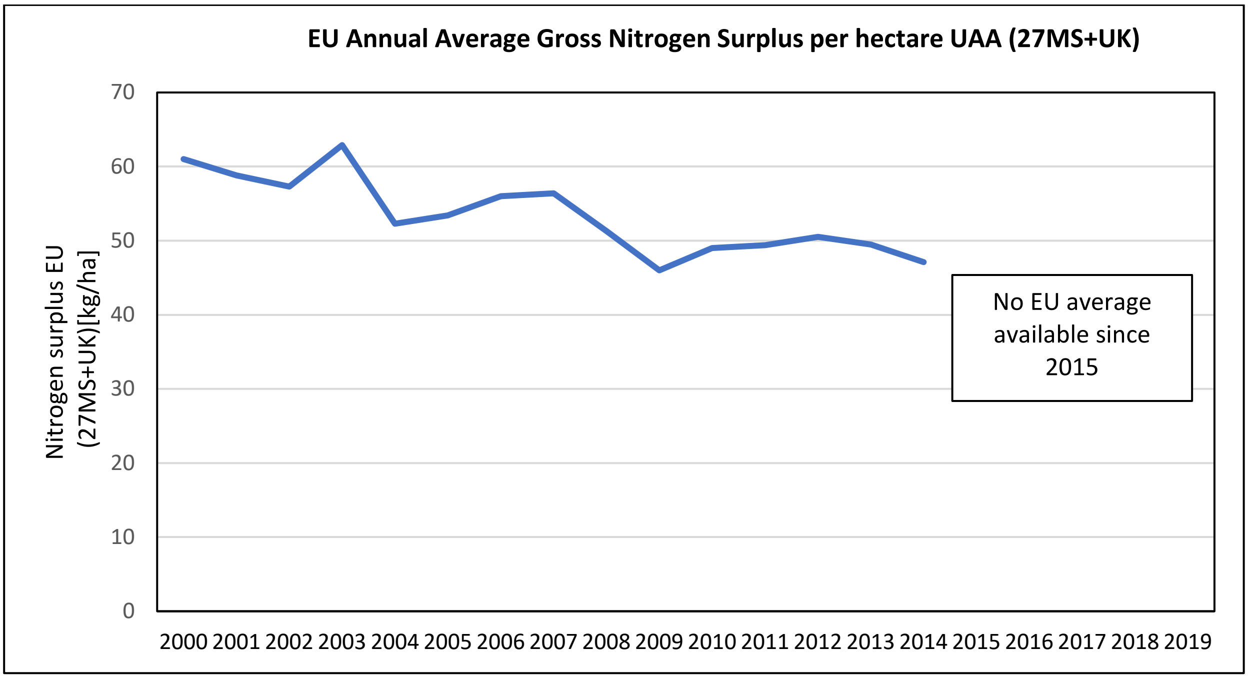
What has been achieved so far?

Since 1991, a substantial reduction of nitrogen and phosphorus discharge to the environment (expressed as gross surplus) for Europe as a whole has been achieved (see Figures 8 and 9). The Nitrate reports delivered by MS show that there is a wide variety in the development of gross nitrogen surplus reported since 2000 (Country Fiches (EC, 2021a)). Some MS report a decrease of the nitrogen surplus since 2000, whereas others report a stable situation or an increase. In absolute numbers, the highest decrease of nitrogen surplus can be identified among the MS with the highest agricultural pressures[1]. During the last reporting periods the reduction, however, seems to have stagnated. In its summarising report, the EC identified that for MS and the UK (EU27+UK) in total, between the reporting periods 2008-2011 and 2012-2015, both net nitrogen and phosphorus surplus slightly increased at the EU level from 31.8 to 32.5 kg N/ha UAA (Utilised Agricultural Area) and from 1.8 to 2.0 kg P/ha UAA respectively (EC, 2021b). For the last reporting period (2016-2019), nitrogen and phosphorous discharge in the environment from agriculture was reported by 14 MS. The reports show mixed results, with both increases (8 MS) and decreases (6 MS) of the nitrogen and phosphorous surplus (EC, 2021b).

[1] Nitrogen and phosphorous surplus or deficit in agricultural soils are being reported by Eurostat since 1990 (https://ec.europa.eu/eurostat/databrowser/view/t2020_rn310/default/table?lang=en).

Figure 8: Gross nitrogen surplus EU annual average (27 MS+UK) [kg/ha]

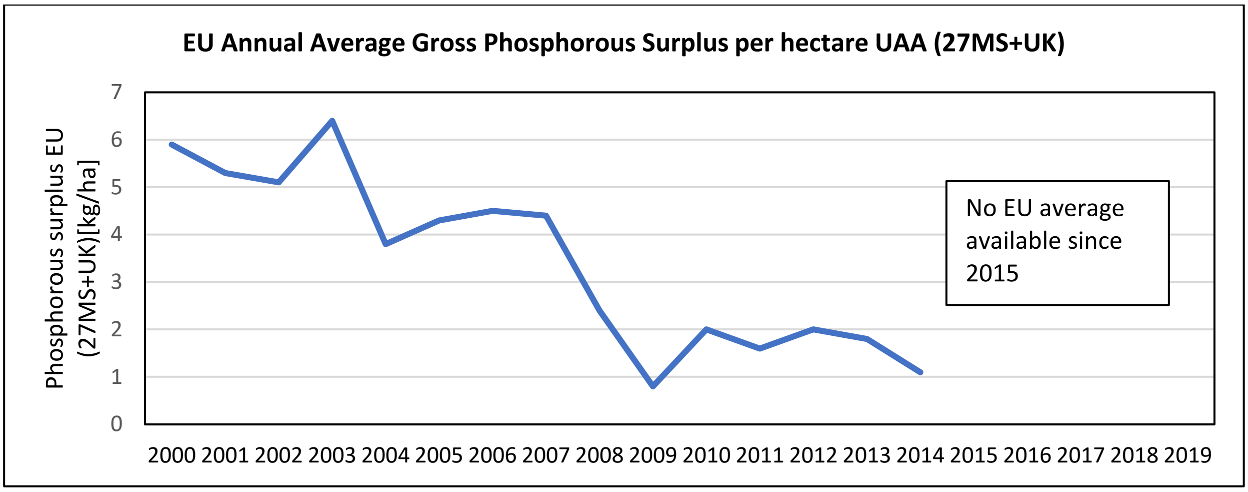
Since 2015, no EU average could be reported due to missing MS reports.



Source: Data retrieved from Eurostat, 13 April, 2022, https://ec.europa.eu/eurostat/databrowser/view/t2020_r310/default/table?lang=en

Figure 9: Gross phosphorous surplus EU annual average (27 MS+UK) [kg/ha]

Since 2015, no EU average could be reported due to missing MS reports.



Source: Data retrieved from Eurostat, 13 April, 2022, https://ec.europa.eu/eurostat/databrowser/view/t2020_rn310/default/table?lang=en

Impacts on water quality

As described in Chapter 4 (Section 4.5), design criteria for monitoring networks may differ between MS. This means that conclusions at a European level based on these data should be used with caution. When observing the developments in the quality of groundwater and surface water, the results from the last reporting period (2016-2019) show that, although groundwater quality has improved since its introduction, it seems to have stabilised since 2012. In 2016–2019, 14% of the groundwater monitoring stations exceeded the limit value of 50 mg nitrates per litre in the annual average. This result is comparable to the previous reporting period (2012-2015), when 13% of the groundwater monitoring stations exceeded this limit value.

The objectives set by the ND for surface water are expressed as the level of eutrophication. This is a combination of both nutrient levels and biological parameters. At the EU level, 36% of rivers and 32% of lakes, 31% of coastal, 32% of transitional water, and 81% of marine waters were reported as eutrophic (EC, 2021b). Although most MS have used the Guidance document on eutrophication (Guidance no. 23)[2], the parameters used for the classification varied widely among MS. This makes it difficult to compare MS. What is more, no trends are available at the EU level for the trophic status either, although country fiches seem to point out that eutrophication manifests itself as a persistent widespread issue (EC, 2021a)[3].

It can be concluded that for both groundwater and surface waters, a considerable part of the MS still faces significant challenges in achieving the objectives of the ND regarding nitrate in groundwater and eutrophication of surface waters. In its report, the EC suggests that the 'low hanging fruit' has already been collected and farther-reaching measures are needed to improve progress towards the objectives of the ND (EC, 2021b).

Challenges of cross-sectoral implementation

Besides the implementation of the obligations set by EU directives like the ND and the WFD, multiple other initiatives have been developed by MS to reduce agricultural pressures and improve water quality (for some examples, see for instance the cases studied in the H2020 projects Fairway (Home (https://www.fairway-is.eu/), last accessed 5 April 2022) and Waterprotect (Home | Water Protect (water-protect.eu), last accessed 5 April 2022)). The reasoning for these initiatives often came from the increased awareness that the existing national legal frameworks were insufficient to adequately protect drinking water resources from agricultural pollution (Keessen et al., 2011, Doody et al., 2012, Jacobsen et al., 2017).

These initiatives resulted in varying degrees of success in water quality improvement. The explanation for these variations in success might be related to obstacles or conflicting interests on a national and European scale, for instance with economic pressure resulting in high fertilisation intensity and intensive animal breeding. A case study analysis in 11 European countries showed that EU legislation on agriculture and water quality is often implemented in separate (policy) silos in existing legislation (Wuijts et al., 2021). Consequently, policy plans and programmes of measures on agriculture and water quality are developed along parallel tracks. To achieve water quality improvement would require a more cross-sectoral implementation. At this moment, cross-sectoral integration takes place at the local-regional level, and is not self-evidently covered in existing workflow arrangements,

2 Guidance document on eutrophication assessment in the context of European water policies. Guidance document No 23 - Publications Office of the EU (europa.eu)

3 More detailed information can be found on: Workbook: WISE_SOW_gwPollutant (europa.eu), last accessed 13 April 2022.

responsibilities, and instruments. For this reason, implementation would benefit from more advanced cross-referencing at the EU level.

Future development of nutrient emissions

The objectives of the Biodiversity and the Farm to Fork Strategies are evidently linked to the objectives of the Nitrates Directive.

On the scale of Europe, De Vries et al. (2021) calculated the nitrogen emission reductions that would be necessary to achieve environmental objectives set for water quality and air quality. The authors conclude that the impacts of runoff are the most critical for water quality and require the highest reductions in nitrogen inputs[4] (–43%). Also, the authors concluded that the strongest reductions are needed in hotspot regions with intensive livestock farming. This suggests that achieving the objectives set by the Biodiversity and the Farm to Fork Strategies (a reduction of nutrient emissions by 50%) would also lead to compliance with the objectives of the ND. As this study was carried out on a European scale, more detailed information on regional characteristics could lead to a more differentiated result.

By reducing emissions, the nutrient load leaching to surface water and groundwater will be reduced, which will affect water quality positively. As described in Chapters 3 and 4, this relationship between emissions and water quality is complex and depends on multiple variables, such as the characteristics of the soil, hydrogeology and hydrochemistry, climate conditions, type of crops grown, and the ecology of the surface water the nutrients are leaching into (effects on eutrophication).

Changes in groundwater quality due to changes in agricultural practices will manifest themselves after years or multiple decades, depending on the regional hydrogeological characteristics. The response of the water system to agricultural practices also strongly depends on regional characteristics. Effects on surface water quality manifest themselves more rapidly. The impacts on groundwater quality and surface water quality are also influenced by the effects of climatological circumstances and climate change, e.g. by periods of droughts and excessive rainfall (Klages et al., 2020).

The time lag between interventions and effects also means that the most recent reports (2016-2019) provide information on the first effects of agricultural interventions from the national action programmes made in the period 2012-2015, which can be identified in the first metres of the soil, drains and soil moist. This implies that actions taken in the context of the Biodiversity and the Farm to Fork Strategies will manifest themselves in the reporting periods beyond 2030 (the time horizon of the nutrient objectives).

In the Biodiversity and the Farm to Fork Strategies, no distinction has been made in the objectives for the different environmental compartments, air, soil, and water. Strategies for the reduction of environmental losses may be more beneficial to one compartment than to the other. Taking in mind the achievements so far, it is beyond doubt that the nutrient objectives set by these Strategies require major actions by the agricultural sector, and this cannot be achieved without implications for the livelihoods of farmers. Furthermore, such major actions may introduce the risk of pollution swapping: interventions to reduce emissions of one pollutant may aggravate other emissions (e.g. manure injection) (Velthof et al., 2020).

Economic pressure in agricultural practice severely limits local room to manoeuvre to further improve water quality. Although measures like catch crops and buffer zones will contribute to water quality improvement, what can be achieved in the local optimisation process is only a fraction of what can be achieved with more structural policy choices that reduce inputs and pressures at their source. Creating

4 N-inputs include fertiliser, fixation, deposition (De Vries et al., 2021).

a sustainable balance requires understanding the impacts of complex political choices and the capacity and willpower of actors to follow up on these impacts.

In the Farm to Fork Strategy, the EC stipulates that a sustainable food system is essential to achieving the climate and environmental objectives of the European Green Deal (and upcoming Climate Directive). The initiative also highlights this as an opportunity to improve the incomes of primary producers and reinforce the EU's competitiveness. Schulte and De Vries (2021) calculated that with current nutrient use efficiency crop production would be reduced by 50% when respecting the environmental threshold values for air and water quality. With improved nutrient management, 80% of overall current crop production can be obtained within thresholds. This underlines the importance of innovation and capacity building in light of the Green Deal. In hotspot regions however, even more nutrient efficiency would be required to maintain crop production (more than 90%). This is technically not feasible in practice. For this reason, extensification – by decreasing livestock density or by increasing the proportion of crops in the rotation that are less susceptible to nitrate loss via leaching – is required in these regions to meet environmental targets.

Other studies on local practices also highlight that continuous research and innovation is key to developing the necessary solutions for sustainable practices both at the EU and local level. Investment in the development of innovative technologies to improve the technological basis for precision farming will provide long term benefits when they are upgraded from pilot scale to full scale and widely applied sustainable resource management concepts (Home | Water Protect (water-protect.eu), last accessed 5 April 2022).

6. POLICY RECOMMENDATIONS

Citizens are concerned about monitoring related to the objectives and requirements of the Nitrates Directive (both health-based and ecologically based objectives). In their request for this study, the PETI Committee has set these questions in the wider context of legislation and policy development regarding agriculture and water quality management (see Chapter 1).

EU level analyses versus national reports

There are significant differences between EU Member States in the density of groundwater and surface water monitoring stations as well as in the frequency by which these stations are sampled. Differences between MS in current concentration levels, total agricultural area, variation in type of agriculture, and variation in natural soil, aquifer and surface water characteristics can be regarded as design criteria and as such will create differences in the setup of the monitoring networks between MS. These differences make the current data set less suitable to produce figures and maps on water quality status and trends at the EU level.

Policy recommendation:

> Assessment of agricultural impact on the quality of surface water and groundwater at EU level requires a coordinated formulation of the monitoring goals, using a selection of national monitoring stations with the help of national experts.

Development of nutrient emissions

Since 1991, nutrient emissions from agriculture have been reduced substantially, although this descending trend seems to consolidate during the last decade. Groundwater quality has improved as well but seems to have stagnated since 2012. Trends in the development of eutrophication cannot be provided at EU level as this information was not provided by all MS in the last progress reports. Moreover, there is a wide variety in the parameters used by MS in the assessment of eutrophication of surface waters which complicates comparison.

The Biodiversity and the Farm to Fork Strategies within the European Green Deal aim to reduce nutrient losses to the environment by at least 50% by 2030. Recent European studies show that, on average, this level of ambition is also necessary to comply with the objectives of the Nitrates Directive. To achieve such a reduction requires more structural policy choices. Economic pressure in agricultural practice severely limits local room to manoeuvre to further improve water quality. Improved nutrient management and other innovative solutions could limit production losses. Creating a sustainable balance requires understanding of the impacts of complex political choices and the capacity and will-power of actors to follow up on these impacts.

The Farm to Fork Strategy highlights the transition to a sustainable food system as an opportunity to improve the incomes of primary producers and reinforce the EU’s competitiveness.

Policy recommendation:

> In view of current policy initiatives such as the European Green Deal and From Farm to Fork, the EU, its Member States, and partnering states should incorporate the impact on water quality in assessments and policy choices at all levels. The ambitions also require the willingness of the EU and MS to make explicit choices on how to balance environmental protection, food supply and economic welfare. EU support for both research and innovation and sustainable practices is indispensable for this. Further revision of the CAP is necessary to support the objectives set by these initiatives.

Implementation of EU policy

The legislative EU framework related to nitrate in the environment is extensive and complex, see Chapter 2. Based on information from various EU projects and international expert exchanges (H2020 WaterProtect, H2020 Fairway, EIP Water, EIP Agri, joint DWD and WFD expert meeting), several recommendations have been derived that are of relevance to monitoring of nutrients.

<u>Coherence and consistency: Improve (policy) effectiveness through increased cross-referencing</u>

The European Innovation Partnership on Water (EIP Water) identified the 'inconsistency and fragmentation of policies, regulations and governance structures' as 'low hanging fruit' whose improvement would enhance the development of the sector (EC 2014). This also extends to monitoring requirements. Coherence and consistency are key factors for a successful EU regulatory and policy regime that aims to prevent and manage the diffuse pollution of drinking water resources caused by agriculture. Policy effectiveness and cost-effectiveness will improve through increased cross-referencing across different directives and policies, as well as further harmonisation of monitoring and reporting requirements.

A focus on the interdependence between the WFD, DWD, GWD, the ND and the CAP will contribute to a more effective nutrient policy. At present, their connectedness is not formalised. Requirements from the DWD and GWD that relate to institutional frameworks could be included in the WFD as an additional component to consider (Boekhold et al., 2021). As such, the programmes of measures developed and implemented under the WFD would be better harmonised with the thresholds and relevant requirements in the DWD and GWD, including time frames and monitoring.

Policy recommendation:

> Improved correlations and cross-referencing between directives will strengthen the overall framework of nutrient policies and directives, making them more effective.

Coherence and consistency: cross-sectoral approach

Complexities and inconsistencies of European legislation become most explicit at the local level where different sectoral policy objectives must be implemented simultaneously, integrated measures must be taken, and their effects monitored. The cascading of all relevant governance arrangements down from the EU level to farm scale often results in a plethora of policy and legal instruments to control nutrient emissions from agriculture in order to protect water quality (see Chapter 2). The perception of stakeholders in actual local governance has often diverged from the intention of the original directives. At local level, a lack of knowledge of the overall legislative framework, the complexity of water systems' responses and the role of different often competing interests, may obstruct cross-sectoral approaches. Well-designed feedback mechanisms could support connections between local/regional challenges.

The complexity of nutrient policy asks for sufficient capacity (knowledge and means) to support a transdisciplinary and cross-sectoral approach, also across scales. A combination of top-down and bottom-up approaches will give extra impetus and improvement. The EU could support local capacity building by facilitating international and intersectoral learning.

Policy recommendation:

> Adoption of a better facilitated cross-sectoral approach and provisioning of guidance to policy application at the local level will improve stakeholder networks. Higher effectiveness can be achieved when these networks operate across institutional levels and hydrological scales. This requires sufficient capacity at the local level.

Trade-offs funding mechanism under the Common Agricultural Policy

Potential unintended negative consequences of the CAP's funding mechanism have been identified (see Chapter 2). Existing funding incentives may lead to competition between initiatives aimed at stimulating farming communities to become more economically sustainable and sacrificing sustainable practices to engage competitively in markets. Issues of cross-compliance such as increasing pollutants to remain eligible for funding suggest a need for cross-referencing between the requirements of the CAP and other directives, such as the ND, the DWD and the WFD.

Policy recommendation:

> Introducing guidelines or additional peripheral requirements for the CAP and RDR to uphold the underlying principles of other Directives, including the ND, such as Article 4.1 related to a code of conduct, is necessary to improve the effectiveness of the overall framework.

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ANNEX I - PETITIONS AND RESPONSES BY THE EC ON THE DIFFERENT KINDS OF EUROPEAN NITRATE MEASURING SYSTEMS

NOTICE TO MEMBERS

Subject:

Petition No 0482/2020 by M.B. (Austrian) on the different kinds of European nitrate measuring systems

Petition No 0490/2020 by E.W. (Austrian) on the different kinds of European nitrate measuring systems

Petition No 0491/2020 by C.R. (German), signed by 17 others, on the different kinds of European nitrate measuring systems

Petition No 0499/2020 by Christof Christensen (German) on the different kinds of European nitrate measuring systems

Petition No 0535/2020 by K.E. (German) on the different kinds of European nitrate measuring systems

1. Summary of petitions 0482/2020, 0490/2020, 0491/2020, 0499/2020 and 0535/2020

The petitioners claim that, as a result of the review of the Fertilisers Regulation, the transposition of the Nitrates Directive has been delayed by several years. In their opinion, however, there are problems with the measurement systems across the EU, as the measuring stations in the Member States do not use the same standards and thus results cannot easily be compared. This also causes competition problems in European agriculture. The petitioners ask how the EU will guarantee the comparability of measurement results across the Member States, whether there is an awareness of the differences among the measuring systems, and whether an EU regulation on measuring systems might lead to comparable results.

2. Admissibility

Petitions No 0482/2020, 0490/2020, 0491/2020, 0499/2020
Declared admissible on 27 July 2020. Information requested from Commission under Rule 227 (6).

Petition 0535/2020
Declared admissible on 30 July 2020. Information requested from Commission under Rule 227 (6).

3. Commission reply, received on 12 October 2020

Petitions 0490/2020, 0491/2020, 0499/2020 and 0535/2020

Following the revision of the German Fertiliser Regulation adopted in April 2020, the petitioners are concerned about the equal implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates (Nitrates Directive)[5].

The petitioners question how the EU guarantees the comparability of the monitoring in the different Member States and whether the Commission has information on the different designs of the

[5] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, *OJ L 375, 31.12.1991, p. 1–8.*

monitoring station systems within the EU. They ask if the Commission considers that the implementation of a uniform European-wide monitoring regulation would lead to comparable results in the different Member States.

The petitioners also feel that there are very different requirements for farmers in the Member States

The Commission's observations

The Nitrates Directive requires Member States to identify ground- and surface waters that are polluted or that are at risk of becoming polluted by nitrates. Areas of land, which drain into these polluted waters, shall be designated as nitrate vulnerable zones or NVZ. The NVZ shall be reviewed at least every four years. Member States are exempt from the obligation to identify specific vulnerable zones, if they apply action programmes throughout their national territory

In order to reduce and prevent further pollution, Member States must establish action programmes that shall take into account the local situation, such as agricultural pressure, the level of pollution, the properties of the soils and the climatological conditions.

Member States shall draw up and implement suitable monitoring programmes to assess the effectiveness of the action programmes. In case they apply the action programme throughout their national territory they shall monitor the nitrate content of waters (surface waters and groundwater) at selected measuring points which make it possible to establish the extent of nitrate pollution.

The Commission made monitoring guidelines available to Member States that contain advice as regards sampling frequency, selection of the sampling site, timing and monitoring of trends of ground- and surface waters, including coastal and marine waters. It is however up to the national authorities to set up the most appropriate and effective monitoring network.

In accordance with the Nitrates Directive, Member States report on the implementation of the Directive every four years with information on codes of good agricultural practice, nitrate vulnerable zones, water monitoring results and relevant aspects of the action programmes.

Based on these national reports, the Commission transmits a summary report on the implementation of the Nitrates Directive to the Council and the European Parliament[6]. The report includes information on the agricultural pressure, the water quality and trends, designation of NVZ and the action programmes. More details about each Member State are made available in the Staff Working Document that accompanies the report.

Conclusion

It is up to the national authorities to set up an appropriate and efficient monitoring network and effective action programmes, taking into account the local situation, such as agricultural pressure, the level of pollution and the pedoclimatic conditions.

The reports submitted every four years by Member States allows the Commission to verify the correct implementation of the Nitrates Directive in each Member State.

The Commission is not required by law to establish a uniform European-wide monitoring system to compare results in the different Member States.

[6] https://ec.europa.eu/environment/water/water-nitrates/reports.html

4. **Commission reply (REV I),** received on 8 March 2021

Petitions 0490/2020, 0491/2020, 0499/2020 and 0535/2020

Following the revision the German Fertiliser Regulation adopted in April 2020, the petitioners are concerned about the equal implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates (Nitrates Directive)[7].

The petitioners question how the EU guarantees the comparability of the monitoring in the different Member States and whether the Commission has information on the different designs of the monitoring station systems within the EU. They ask if the Commission considers that the implementation of a uniform European-wide monitoring regulation would lead to comparable results in the different Member States.

They also feel that there are very different requirements for farmers in the Member States.

Petition 0482/2020, which is linked to the above petitions, was discussed at the Committee on Petitions meeting of 10 November 2020. The Committee suggested to establish harmonised rules for monitoring and to organise a study on how the monitoring systems are implemented in the EU. The request for a study will be brought at the Committee on Agriculture and Rural Development and the Committee on the Environment, Public Health and Food Safety.

The Commission's observations

The Nitrates Directive requires Member States to identify ground- and surface waters that are polluted or that are at risk of becoming polluted by nitrates. Areas of land, which drain into these polluted waters, shall be designated as nitrate vulnerable zones or NVZ. The NVZ shall be reviewed at least every four years. Member States are exempt from the obligation to identify specific vulnerable zones, if they apply action programmes throughout their national territory

In order to reduce and prevent further pollution, Member States must establish action programmes that shall take into account the local situation, such as agricultural pressure, the level of pollution, the properties of the soils and the climatological conditions.

Member States shall draw up and implement suitable monitoring programmes to assess the effectiveness of the action programmes. In case they apply the action programme throughout their national territory they shall monitor the nitrate content of waters (surface waters and groundwater) at selected measuring points which make it possible to establish the extent of nitrate pollution.

The purpose of the monitoring is to determine the extent of the nitrate pollution and the actions needed to prevent or reduce that pollution and is not to compare the extent of the pollution between the Member States.

The Commission made monitoring guidelines available to the Member States that contain advices as regards sampling frequency, selection of the sampling site, timing and monitoring of trends of ground and surface waters, including coastal and marine waters. It is however up to the national authorities to set up the most appropriate and effective monitoring network.

[7] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, *OJ L 375, 31.12.1991, p. 1–8.*

In accordance with the Nitrates Directive, the Member States report on the implementation of the Directive every four years with information on codes of good agricultural practice, nitrate vulnerable zones, water monitoring results and relevant aspects of the action programmes.

Based on these national reports, the Commission transmits a summary report on the implementation of the Nitrates Directive to the Council and the European Parliament[8]. The report includes information on the agricultural pressure, the water quality and trends, designation of NVZ and the action programmes. More details about each Member State are made available in the Staff Working Document that accompanies the report.

Conclusion

It is up to the national authorities to set up an appropriate and efficient monitoring network and effective action programmes, taking into account the local situation, such as agricultural pressure, the level of pollution and the pedoclimatic conditions.

The reports submitted every four years by the Member States allows the Commission to verify the correct implementation of the Nitrates Directive in each Member State.

The Commission does not consider it appropriate to implement a uniform European-wide monitoring system to compare results in the different Member States.

The Commission could, however, consider a study on how the monitoring systems are implemented by Member States.

8 https://ec.europa.eu/environment/water/water-nitrates/reports.html

ANNEX II - NUMBER OF MONITORING STATIONS PER MEMBER STATE

Table 2: Number of stations and station density (stations per 1,000 km2 of land) of reported groundwater monitoring of annual average nitrate measurements in reporting periods 2008-2011, 2012-2015 and 2016-2019, the change (%) between the last two periods, and the annual average sampling frequency in 2016-2019

		Number of stations			Stations per 1000 km²			Change	Sampling per year
MS	**Area km²**	**2008-2011**	**2012-2015**	**2016-2019**	**2008-2011**	**2012-2015**	**2016-2019**	**(%)**	**2016-2019**
AT	83944	1965	1965	1933	23,4	23,4	23,0	-1,6	1,8
BE	30667	2974	2937	2905	97,0	95,8	94,7	-1,1	4,4
BG	110995	426	406	488	3,8	3,7	4,4	20,2	5,7
CY	9249	244	230	241	26,4	24,9	26,1	4,8	1,8
CZ	78874	611	621	657	7,7	7,9	8,3	5,8	1,9
DE	357746	162	697	692	0,5	1,9	1,9	-0,7	0,7
DK	43162	595	1201	1275	13,8	27,8	29,5	6,2	0,8
EE	45347	297	385	369	6,5	8,5	8,1	-4,2	1,4
EL	131692	370	1078	1764	2,8	8,2	13,4	63,6	0,8
ES	505983	4778	4132	4157	9,4	8,2	8,2	0,6	1,7
FI	337547	79	187	193	0,2	0,6	0,6	3,2	1,4
FR	638474	2509	2598	2582	3,9	4,1	4,0	-0,6	1,1
HR	56539	NA	126	132	NA	2,2	2,3	4,8	6,6
HU	93013	1763	1756	1788	19,0	18,9	19,2	1,8	1,7
IE	69946	211	205	200	3,0	2,9	2,9	-2,4	2,9
IT	300578	5070	5035	4618	16,9	16,8	15,4	-8,3	1,7
LT	64899	62	65	60	1,0	1,0	0,9	-7,7	0,9
LU	2595	20	20	20	7,7	7,7	7,7	0,0	3,0
LV	64586	173	199	232	2,7	3,1	3,6	16,6	1,4
MT	315	41	41	44	130,2	130,2	139,7	7,3	1,8
NL	37368	1297	1318	1217	34,7	35,3	32,6	-7,7	1,4
PL	311928	1258	1563	1421	4,0	5,0	4,6	-9,1	0,7
PT	91971	657	580	520	7,1	6,3	5,7	-10,3	1,6
RO	238368	1809	1256	1384	7,6	5,3	5,8	10,2	1,7
SE	449718	326	436	533	0,7	1,0	1,2	22,2	0,7
SI	20277	104	198	211	5,1	9,8	10,4	6,6	1,8
SK	49026	1717	1717	1788	35,0	35,0	36,5	4,1	1,7
UK	244574	3088	3139	2955	12,6	12,8	12,1	-5,9	3,8
EU27+UK	**4469381**	**32606**	**34091**	**34379**	**7,3**	**7,6**	**7,7**	**0,8**	**2,0**

Source: EC, 2021a

NA = not available

Table 3: Number of stations and station density (stations per 1 000 km2 of land) of reported fresh surface water monitoring of annual average nitrate measurements in reporting periods 2008-2011, 2012-2015 and 2016-2019, the change (%) between the last two periods, and the annual average sampling frequency in 2016 -2019

		Number of stations			**Stations per 1000 km²**			**Change**	**Sampling per year**
MS	**Area km²**	**2008-2011**	**2012-2015**	**2016-2019**	**2008-2011**	**2012-2015**	**2016-2019**	**(%)**	**2016-2019**
AT	83944	109	108	128	1,3	1,3	1,5	18,5	10,9
BE	30667	857	835	819	27,9	27,2	26,7	-1,9	7,0
BG	110995	305	318	320	2,7	2,9	2,9	0,6	5,6
CY	9249	10	13	13	1,1	1,4	1,4	0,0	8,5
CZ	78874	571	1917	2086	7,2	24,3	26,4	8,8	7,9
DE	357746	303	241	309	0,8	0,7	0,9	28,2	10,5
DK	43162	161	177	445	3,7	4,1	10,3	151,4	15,0
EE	45347	145	324	280	3,2	7,1	6,2	-13,6	2,8
EL	131692	105	479	284	0,8	3,6	2,2	-40,7	1,2
ES	505983	3730	3903	3525	7,4	7,7	7,0	-9,7	3,6
FI	337547	141	167	147	0,4	0,5	0,4	-12,0	6,2
FR	638474	3331	3390	3251	5,2	5,3	5,1	-4,1	2,4
HR	56539	NA	64	75	NA	1,1	1,3	17,2	9,9
HU	93013	525	530	927	5,6	5,7	10,0	74,9	5,0
IE	69946	252	254	254	3,6	3,6	3,6	0,0	14,5
IT	300578	2463	3154	2288	8,2	10,5	7,6	-27,5	4,8
LT	64899	291	320	289	4,5	4,9	4,5	-9,7	3,4
LU	2595	16	16	16	6,2	6,2	6,2	0,0	6,4
LV	64586	338	222	435	5,2	3,4	6,7	95,9	2,1
MT	315	7	5	NA	22,2	15,9	NA	NA	NA
NL	37368	457	850	852	12,2	22,7	22,8	0,2	13,7
PL	311928	2802	2526	3935	9,0	8,1	12,6	55,8	3,0
PT	91971	146	154	158	1,6	1,7	1,7	2,6	4,4
RO	238368	1113	1224	1123	4,7	5,1	4,7	-8,3	6,0
SE	449718	187	2792	2282	0,4	6,2	5,1	-18,3	1,0
SI	20277	139	136	154	6,9	6,7	7,6	13,2	3,5
SK	49026	852	512	842	17,4	10,4	17,2	64,5	4,6
UK	244574	7378	8404	7947	30,2	34,4	32,5	-5,4	5,6
EU27+UK	**4469381**	**26734**	**33035**	**33184**	**6,0**	**7,4**	**7,4**	**0,5**	**6,3**

Source: EC, 2021a

NA = not available

Table 4: Number of stations of reported saline surface water monitoring of annual average nitrate measurements in reporting periods 2008-2011, 2012-2015 and 2016-2019, and the change (%) between the last two periods

	Number of stations			**Change**	**Sampling per year**
MS	**2008-2011**	**2012-2015**	**2016-2019**	**(%)**	**2016-2019**
AT	NA	NA	NA	NA	NA
BE	10	10	3	-70,0	6,7
BG	7	6	6	0,0	1,8
CY	0	16	16	0,0	2,0
CZ	NA	NA	NA	NA	NA
DE	5	5	51	920,0	5,9
DK	70	44	66	50,0	15,6
EE	23	26	21	-19,2	9,0
EL	11	NA	81	NA	1,1
ES	631	250	594	137,6	2,6
FI	44	75	76	1,3	4,5
FR	21	8	23	187,5	0,7
HR	NA	NA	11	NA	4,5
HU	NA	NA	NA	NA	NA
IE	124	117	122	4,3	3,4
IT	584	577	503	-12,8	5,1
LT	17	16	16	0,0	8,8
LU	NA	NA	NA	NA	NA
LV	45	43	16	-62,8	1,2
MT	31	49	62	26,5	1,4
NL	43	39	34	-12,8	11,7
PL	46	19	19	0,0	28,3
PT	55	6	20	233,3	2,8
RO	54	35	32	-8,6	3,2
SE	233	184	190	3,3	4,5
SI	5	5	5	0,0	12,0
SK	NA	NA	NA	NA	NA
UK	1064	674	586	-13,1	5,4
EU27+UK	**3123**	**2204**	**2553**	**15,8**	**6,2**

Source: EC, 2021a

NA = not available

This study, commissioned by the Policy Department for Citizens' Rights and Constitutional Affairs for the Committee on Petitions (PETI) of the European Parliament, provides an overview of the legal and environmental context in which nitrogen emissions to water are measured in the EU, and how the European Commission makes sure that monitoring systems and their results are comparable throughout the EU. The study explores the development of nitrate concentrations in the EU in view of the European Green Deal and provides (policy) recommendations for EU institutions and Member States, taking into account their respective remits.

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