European Union Network for the Implementation and Enforcement of Environmental Law

Trend reversal in groundwater pollution

Final project report

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Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the European Union (EU) Member States, and of other European authorities, namely from acceding and candidate countries of the EU and European Economic Area (EEA). The association is registered in Belgium and its legal seat is in Brussels, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network's objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns awareness raising, capacity building and exchange of information and experiences on implementation, enforcement and international enforcement collaboration as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the previous years IMPEL has developed into a considerable, widely known organisation, being mentioned in a number of EU legislative and policy documents, e.g. the 8th Environment Action Programme that guide European environmental policy until 2030, the EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil" on Flagship 5 and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation.

Information on the IMPEL Network is also available through its website at: www.impel.eu

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Executive Summary

About 25 % of the groundwater bodies in the EU are in poor chemical status, mostly due to pollution with nitrates and pesticides from agricultural sources. In contrast to the obligation under the Water Framework Directive to reverse upward trends in the concentration of pollutants, the groundwater body area with an upward pollution trend is still nearly double the area with a trend reversal. It is thus urgent to find ways how to improve the implementation of EU water law.

The IMPEL "Trend reversal" project from 2020-2023 aimed to promote an exchange of information and experiences between water authorities in Europe and to develop guidance on best practices of achieving a trend reversal in groundwater pollution. The German-led project team consisted of experts from 5 EU Member States and the UK; altogether 17 authorities from 13 IMPEL member countries participated actively in the project. In a first stage, a survey with questionnaires was conducted to collect information about the current status of pollution trends and examples of trend reversal in participant countries. On the basis of the survey, project team research and input from a mini-conference with external experts, a guideline with best practice examples and recommendations was developed and finalised in October 2023. This report outlines the objectives, structure and activities of the project, the results of the survey, the evolution and conclusions of the "Trend reversal" guideline, and the issues and results of discussion.

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1. Introduction

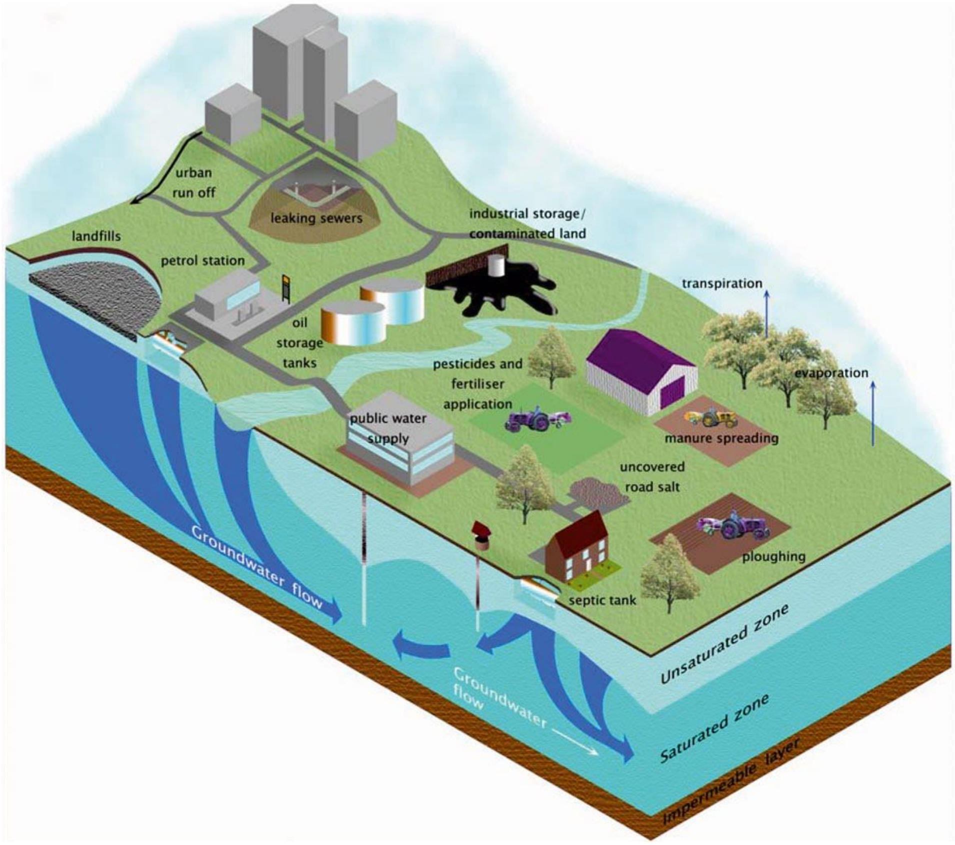
1.1. Background

Under Article 4(1)(b)(iii) of the EU Water Framework Directive (2000/60/EC, short "WFD"), Member States have to implement the measures necessary to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity, in order progressively to reduce pollution of groundwater. In actual fact, however, 24 % of groundwater bodies in the EU were in poor chemical status in 2015 (with 1 % unknown status). This was mostly due to pollution with nitrates and pesticides from agricultural sources. Moreover, according to an EEA report of 2018[1], the total groundwater body area with an identified upward trend of pollution is still nearly double the area with a trend reversal (9.9 % against 5.9 % of area).

To meet the challenges, the WFD (Article 11) envisages a set of basic and, where necessary, supplementary measures to be included in the programmes of measures for each river basin district. Notably, Art. 11(3)(h) of the WFD requires that "for diffuse sources liable to cause pollution", measures to prevent or control the input of pollutants are put in place. Controls may take the form of a requirement for prior regulation, such as a prohibition on the entry of pollutants into water, prior authorisation or registration based on general binding rules where such a requirement is not otherwise provided for under Community [now Union] legislation. These controls shall be periodically reviewed and, where necessary, updated". As regards supplementary measures, Art. 11(4) WFD points to the non-exclusive list in Part B of Annex VI to that Directive. This list starts with legislative and administrative instruments, mentions among other things economic or fiscal instruments, negotiated environmental agreements, emission controls and codes of good practice, and ends with educational, research, development and demonstration projects.

Against this background, the IMPEL "Trend reversal" project has looked especially at the experience of participant countries and tried to derive good practice examples which could be a basis for a number of recommendations on how reversal in groundwater pollution trends can be achieved.

[1] European waters. Assessment of status and pressures 2018. EEA Report No. 7/2018; cf. current EEA information on https://www.eea.europa.eu/publications/europes-groundwater . The results of the river management planning cycle 2015-2021 are not yet publicly available (as of Oct. 2023).



The hazards posing a threat to the quality of groundwater

(Source: UK Groundwater Forum, http://www.groundwateruk.org/Image-Gallery.aspx)

1.2. Objectives and structure of the project

The objectives of the project were to collect information about trends of groundwater pollution in the participant countries and exchange experiences between regulators about examples of trend reversal. On this basis, the participants aimed to develop a guideline with good practice examples from which conclusions and recommendations could be drawn on how best to achieve a trend reversal in groundwater pollution.

Based on Terms of Reference of November 2019, IMPEL's General Assembly originally agreed on a two-year project (ref. no. 2020/11) for 2020-2021. Due to the disruptions by the Covid-19 pandemic, the start of the project was delayed by half a year and most of the envisaged face-to-face meetings and field visits had to be substituted by videoconferences. As a consequence, the terms of reference (ToR) had to be updated in late 2020 and 2021 and the duration of the project extended to 2022 (ref. no. 2022-VI/03). Lateron, in order to leave more time for the organisation of a conference, the inclusion of other countries in the survey and the completion of the "Trend reversal" guideline, it was agreed to add one further year, on the basis of the last updated ToR of May 2022 (see Annex to this report) and a change proposal of October 2022.

Under these circumstances the project actually started with emails to prospective participants in September 2020 and an online kick-off meeting on 22 October 2020, involving 10 participants from 7 countries (DE, DK, EE, ES, MT, RO and UK). In a first stage, a survey was conducted with a questionnaire to collect information about the current status of pollution trends and examples of trend reversal in participant countries. This questionnaire (see below 2.1) was distributed already in September 2020, originally with a two-month deadline, to all IMPEL members who had manifested their interest in the project. However, as it turned out that more countries and authorities showed interest in the trend reversal issue, further replies to the questionnaire were incoming also in the following years. Especially the support of the EU Commission's desk officer for groundwater, Isaac Ojea Jimenez in his function as co-chair of the CIS (Common Implementation Strategy) Groundwater Working Group, helped to enlist further contributors in the last year of the project, and so the last responses and updates to such replies arrived as late as August 2023. In the same month, a report on the survey results was composed.

In parallel, work on the drafting of a "Trend reversal" guideline started with an outline in January 2022 and a first text contribution from Italy in April 2022. Further chapters of the guideline were drafted in the following one and a half years by members of the project team and external contributors (especially Belgium). The guideline text was finalized in October 2023.

A "mini-conference" held with external experts in Frankfurt am Main on 4 September 2023 provided additional input for the guideline and highlighted important aspects and questions that may be addressed in a follow-up IMPEL project.

Apart from this physical event, 11 project team meetings were held via videoconference and two in hybrid format between February 2021 and September 2023. Presentations on the project were given to various IMPEL Water & Land Expert Team meetings, twice via remote connection to meetings of the CIS Groundwater Working Group (in April 2021 and April 2023) and once to a German groundwater conference ("Grundwassertag" on 13 Sept. 2022) in Wiesbaden.

Articles on the project appeared in "IMPEL Weekly" in October 2020 and in the environmental newsletter of the *Regierungspräsidium Darmstadt* ("RP-Journal") in June 2022. A press statement on the Frankfurt conference was published in September 2023 on the IMPEL website and by the Press Office of the RP Darmstadt (in German). An article on the project results is envisaged for the German technical journal "*Wasser und Abfall*" in late 2023.

More information on the products of the Trend reversal project (survey and guideline) can be found below in sections 2 and 4.

1.3. Participants

The project was led by Germany, with *Thomas Ormond* of the Regierungspräsidium Darmstadt (RPDA = Regional authority of South Hessen) acting as project manager. Apart from him, the project team consisted of administrative and technical experts from seven member countries, with a changing composition over time:

1. *Richard Ardo* (Slovak Environmental Inspectorate, SK) – in 2021-2022
2. *Tim Besien* (Environment Agency of England, UK)
3. *Astrid Bischoff* (*HMUKLV* = Hessian Ministry of the Environment etc., DE)
4. *Iustina Boaja* (Geological Institute of Romania) – in 2023
5. *Luc Taliesin Eisenbrückner* (*Miljøstyrelsen* = Environment Agency, DK)
6. *Andrea Fazzone (ARPA Lombardia* = Env. authority of Lombardy region, IT)
7. *Charlotte Greve (Miljøstyrelsen*, DK)
8. *Rasmus Aleksander Højer Kolind* (*Miljøstyrelsen*, DK) – until 2021
9. *Ville Keskisarja (AVI* = Regional State Administrative Agency, FI) – in 2023
10. *Valeria Marchesi* (*ARPA Lombardia,* IT) – until 2022
11. *Liviu Matei* (National Environmental Guard Bacau, RO)
12. *Mads Mortensen (Miljøstyrelsen*, DK)
13. *Ida Rasmussen (Miljøstyrelsen,* DK) – until 2021
14. *Susie Roy (WSP Wood* Consultants, UK)
15. *Cristina Zocchia* (*ARPA Lombardia*, IT) – until 2022

Over the duration of the project, about 26 IMPEL member countries signalled at some point or other their interest in participating in the project or at least being informed about the results. Under the current multi-annual programme for 2022-2024, 16 countries have registered under "Manifestation of interest" (MoI) for this project: Albania (AL), Belgium (BE), Croatia (CR), Denmark (DK), Finland (FI), Germany (DE), Hungary (HU), Ireland (IE), Italy (IT), Kosovo (KS), Lithuania (LT), Netherlands (NL), Portugal (PT), Romania (RO), Slovakia (SK) and the United Kingdom (UK).

In fact, 16 administrative authorities from 12 countries (DE, DK, FI, IT, Luxembourg - LU, Malta – MT, NL, PT, RO, SK and UK) participated actively by replying to the questionnaire. In addition, the Flemish environmental administration (VLM, Belgium) contributed a text chapter to the Trend reversal guideline. Apart from the project team, experts from Estonia and Malta took part in some of the online meetings and representatives from Albania, Hungary and Luxembourg in the final conference in Frankfurt on 4 September 2023.

2. Survey on trends and trend reversal practices in participant countries

2.1 Questions

With the questionnaire of September 2020, the following questions were asked to participants:

1. Please indicate your name, organization, country and (national/regional/local) area of competence.
2. What is the chemical status of groundwater in your area?
3. What is the trend regarding pollution of groundwater in your area?
4. Which chemical substances cause trends in groundwater pollution in your area (e.g. nitrate, pesticides, solvents, hydrocarbons, PFAS) and where do they come from?
5. Which methods are used to measure/assess trends in groundwater pollution?
6. Are there positive examples of reversing upward trends in groundwater pollution in your area? Which parameter(s), to what extent, and in which period of time was trend reversal achieved?
7. How was the trend reversal in this case / in these cases accomplished? Which actors were responsible and what instruments did they use?
8. In particular: What was the role of voluntary agreements and/or binding administrative acts and sanctions in this context? What role was played by economic stakeholders (farmers, industry etc.), water suppliers, local government, NGOs and the general public?
9. Was a Payments for Ecosystems Services approach used (i.e. incentives to farmers or landowners in exchange for managing their land in an environmentally sound way)?
10. In what way was the trend reversal steered/influenced by the river basin management plan, the programme of measures or lower-level planning (e.g. management within water protection zones / safeguard zones)?
11. How far can the positive experience be generalized and similar measures be taken in other cases?
12. Do you have any additional remarks?
13. What do you expect from the IMPEL project on trend reversal? What could be the most useful elements of an IMPEL guideline in this field?

2.2 Replies

Between January 2021 and August 2023 altogether 16 water authorities, environmental agencies or (in one case) a water supplier from 12 member countries gave replies to the questionnaire: Denmark (DK), Finland (FI), Germany / Hessen and Berlin (DE/HE, DE/BE), Italy/Lombardy (IT/LO), Luxembourg (LU), Malta (MT), Netherlands (NL), Portugal (PT), Romania (RO), Slovakia (SK), Sweden (SE), United

Kingdom/England (UK/EN), England/Lincolnshire and Northamptonshire (UK/EN/LI+NO), United Kingdom/Northern Ireland (UK/NI) and United Kingdom/Scotland (UK/SC).

The answers were analyzed in a report of 25 September 2023 by *Susie Roy* and *Natalie Sims* (WSP, UK). The results may be summarized for Questions 2-11 and 13 as follows:

2. Chemical status of groundwater

Groundwater bodies across survey respondents exhibit diverse chemical statuses. Some countries report a mix of good and poor chemical statuses (with poor status often a result of anthropogenic influences, including agricultural practices). Some countries reported higher numbers of groundwater classified as "good" chemical status in comparison to "less than good" (e.g., DK, FI, DE, RO, SK, UK/NI, and UK/SC). Similar numbers/percentages of groundwater bodies classified as "good" chemical status in comparison to "less than good" (e.g., LU, UK/EN), and IT/LO and MT reported a higher proportion of groundwater bodies with "poor chemical status.

3. Trend regarding pollution of groundwater

Trends in groundwater bodies within countries and pollutants exhibit variability, which is likely reflecting distinct pressures or geological conditions affecting specific groundwater bodies. Some respondents noted no reported trends in groundwater bodies (e.g. FI, DE/HE, MT). Decreasing trends were observed by certain respondents (e.g. IT/LO, LU), while others noted an increasing trend (e.g. DE/BE). Some respondents noted that there might be limited decreasing trends in pollution observed due to lengthy groundwater retention times, requiring additional time to see impacts of implemented measures.

4. Chemical substances and sources of pollution

Respondents have reported a range of pollutants impacting groundwater quality, including nitrates, chloride, pesticides, and hydrocarbons. Emerging pressures from PFAS and pharmaceuticals are also noted (FI, DE/BE, IT/LO). Some areas experience increased concentrations of sulphates, arsenic, lead, and specific pesticides. Nitrate remains a significant concern in multiple countries. The sources of pollutants contributing to poor chemical status are often attributed to anthropogenic activities, such as agriculture, mining, and industrial processes.

5. Methods used to measure/assess trends in groundwater pollution

The methods that are used to assess and measure trends in groundwater pollution did vary slightly between countries. For example, varying statistical tests included Wilcoxon, Mann-Kendall, and Theil-

Sen, which are used for trend analyses. National monitoring programs of groundwater bodies are also highlighted as key for establishing trends.

6. Positive examples of reversing upward trends in groundwater pollution

Some respondents did report positive examples of reversing upward trends in groundwater pollution. Respondents that have reported trend reversal have mostly been for nitrates (DK, NL, UK/EN, UK/NI, UK/SC). The duration of time required to achieve trend reversal varies, and in some cases, it spans decades, potentially attributed to groundwater retention times.

7. Reasons for trend reversal and responsible actors

Various regions have implemented measures to achieve positive trend reversals in groundwater pollution. Strategies have included regulations, bans, and targeted actions. Decreasing pollutant concentrations are observed as a result of increased water protection, reduced fertilizer and pesticide use, better wastewater treatment, and site remediation.

8. Role of voluntary agreements and/or binding administrative acts and sanctions

Based on the responses, it would appear that many countries have opted for regulatory actions or sanctions as part of their strategy to address groundwater pollution. A couple of respondents have noted that voluntary agreements do not have a huge effect (DK, DE/BE).

9. "Payments for Ecosystems Services" approach

Yes, in some countries it is reported that a Payments for Ecosystems Services approach is used (e.g., IT/LO, LU, NL, PT). These have included collaborative programs and cooperations have emerged to aid farmers in pesticide and nitrogen reduction, often accompanied by subsidies and support mechanisms.

10. Influence of river basin management plans or other planning

Based on responses from the questionnaire, a couple of countries have reported that RBMPs and PoMs have had positive influences on trend reversal (DK, FI). However, the majority of respondents have not reported a clear link between the RBMPs and PoMs and trend reversal. A couple of countries have reported that more time is needed to fully understand the impacts of RBMPs and PoMs on trend reversal (LU, MT).

11. Generalization and lessons for other cases

Based on the responses from the questionnaire, the extent to which positive experiences can be generalized and applied in other areas varies across countries and context. Effective monitoring, regulations, cooperative approaches, knowledge of best practice are key for addressing groundwater pollution challenges.

13. Need for IMPEL guidance

The responses highlight the need for practical guidance and examples of effective measures to reverse trends in groundwater pollution. Countries have expressed an interest in sharing experiences, methodologies, and successful approaches from other countries to establish best practice and lessons learnt.

For details see the survey report ("IMPEL written response analysis") of September 2023. This report can be accessed on the "Trend reversal" project site of IMPEL Basecamp.

3. Exchange of experience and issues for discussion

Especially the hybrid project meeting on 11 October 2022 that took place in Lisbon back to back with the IMPEL Water & Land Conference, and the Mini-conference in Frankfurt of 4 September 2023 were fora for discussion, information about scientific research and exchange of practical experience between participant countries. The following presentations were held and then published on the project site of IMPEL Basecamp and (in the case of the conference) via an internet link for participants:

1) Project meeting on 11 October 2022 (Lisbon/hybrid):

- Trend reversal of nitrate pollution in the German State of Hesse (*Astrid Bischoff*, DE),
- Reversing nitrate pollution in Denmark (*Luc T. Eisenbrückner*, DK),
- Reversing trends in groundwater pollutants in England (*Tim Besien*, UK).

2) Mini-conference on 4 September 2023 in Frankfurt

- IMPEL and the „Trend reversal" project (*Thomas Ormond*, DE),
- Reversing nitrate trends in groundwater since the 1980's – the Danish example (*Birgitte Hansen*, DK),
- Trend reversal of nitrate pollution in Hessen from the perspective of water authorities (*Astrid Bischoff*, DE),
- Trends in groundwater pollution - Necessary measures from the perspective of a water supplier (*Judith Grimm*, DE),
- Practical experiences in cooperation with farmers (*Matthias Peter*, DE),
- The influence of soil texture on nitrates leachability - Romania – (*Iustina Popescu Boaja*, RO),
- A brief history of reversing upward trends in groundwater nitrate pollution in England (*Tim Besien*, UK),
- Nitrate trends in the chalk of South-East England (*Susie Roy*, UK),
- Statement on envisaged nitrate project (*Annabill Rasp*, DE).

The Frankfurt conference, which was attended by 29 experts (20 of them from German authorities, water suppliers and consulting offices), focused especially on experiences in Denmark, Germany and the UK. Very instructive for the audience was especially the best practice example of Denmark, where 40-50 % reductions of nitrate pollution were reached in the decades after 1980. But progress in more recent years (after 2016) has become more challenging, after rules were relaxed. A register for fertilisation has proven to be very effective. Economic aspects were and are of course important, here as elsewhere. An epidemiological link between colorectal cancer risk and nitrate in drinking water was also highlighted.

The experience in other countries seemed rather less encouraging. In the German state of Hessen, a special focus was put on voluntary measures and cooperation agreements between water suppliers and farmers, with some local successes but no overall reversal of pollution trends. Often progress is hampered if clear and stringent rules, consistent funding and consequences in the case of non-compliance are lacking. In addition, growing awareness and a reversal of nitrate trends should not be taken for granted. Some evidence was presented showing that even young farmers may not be fully engaged in environmental improvement. There was some discussion at the conference about possible reasons, such as the lack of environmental issues in farmers' vocational training.

The UK speakers offered rich information on both the policy and technical aspects of nitrate reduction in England. The policy in the decade after the mid-90s, which relied on full compensation to farmers for loss of income, did achieve a lowering of nitrate levels, but as soon as this policy was changed for financial reasons, farmers reverted to ploughing-up of grass-land and the level of nitrate pollution increased again. The success of the more recent policies seems to be limited. The UK experience is therefore that significant reductions in nitrate leaching are possible if you pay farmers to make changes ("payments for ecosystem services" approach) and offer a long-term orientation framework.

The Romanian experience is that the country fortunately lacks a long history of intensive agriculture, and thus nitrate pollution, and that policymakers are trying not to repeat the mistakes that were made elsewhere. Soil experiments play a role in helping to inform future agricultural policy.

Participants of Trend reversal mini-conference in Frankfurt, 4 Sept. 2023 (Photo: *Johanna Kunze* / RPDA)

4. Work on the Trend reversal guideline

The structure of the guideline and the responsibilities for the various chapters were decided on at various meetings in spring 2022. The following authors drafted substantial text sections in the guide-line:

1.	1. Introduction	*Thomas Ormond*
2.	Status, trends and strategies in the participant countries	*Susie Roy, Thomas Ormond*
3.	Good practice example 1: Reversing nitrate pollution in Denmark	*Luc Taliesin Eisenbrückner, Charlotte Greve, Mads Mortensen*
4.	Good practice example 2: Groundwater catchment schemes in England	*Tim Besien, Susie Roy, Helen Bray*
5.	Good practice example 3: Water protection zones and cooperation agreements in Hessen/Germany	*Astrid Bischoff*
6.	Good practice example 4: Measures to reduce pesticide pollution of groundwater in Lombardy/Italy	*Andrea Fazzone, Valeria Marchesi, Cristina Zocchia*

7.	Good practice example 5: Guiding farmers in the context of the Nitrates Directive in Flanders/Belgium	*Sebastien Janssens*
8.	Conclusions and recommendations	*Tim Besien, Sebastien Janssens, Ville Keskisarja, Thomas Ormond*
9.	Annex: Bibliography and links	*Thomas Ormond*

The guideline was drafted between April 2022 and September 2023. The project team plus other project participants were asked in regular intervals for comments by email on the evolving document. *Thomas Ormond* as project manager was charged with the final editing.

5. Conclusions and recommendations

From the discussions and the expert input throughout the project, the following conclusions and recommendations were drawn, as documented in the "Trend reversal" guideline (with slight abridgements in no. 8):

1. Many groundwater bodies in the EU are not at good chemical status. The main pollutant leading to poor status is nitrate (9% of GWBs covering 18% of the GWB area), followed by pesticides, ammonium, chloride, sulphate, lead, nickel and arsenic. The main cause of this is agriculture with 20% of GWB area being affected by agricultural diffuse pollution (compared to 5% from sewage and 4% each from contaminated sites and industrial plants).
2. The EU environmental legislation, e.g. Water Framework, Groundwater and Nitrates Directives, has had a supplementary and progressive role in setting up a governance framework for safeguarding European groundwaters. However, implementation reports by the European Commission do not show any positive progress in groundwater bodies' overall status. Measures have been implemented widely across the EU and in participant countries, but they are often determined by budgets and policies in place. Long recovery time, restoration challenges and the fact that certain human pressures are difficult to mitigate without severe socio-economic consequences are other reasons why an overall positive trend is not yet noticeable.
3. Trend assessments by the EEA (for the EU as a whole) and in several participant countries of this project show that nitrate concentrations in groundwater have risen slowly over the past 20 years and still continue to rise. A trend reversal on a nationwide scale has so far been achieved only in Denmark.
4. Denmark has generally managed to reduce nitrate pollution of groundwater since the late 20th century. Overall there is a clear trend of a reversal at the beginning of the 1980s towards a more sustainable agricultural N management and a decline of N-surplus. Nitrogen field balance has been reduced by more than 40 % from 1990 – 2020 without a decrease in yields. There is also a clear trend towards a declining nitrate content in oxic groundwater based on the year of groundwater formation. In the last decade since 2012, at 31% of

measuring points a decrease of nitrate was found, at 50% the situation was stable, and 18% showed an increase. After significant improvements in wastewater treatment (sewage was originally a major source of groundwater pollution), this reduction has been mainly achieved by a decrease in the use of inorganic fertilizers. In addition, the storage and application of manure have improved and the risk of accidents and leaks has been reduced. There is also an efficient control system to ensure compliance with the rules.

5. In other countries, a trend reversal in nitrate pollution has been observed locally, under certain specific conditions. Similar experiences have been made e.g. in Germany, England and Belgium. Some of the mitigation measures have not yet shown a positive effect due to long recovery times.
6. In the German state of Hessen, cooperation agreements between water suppliers and farmers to reduce groundwater pollution in water protection areas have had some success, provided the agreements were implemented with intensive consultancy, good communication between all parties, compensation payments for economic losses and sanctions in the case of non-compliance.
7. In England, catchment schemes are used to protect vulnerable water resources, involving partnerships of water suppliers and landowners, advice by "catchment officers" and government funding on the one hand, but also financial penalties and/or prosecution for non-compliance with water law on the other. The Environment Agency has set nutrient emission limits for sectors (like agriculture) and for individual farms, leaving them scope to decide how to reach these limits. As a new idea to promote winter cover crops for reducing nitrate leaching, a "reverse auction" was used via the EnTrade environmental market platform to allocate water company funding, and efficiently scale the uptake of the measure.
8. In Flanders (the northern part of Belgium), there has been a succession of approaches of counselling farmers since 2007, as part of the flanking policy for achieving the goals of the EU Nitrates Directive. Since 2021, counselling is done by the B3W service or "counselling service towards a better soil and water quality", again with public money and based on a public contract with the administration (VLM) as commissioning party. B3W is a multidisciplinary team formed by 13 technical and research centres for agriculture, in which the research centres for agriculture have more weight than before. B3W sets an additional focus on the importance of soil as an underlying requirement for nutrient uptake and for environmental performance. An external advisory committee with the relevant public administrations and the farmers organisations contributes in the establishment of an annual work programme, allowing some flexibility in the field operations and thematic focuses. Peer to peer learning between farmers is a keystone in the goal to apply sustainable practices and techniques on their farms; B3W counsellors have an initiating and supporting role. A positive and fair approach, in which the challenges are clear as well as the possibilities in adopting the right techniques and practices, should stimulate self-questioning about existing practices among the farmers. By way of "thematic exchange moments", an individual farmer acts as an ambassador for a proven good technique, and talks about tricks and tips. On a so-called "persuasion field", a farmer applies under the guidance of B3W a good technique for the first time on his farm and tells his colleagues about the results and findings. "Focus-groups" bring some farmers together and allow them to do small-scale tests on their farms to gain experience on existing or more innovative techniques. Individual guidance is part of the B3W services, but limited to

some farmers that are behind on the "right" technique. Information dissemination through diverse communication formats and media is a task of increasing importance within the B3W service. Info-graphics, short films, more in-depth booklets, press-articles, blogs about the "persuasion fields", social media … should allow effective information transfer, promote the uptake of the right techniques and practices on the farms and enhance sustainability.

9. In the Italian region of Lombardy, mitigation measures have managed to reduce the use of pesticides since 2015 and thus the pollution of groundwater with substances like Bentazon, Metolachlor and Terbuthylazine. This was achieved by binding standards, public information and indirect controls via electronic registers relating to agropharmaceutical products and their use by farmers.

10. The Romanian experience is that the country fortunately lacks a long history of intensive agriculture, and thus nitrate pollution, and that policymakers are trying not to repeat the mistakes that were made elsewhere. Soil experiments play a role in helping to inform future agricultural policy.

11. In Malta there is still a negative trend of nitrate pollution, and in addition groundwater bodies are threatened by salinisation, as a consequence of seawater intrusion. A trend reversal could not be achieved in the last monitoring cycles.

12. Both recovery and restoration of groundwater bodies take a long time, as do changing practices that cause pressure on groundwater. So there is a need to continue following and fully implementing both EU and national environmental legislation.

13. Experience shows that measures must be implemented over the long-term (i.e. a minimum of several decades) without substantial changes. This gives landowners and operators certainty to make investment decisions on farming infrastructure and equipment.

14. There is a need to develop strong local relationships between advisors and farmers to build trust. This trust is important when implementing voluntary land use changes. In this context, it is important to find a balanced approach between successful groundwater protection and agricultural productivity.

15. It should be considered to run a demonstration farm scheme, so that other farmers can learn locally from best practice in reducing nitrate leaching and observe that groundwater protection measures do not necessarily lead to yield reductions.

16. All farm measures and schemes should be considered holistically so that advisors and regulators communicate a single agreed position with all farmers. This will help to avoid confusion and improve the efficiency of any scheme/measure as potentially there may be a number of on-farm initiatives happening at any one time e.g. EU farm to fork strategy, Common Agricultural Policy, the Organic Farming Plan, Welfare of Farmed Animals initiative etc.

Annexes

Annex I . Survey Analysis

IMPEL Project: "Trend reversal in groundwater pollution"

Analysis of the responses to the questionnaire

by Natalie Sims and Susie Roy (WSP) – final version 11 October 2023

This questionnaire was sent out originally to IMPEL members in September 2020 and further distributed by the CIS Groundwater Working Group to its members in the spring of 2023.

A total of 17 replies from 12 different IMPEL member countries was received: Denmark (DK), Finland (FI), Germany / Hessen and Berlin (DE/HE, DE/BE), Italy/Lombardy (IT/LO), Luxembourg (LU), Malta (MT), Netherlands (NL), Portugal (PT), Romania (RO), Slovakia (SK), Sweden (SE), United Kingdom/England (UK/EN), England/Lincolnshire and Northamptonshire (UK/EN/LI+NO), United Kingdom/Northern Ireland (UK/NI), United Kingdom/Scotland (UK/SC).

The individual responses to the questions below have been abridged and formatted for better consistency. They are listed in alphabetical order of member country name and preceded by a short summary for each question.

Question 2:

What is the chemical status of groundwater in your area?

Summary of answers

Groundwater bodies across survey respondents exhibit diverse chemical statuses. Some countries report a mix of good and poor chemical statuses (with poor status often a result of anthropogenic influences, including agricultural practices). Some countries reported higher numbers of groundwater classified as "good" chemical status in comparison to "less than good" (e.g., DK, FI, DE, RO, SK, UK/NI, and UK/SC). Similar numbers/percentages of groundwater bodies classified as "good" chemical status in comparison to "less than good" (e.g., LU, UK/EN), and IT/LO and MT reported a higher proportion of groundwater bodies with "poor chemical status.

Individual answers

DK: (*DK note that their questionnaire response focuses on nitrates)* Groundwater data is based on the 3rd RBMPs. Out of 2050 groundwater bodies, 1345 are classified as good, 22 are classified as poor, and 683 as unknown. For a groundwater body to be in poor chemical status for nitrate, the threshold concentration/value of 50 mg/L is exceeded for 20% of the volume in the groundwater body. Chemical status is noted to be updated in 2021 and will include status for trace elements, pesticides and other pollutants.

FI: In 2019, chemical status is less than good in 95 groundwater areas/bodies (approximately 3,900 groundwater areas, of which approximately 3,600 are classified as groundwater bodies). Furthermore, a total of 380 groundwater areas are so called risk areas. About half the groundwater areas in less than good status is in Southern FI (approx. 40 in less than good out of 1,000 groundwater bodies).

DE/BE: According to the current assessment of the chemical status of groundwater bodies, 67.3% of all groundwater bodies are currently in good chemical status, while 32.7% have not yet achieved good chemical status.[1]

DE/HE: For 29 out of 127 groundwater bodies within the State of Hesse the chemical status is classed as "poor". Groundwater contamination attributable to nitrogen compounds remain the main reason why Hessian groundwater bodies (gwb) exhibit “poor” chemical status. Threshold values for nitrate (20 gwb), sulphate (4 gwb), ammonium (6 gwb), pesticides (6 gwb), phosphate (4 gwb) and/or chloride (6 gwb) were exceeded.

IT/LO: In 2019 chemical status was reported nine groundwater bodies as good, with 19 groundwater bodies as poor.

LU: For the WFD period (2015-2020) for chemical status, three groundwater bodies were classified as good, and three groundwater bodies were classified as bad.

MT: In the 2nd RBMPs, chemical status assessment was conducted for nitrates, pesticides, sea water intrusion, and other chemicals such as chloride, sodium, sulphate, boron, and heavy metals. Out of the 15 groundwater bodies evaluated, 12 were determined to be in poor status. The remaining three groundwater bodies that met the required standards encompass only 3% of the total area of the river basin district. These bodies are Mizieb Mean Sea Level, Mellieha Coastal, and Comino Mean Sea Level.

NL: Chemical status of groundwater bodies reported in Stroomgebiedbeheerplannen 2022-2027.[2]

PT: For the 3rd RBMPs 28% of groundwater bodies were in less than good chemical status.

RO: At national level, 143 groundwater bodies have been delimited, of which 110 are groundwater bodies and 33 are bodies of deep groundwater. It has been reported that out of these 143 groundwater bodies nationwide, 15 groundwater bodies are not in good chemical condition due to nitrates and/or ammonium.

SK: In 2020, out of a total of 75 groundwater bodies**,** 11 groundwater bodies were in poor chemical status (14.3%) and 64 in good chemical status (85.7%). The most important area of groundwater in SK is Žitny Island. It is the biggest reservoir of groundwater in middle Europe (1200 km^2) and is the most endangered area of groundwater.

SE: See the national database for WFD implementation in SE, VISS[3] or WISE[4].

UK/EN: Groundwater bodies % of chemical status:

- 2005, good (58%), poor (42%);
- 2015, good (53%), poor (47%); and
- 2019: Good (45%), poor (55%).

UK/EN/LI+NO: 5 of 20 groundwater bodies are at poor chemical status, the remaining 15 are at good chemical status.

UK/NI: As of 2020, 63 groundwater bodies are at good status and 12 are at poor status based on draft classification.

[1] https://www.umweltbundesamt.de/themen/wasser/grundwasser/zustand-desgrundwassers/chemischer-zustand-des-grundwassers
[2] https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/stroomgebiedbeheerplannen-2022-2027/
[3] https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/stroomgebiedbeheerplannen-2022-2027/
[4]https://tableau.discomap.eea.europa.eu/t/Wateronline/views/WISE_SOW_GroundWaterBody/GWB_ChemicalStatus?:embed=y&:showShareOptions=true&:display_count=no&:showVizHome=no

UK/SC: Generally good status with some exceptions, 43 out of 403 groundwater bodies are at poor chemical status. The chemical status failure is due to several determinants linked to different anthropic activities such as agriculture, mining, land contamination etc.

Question 3.

What is the trend regarding pollution of groundwater in your area?

Summary of answers

Trends in groundwater bodies within countries and pollutants exhibit variability, which is likely reflecting distinct pressures or geological conditions affecting specific groundwater bodies. Some respondents noted no reported trends in groundwater bodies (e.g. FI, DE/HE). Decreasing trends were observed by certain respondents (e.g. IT/LO, LU), while others noted an increasing trend (e.g. DE/BE). Some respondents noted that there might be limited decreasing trends in pollution observed due to lengthy groundwater retention times, requiring additional time to see impacts of implemented measures.

Individual answers

DK: Both increasing and decreasing trends can be found nationally. For detailed tend analysis, further information may be found in "Status and trends of the aquatic environment and agricultural practice in DK – Report to the European Commission for the period 2016-2019 in accordance with article 10 of the Nitrates Directive (1991/676/EEC)"[5]. It is reported that data analysis in this report only vaguely shows that nitrate content of Danish groundwater has been improving, this might be due to the groundwater age and infiltration time has not been considered.

FI: Compared to the previous assessment in 2013, the chemical status in groundwater area has been the same, but the number of risk areas has increased in about 30 areas (+9%). The status of groundwater is at risk, especially in areas where there are a lot of human activity nearby. For example, the number of groundwater areas in less-than-good chemical status increased by 6 (+35%, 17→24) compared to the previous assessment in the Region of Uusimaa (county around Helsinki).

DE/BE: Increasing trend of emerging trace organics due to higher prescription rates and consumption of pharmaceuticals, more stringent thresholds and increased analytical sensitivities. In contaminated sites, trends are constant or slight decrease (e.g. vinyl chloride, MTBE, phenazone).

DE/HE: Significant and sustained upward or downward trends of nitrate concentrations in Hessian groundwater could only be detected in very few monitoring sites. The majority of monitoring sites did not show any significant and sustained upward or downward trends of nitrate concentrations.

IT/LO: The trend in the quality of groundwater has generally improved the last three years. In 2017, the chemical status was reported as good for 28.57%, this has increased to 32.14% in 2019.

LU: One downward trend was identified regarding metazachlore-ESA in the groundwater body 'Devon'.

[5] See chapter 3.4.3 and 3.4. in the "Status and trends of the aquatic environment and agricultural practice in Denmark – Report to the European Commission for the period 2016-2019 in accordance with article 10 of the Nitrates Directive (1991/676/EEC)". Available at https://cdr.eionet.europa.eu/dk/eu/colqyikgg/envyhl1rq

MT: For nitrates, 2/15 groundwater bodies showed an increase between the 1st RBMP to the 2nd RBMP, 1/15 showed a significant decrease, 12/15 showed no significant trend. For chlorides, 6/15 groundwater bodies showed an increase between the 1st RBMP to the 2nd RBMP. There was no significant trend for 9/15 groundwater bodies.

NL: There are no trends reported for the groundwater bodies.[6] In individual filters, however, increasing trends are for example reported for arsenic, chloride, and phosphorus.[7]

PT: Almost the 28% of groundwater bodies show stability in the trend. For nitrate more detailed information is given in the reporting for the nitrate directive.[8]

RO: Due to the dynamics of groundwater and the time required for the measures to take effect (e.g., longer residence time of groundwater), the impact on water chemistry will take time (e.g., after a few years or even decades).

SK: In the groundwater of Žitný ostrov, there are frequent increased concentrations of total iron, manganese and ammonium ions. The predominant nature of land use (e.g., agricultural or urbanized land) results in increased content of oxidized and reduced forms of nitrogen in the waters. Anthropogenic pollution is reflected in exceeded Cl- and SO42- limits.

In the monitored period of 2019 and 2020, increase concentrations of arsenic (20 times) and lead (1 times) were recorded in the group of trace elements. Atrazine and desethylatrazine led to groundwater contamination, and naphthalene exceeded limits in both years. Other pesticides that exceeded the limit value in 2020 include promethrin, terbutrin and tebuconazole. From the group of polyaromatic hydrocarbons, the concentration of naphthalene was most often exceeded in both years (2019 and 2020). In 2019 - 62 times and in 2020 22 times.

SE: Documents were provided detailing information for trend assessments done by the regional water authorities. Also see SGUs (Geological Survey of Sweden) webpage on trends in groundwater chemistry for more general information.[9]

UK/EN: Nitrates were the most common cause of groundwater test failure. In 2015, 25.5% of groundwater bodies failed the trend test due to nitrate, with 36.9% of groundwater bodies having failed of any test due to Nitrate. In 2019 this had changed to 26.9% of groundwater bodies failed the trend test due to nitrates, with 39.8% of groundwater bodies failed due to any test due to nitrate.

UK/EN/LI+NO: 4/5 of the failing groundwater bodies due to agricultural nitrate impacts. These trends are either increasing or plateauing, but not yet reducing due to the lag time of measures taking effect. The final failing groundwater body is a result of point source pesticide pollution, which is being remediated. The source is still present so although concentrations in the wider aquifer are reducing, however should remediation stop there is a risk that this effect could be reversed.

UK/NI: Variable. Some areas are improving, some are consistent, and some are deteriorating.

UK/SC: Generally stable with some improving trends however variable depending on the determinants tested.

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6 https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/stroomgebiedbeheerplannen-2022-2027/
7 https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/grondwater/grondwater-krw/krw-achtergrondrapporten/@237288/rhdhv-2020-trendanalyse-grondwaterkwaliteit/
8 https://www.rivm.nl/bibliotheek/rapporten/2020-0184.pdf
9 https://www.sgu.se/grundvatten/trender-i-grundvattenkemi/

Question 4.

Which chemical substances cause trends in groundwater pollution in your area (e.g. nitrate, pesticides, solvents, hydrocarbons, PFAS) and where do they come from?

Summary of answers

Respondents have reported a range of pollutants impacting groundwater quality, including nitrates, chloride, pesticides, and hydrocarbons. Emerging pressures from PFAS and pharmaceuticals are also noted (FI, DE/BE, IT/LO). Some areas experience increased concentrations of sulphates, arsenic, lead, and specific pesticides. Nitrate remains a significant concern in multiple countries. The sources of pollutants contributing to poor chemical status are often attributed to anthropogenic activities, such as agriculture, mining, and industrial processes.

Individual answers

DK: DK are not able to comment on trends of other chemical substances than nitrate as data isn't published - so pesticides is commented on instead. From 1989-2019, DKs groundwater monitoring analysed substances in wells and waterworks' intakes. In 2019, pesticides were found in 58% of monitored intakes, with 22.6% exceeding the 0.1 µg/l threshold and 9.2% surpassing the 0.5 µg/l sum of pesticides limit. New metabolites like chloridazon desphenyl, chloridazon methyl desphenyl, N,N-dimethylsulfamide, and 1H-1,2,4-Triazole, tested since 2017, are increasingly detected due to improved monitoring. In contrast, 2,6-dichlorobenzamide, detected for years, exhibits declining detections and threshold exceedances over the past two decades.

FI: Chloride, solvents, old pesticides that are no longer in use, and ammonium. There are increasing pressures from PFAS, various pharmaceuticals and microplastics, though these have not been extensively studied in Finnish groundwater. Sources of chemicals are from antiskid treatment/de-icing of traffic, transport of dangerous substances, polluted land areas, agriculture, industry and soil extraction.

DE/BE: Main pollutants include:

- Trace organic compounds (e.g., pharmaceuticals and transformation products) from treated wastewater;
- Substances of contaminated sites (aniline, PFAS, vinyl chloride, phenazone);
- Sulphates in surface water from opencast mining;
- Humic substances in geological background; and
- Ammonia due to former fields irrigated with sewage.

DE/HE: The major pollutants in Hessen’s groundwater are nitrate, pesticides, ammonium and chloride. The first three substances are emitted mainly by agriculture; the chloride comes from saltwater discharge by the potash industry in some Eastern areas of Hessen. The number of groundwater bodies in poor condition due to nitrate has risen from 17 in 2008 (according to the RBMP of 2009) via 19 in 2013 to 20 in 2020.

IT/LO: In 2018 (where 61% of groundwater bodies are in a poor state), the chemicals were: trichloromethane (25%), ammonium ion (21%), arsenic (18%), bentazone (11%), summation of trichlorethylene and tetrachlorethylene and the summation of phytosanitary drugs (7%), nitrates and summation of organohalogenated compounds and zinc (4%).

- Arsenic and ammonium ions also exceeded thresholds;
- Nitrates and PFAS also found in groundwater bodies; and
- Sources of pollution: industrial and agricultural, Lombardy is a densely populated region.

LU: Metazachlor-ESA (which is a chemical is a transformation product of Metazachlor, a herbicide used in agriculture).

MT: Poor chemical status in the groundwater bodies mostly is the result of the presence of nitrates, resulting from arable agriculture and animal manure, and chlorides, resulting from the intrusion and mixing of seawater because of the increased vulnerability for intrusion of the floating lens aquifer system of the Maltese islands.

NL: Poor status for phosphorus in dune areas (west of NL) and chloride on the islands (north of NL) and nitrate (south NL in the loess region). In drinking water a diversity of substances found with increasing trends including chloride, bentazon, nickel and arsenic.[10]

PT: Nitrate, total phosphorus, ammonia, pesticides (including terbuthylazine, desethylterbuthylazine, metolachlor, tebuconazole and desethylsimazine) from agriculture. Hydrocarbons (toluene, xylene, acenaphthene, fluorene, phenanthrene and pyrene) from the oil refinery industry. Chloride comes from high groundwater extraction in coastal zone, in the south region.

RO: Nitrates.

SK: Substances include sulphates, arsenic, and lead. In 2020: Atrazine, desethylatrazine contributed to groundwater contamination. Other pesticides that exceeded limit concentrations included: promethrin, terbutrin and tebuconazole. For Polyaromatic hydrocarbons: In 2019 and 2020, concentrations of naphthalene were most often exceeded. Other monitored indicators in this group that exceeded limit values included phenanthrene, acenaphthene, benzo (b) fluoranthene, benzo (k) fluoranthene, chrysene, phenanthrene, fluoranthene, fluorene, naphthalene, pyrene; and volatile aliphatic hydrocarbons: vinyl chloride.

SE: Upward trends: chloride and conductivity, downward trends: nitrate and pesticide. Pesticide, PFAS and main reasons for poor status. The most common stated reason for poor status on chloride seems to be road salt. Some groundwater bodies with poor status and risk for chloride based on salinization from seawater/high abstraction.

UK/EN: Substances causing failure for 2019 across all tests and groundwater bodies: nitrate (108), orthophosphate (36), copper (35), chloride (35), zinc (34), sulphate (34), iron (34), manganese (33), nickel (22), ammoniacal Nitrogen (14) and other (87).

UK/EN/LI+NO: 4/5 groundwater bodies due to agricultural diffuse nitrate application, and 1/5 - pesticides (e.g. mecoprop, metaldeyhe) from a historic landfill.

UK/NI: Substances causing failure: chlorine (from saline intrusion in one area and unconfirmed source in another area); aluminium (unconfirmed source); TCE (historical contamination); lead (unconfirmed source); nitrate (agriculture); and arsenic (unconfirmed source).

UK/SC: The chemical status failure is due to several determinants linked to different anthropic activities such as agriculture, mining, land contamination etc. Nitrates are due to diffuse pollution from agriculture use of fertilisers

[10] https://www.rivm.nl/bibliotheek/rapporten/2020-0044.pdf

Question 5.

Which methods are used to measure/assess trends in groundwater pollution?

Summary of answers

The methods that are used to assess and measure trends in groundwater pollution did vary slightly between countries. For example, varying statistical tests included Wilcoxon, Mann-Kendall, and Theil-Sen, which are used for trend analyses. National monitoring programs of groundwater bodies are also highlighted as key for establishing trends.

Individual answers

DK: Three types of monitoring initiatives in DK 1) the Groundwater Monitoring Initiative (GRUMO), 2) the Agricultural Catchment Monitoring Programme (LOOP), 3) the Waterworks' Well Monitoring Programme. The collected data is made available on the database JUPITER. Data is analysed annually at GEUS for a Danish groundwater status report. The Danish trend analysis is calculated by means of yearly means across different monitoring periods.

FI: Groundwater monitoring programmes, monitoring of water pollution from agriculture and forestry, and mandatory monitoring related to environmental permits

DE/BE: Analysis of trace organics include HPLC-MS-MS and GC-MS, with extraction methods including ion chromatography, conductivity, photometric determination, organic sum parameters such as TOC, DOC. Non-target screening with high resolution HPLC and monitoring of the observation and production wells as wells. We monitor regulary chemical and physical parameters in the production and groundwater observation wells.

DE/HE: Groundwater extracted by deeper wells have naturally lower nitrate concentrations than shallow groundwater wells. It is necessary to analyse not only NO3- but also the Nmin-value (mineralized nitrogen) in different soil horizons and different time periods. Calculation of the N-balance (input-output balance) at farm level is important to estimate the N-surplus of the farm. Statistically, the trend assessment for groundwater pollution is based on a linear regression test. For trend assessment, all monitoring points have to be considered (raw concentration data from surveillance and operational monitoring).

IT/LO: The legislation that regulated groundwater and protects it from pollution in IT is done by Legislative Decree 152/2006 (Directive 2000/60EC) and Legislative Decree 30/2009 (implementation of European Directive 2006/118/EC). The Higher Institute for Environmental Protection and Research (ISPRA) has issued guidelines for assessing the upward and reversing trends. Mann Kendall is used for pollutants in groundwater.

LU: The Wicoxon-Test is used to assess trends in groundwater pollution. The median concentrations in the first two and two years of the reference period are compared for each monitoring station. This assessment is carried out per groundwater body.

MT: In the trend assessment process in the development of the 2nd RBMP, assessments for significant trends were undertaken using the Mann-Kendall assessment method at 95% confidence level for each monitoring station.

NL: Standard protocols to assess groundwater pollution:

- Assessment of trends and trend reversal[11];

[11] https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/grondwater/grondwater-krw/protocol-toetsen/

- Assessing trend analysis in groundwater bodies[12]; and
- Assessing trend analysis in drinking water areas[13].

PT: Mann-Kendall method with the Sen slope.

RO: At the national level, the Water Law no. 107/1996 ensures that direct discharges of wastewater into groundwater are prohibited. In protected areas for drinking water intakes, measures have been imposed to prohibit 23 activities and to use the land with restrictions (to prevent contamination).

SK: National monitoring programme since 1982 (led by the Slovak Hydrometeorological Institute). Between 1995-2006, groundwater quality were assessed in 26 water management areas. Since 2007 groundwater quality has been monitored as part of basic and operational monitoring.

SE: Mann-Kendall and Theil-Sen statistical methods are used.

UK/EN: Data from the Groundwater Quality Monitoring Network is analysed once every River Basin Planning Cycle. Trend assessment was performed using the R programming language and software to determine significant upward trends using the Sen's and Mann-Kendall statistical tests. These tests were selected as the most appropriate statistical methods for the available groundwater data.

UK/EN/LI+NO: Ongoing representative groundwater monitoring.

UK/NI: Trend analysis completed within classification tests.[14]

UK/SC: Groundwater sampling and analysis, and statistical assessment of analytical results including maximum, average, trends, and projections. The results from single monitoring locations are assessed within the groundwater body group to evaluate trends over large areas.

[12] https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/grondwater/grondwater-krw/krw-achtergrondrapporten/@237288/rhdhv-2020-trendanalyse-grondwaterkwaliteit/
[13] https://www.rivm.nl/bibliotheek/rapporten/2020-0044.pdf
[14] https://www.daera-ni.gov.uk/publications/groundwater-classification-methodology-trend-assessment-and-points-trend-reversal-2015

Question 6.

Are there positive examples of reversing upward trends in groundwater pollution in your area? Which parameter(s), to what extent, and in which period of time was trend reversal achieved?

Summary of answers

Some respondents did report positive examples of reversing upward trends in groundwater pollution. Respondents that have reported trend reversal have mostly been for nitrates (DK, NL, UK/EN, UK/NI, UK/SC). The duration of time required to achieve trend reversal varies, and in some cases, it spans decades, potentially attributed to groundwater retention times.

Individual answers

DK: For livestock farming in DK, rules have been made to ensure that pollution of groundwater and surface water do not take place. The order is called Order on Commercial Livestock, Livestock Manure, Silage, (the Livestock Manure Order).

The Livestock Manure Order has notably contributed to positive environmental outcomes. Ammonia emissions decreased by 42% from 1990 to 2015, nitrate discharge reduced by about half since the mid-1990s, and the national phosphorus surplus dropped by 75% from 1990 to 2016. Moreover, the regulation likely helped curb direct discharges of livestock manure and organic matter, which can lead to increased oxygen consumption and oxygen depletion to possible damage to fish and small animals in the aquatic environment.

FI: Both in the Region of Häme and in the Region of Southwest FI (counties in Southern FI) the number of groundwater areas in less-than-good chemical status decreased by three areas compared to the previous assessment in 2013 (38%, 8→5, in both regions).

DE/BE: Positive examples given are:

- MTBE: restriction of groundwater withdrawal, monitored natural attenuation;
- Mecoprop: implementation of groundwater treatment facility in 2000, reversal trend within the last 10 years;
- Vinyl chloride: local restrictions in groundwater withdrawal of drinking water, pump and treat, implementation of groundwater treatment facility 10 years ago, reversal trend since 2016;
- Phenazone: groundwater restrictions since 1997, implementation of groundwater treatment facility, reversal trend since 1997;
- Ammonia: local restrictions in groundwater withdrawal, implementation of groundwater treatment facility in 2010, reversal trend since 10 years; and
- Arsenic: encapsulation of contamination source in 1999, reversal trend since 2006.

DE/HE: See attached case studies/fact sheets in the annexes.

IT/LO: Noted there are challenges in establishing trend reversals when dealing with groundwater pollutants. The latency times and the absorption capacity of the soils and the depth of the aquifers are factors that strongly interact with the concentrations found. Due to this, an example related to surface waters was given. For example, in the case of pesticides, we have found a decrease in detections beyond the limits of quantification over the last years

As required by Directive 2009/128/09, IT, as well as any other Member State, has adopted a National Action Plan (PAN). The Lombardy Region has issued with D.g.r. n. 1376 of 11 March 2019, the implementation of the PAN to contextualize the principles of sustainable use in our region (PAR – PAN at a Regional scale).

LU: One downward trend was identified regarding metazachlore-ESA in the groundwater body 'Devon' in the period 2015-2020.

MT: Trend reversal was not achieved when considering the data from the last two monitoring cycles of the RBMP. However, the following trends were observed: A downward trend of nitrate concentrations was observed in 2/14 monitored stations in the Malta Mean Sea level, and 1/7 monitored stations in the Gozo Mean Sea Level. In these aquifer bodies, no significant trend was observed in all other monitored stations.

In the case of the Comino Mean Sea Level and Victoria-Kercem Perched aquifers, given the small spatial extent of these aquifer systems, monitoring is carried out in one station within each aquifer, and for both aquifers a downward trend of nitrate concentration was observed.

In the case of chloride content, there was only one station out of 14 monitored stations in the Malta Mean Sea Level, where a downward trend from the 1st RBMP to the 2nd RBMP was observed. Seven of the stations within the Malta Mean Sea Level aquifer showed no significant trend.

NL: Nitrate concentrations in groundwater bodies have decrease since the late nineties. See more information in the "Agricultural practices and water quality in the NLs: status (2016-2019) and trends (1992-2019)" report.[15]

PT: Reported there is a delay between the implementation of measures and the observation of trend reversal in the data on monitoring networks. Some positive indicators examples are in Nitrate Vulnerable Zones.

RO: All groundwater bodies have a good quantitative status in 2019, and between the 1st and 2nd generation of RBMPs there was a slight increase in the proportion of water bodies with a good chemical status (from 93% to 98%). In the 2nd generation of RBMPs, significant pressures were identified, which are addressed through a series of measures (a set of measures). Some measures have been completed since the first PoMs, but a number of obstacles have been encountered, including lack of funds, delays and a lack of instruments in relation to the implementation of the first PoMs.

SK: No data available yet.

SE: Downward trends were provided as an attached file. Trend reversals (i.e. groundwater bodies with previous upward trends that have been broken) were not possible to read out from VISS or the files directly.

UK/EN: There are a small number of examples of trend reversal across EN. For example, in 1990 the Nitrate Sensitive Area Scheme was introduced, and at a fast responding spring source (e.g. Old Charlford) there was a rapid decrease in nitrate concentrations.

UK/EN/LI+NO: No trends established for nitrates, this is due to the lag time in the order of decades for changes to take effect at the groundwater body scale. There are early signs of improvement in terms of rising trends slowing down and even plateauing, and additional implementations have only been implemented within the last 10 years other than NVZ designations.

For the point source pesticide pollution, the pollutants are now contained, and so the wider aquifer chemistry is improving and there is a downward trend of contamination. This is reliant on remediation efforts. The project is moving towards a 'source removal' phase which will provide a permanent solution and give confidence in groundwater quality improvement.

UK/NI: No examples available.

UK/SC: Reversing trends are observed in groundwater at single monitoring location scale but not at groundwater body scale. However, lowering trend in high nitrate concentration

[15] https://www.rivm.nl/bibliotheek/rapporten/2020-0184.pdf

areas is observed over several years period (>12 years). The lowering trends have been observed in the Strathmore groundwater body group.

Question 7.

How was the trend reversal in this case / in these cases accomplished? Which actors were responsible and what instruments did they use?

Summary of answers

Various regions have implemented measures to achieve positive trend reversals in groundwater pollution. Strategies have included regulations, bans, and targeted actions. Decreasing pollutant concentrations are observed as a result of increased water protection, reduced fertilizer and pesticide use, better wastewater treatment, and site remediation.

Individual answers

DK: For livestock farming in DK, rules have been made to ensure that pollution of groundwater and surface water do not take place. The order is called Order on Commercial Livestock, Livestock Manure, Silage, (the Livestock Manure Order) It lays down rules on the storage, handling and use of livestock manure and must ensure that contamination of groundwater and surface water do not take place. Large parts of the Nitrates Directive, (Directive 91/676 of 12 December 1991) have been implemented in the Livestock Manure Order.

DK have had a history of various crucial provisions introduced since 1986-2017 (specific details of measures and action plans may be found in the questionnaire response).

FI: The positive trend in the Region of Häme and in the Region of Southwest FI was achieved through more detailed information, implemented measures or natural recovery.

DE/BE: Trend reversal achieved:

- MTBE: restriction of groundwater withdrawal, monitored natural attenuation;
- Mecoprop: implementation of groundwater treatment facility in 2000;
- Vinylchloride: local restrictions in groundwater withdrawal of drinking water, pump and treat, implementation of groundwater treatment facility 10 years ago;
- Phenazone: groundwater restrictions since 1997, implementation of groundwater treatment facility;
- Ammonia: local restrictions in groundwater withdrawal, implementation of groundwater treatment facility in 2010; and
- Arsenic: encapsulation of contamination source in 1999.

Relevant actors include the water suppliers (*Berliner Wasserbetriebe*) as well as local and federal authorities.

DE/HE: Case studies are attached with the questionnaire. In general, the legal basis for the described measures is a mixture of water law and agricultural law. On one hand, groundwater bodies used for public water supply are protected by local ordinances issued by the regional authorities (Regierungspräsidien) and the establishment of water protection areas. The ordinances contain a set of rules and prohibitions whose breach is penalized by administrative fines. Under the state law of Hessen, the ordinance rules concerning agricultural practices may be substituted by cooperation agreements between local farmers and the Water Supply Company or municipality.

On the other hand, the Fertilization Ordinance (DüV) is the national instrument in DE to implement the EU Nitrate Directive. The DüV (2020) introduces further measures - especially in the nitrate-polluted areas - with the aim of reducing or avoiding nitrate inputs from agriculture into the environment. In addition, the use of pesticides is governed by EU regulations (such as EC 1107/2009) and by Germany's Plant Protection Act (Pflanzenschutzgesetz), underpinned by an action programme.

IT/LO: Among the various measures introduced by the PAR (regional action plan) in Lombardy include:

- Make the procedure for obtaining qualifications more efficient;
- Implementing the control system, regulation and maintenance of sprayers on the Lombard territory;
- Increase the circulation of bulletins containing information for correct defense strategies;
- Improve knowledge of the amount of health and health products used in the Lombardy region activating the online treatment register;
- Increase the network of stations for the detection of agro-meteorological data; and
- Limitation in the use of substances that have shown a greater number of exceedances of environmental quality standards.

LU: Metazachlore was banned in drinking water safeguard zones with the implementation of the grand ducal regulation of the 12 of April 2015.[16]

MT: As part of the 2nd RBMP, measures have been put in place to address pollution from nitrates and chlorides. Within the assessment timeframe of the 2nd RBMP, the quantity of monitoring stations where a downward trend was achieved cannot be directly related to one or more measures which are being implemented as part of the 2nd RBMP. Monitoring of trend reversal in the MT River Basin District is challenging due to long groundwater residence times in the main sea level aquifers.

NL: The Nitrate Action Programme describes the national policy.

PT: The implementation of Action Programme in the scope of Nitrate Directive has been important.

RO: In 2013, RO has a revised action program for the implementation of the Nitrates Directive, which applies to the entire national territory. The revised legislation has made significant improvements compared to the previous action program for the implementation of the Nitrates Directive. The Romanian authorities have decided to implement a "whole-territory approach" instead of designating areas vulnerable to nitrates and have modified some measures the national action program, significantly improving them. Drinking Water Directive With regard to drinking water, no new data are available since the last report of the European Institute of Romania (2017), indicating that 99.44% of all drinking water analysed, complied with the Drinking Water Directive.

SK: No data available yet.

SE: This is not possible to easily read out from the information in VISS for the specific groundwater bodies. It is thought in general though the decreasing concentrations of pollutants for some groundwater bodies are likely a result of increased water protection, decreased use of fertilizer, pesticides and road salt above/around groundwater bodies, better treatment of wastewater and remediation of polluted sites. Decreasing salt and sulphate concentrations can be a result of decreasing water abstraction in the area.

UK/EN: In Nitrate Sensitive Area Scheme, farmers are paid to make significant land use changes. The Scheme imposed an annual maximum of 250 kg/ha of total N as animal manure applied to any scheme field, with other restrictions dependent on the option selected (e.g. 'Basic' option, 'Premium Arable' option, 'Premium grass' option).

[16] https://legilux.public.lu/eli/etat/leg/rgd/2015/04/12/n1/jo

Measurements from 22 Nitrate Sensitive Areas introduced in 1994/5 showed an overall 34% decrease in the nitrate concentration of water leaching from the soils from 115 mg/l (1994/5-1995/6) to 76 mg/l (1998/9-1999/2000).

UK/EN/LI+NO: Interventions in the high nitrate areas – the Environment Agency and the water company have undertaken a series of partnership projects to trial and promote land management interventions with local farmers, including cover crops, oversowing maize, timings of fertilizer application, changes to farm machinery, as well as general awareness raising of the risks and impacts.

Other interventions have included groundwater remediation of the point source pollution – a pump and treat plant has been operating for 15 years, with abstraction wells creating a hydraulic barrier to capture pollution and prevent it spreading into the wider aquifer. This has been managed by the Environment Agency. The Environment Agency is now working with the water company to accelerate this remediation and target the source of the pollution, to negate the need for ongoing treatment.

UK/NI: N/A

UK/SC: Lowering trends are observed in Nitrate Vulnerability Zones. The main drive is likely to be the introduction of Nitrate Vulnerability Zones however, this cannot be confirmed as groundwater monitoring started after the introduction of these zones.

Question 8.

In particular: What was the role of voluntary agreements and/or binding administrative acts and sanctions in this context? What role was played by economic stakeholders (farmers, industry etc.), water suppliers, local government, NGOs and the general public?

Summary of answers

Based on the responses, it would appear that many countries have opted for regulatory actions or sanctions as part of their strategy to address groundwater pollution. A couple of respondents have noted that voluntary agreements do not have a huge effect (DK, DE/BE).

Individual answers

DK: Voluntary agreements are not believed to have had the biggest impact in DK. However, in the later years, there are examples of water supply facilities buying farming areas and forests to keep the groundwater body from deteriorating, by not applying pesticides and manure. Many municipalizes are also announcing the end of using pesticides on their areas, to protect the groundwater bodies, but also to improve biodiversity and organic areas.

FI: -

DE/BE: Voluntary agreements have showed no effects, binding administrative acts and sanctions are necessary and more effective. Existence of drinking water protection areas is valuable. Regarding occasionally self-inflicted contaminations (e.g., former sewage irrigations fields, wastewater treatment plants) the water suppliers take responsibility.

DE/HE: The government of the State of Hesse favours a two-stage approach focusing on binding administrative instruments (1st stage) and supplementary measures, especially voluntary agreements between the farmers and the local public water supply companies (2nd stage). As command-and-control policies are difficult to implement in the agricultural context and not able to solve all problems of diffuse groundwater pollution, the government of Hessen has supported the introduction of voluntary agreements between farmers and water utilities.

IT/LO: Voluntary agreements have been made, however mainly on surface waters. With regard to groundwater, there is currently no experience of Voluntary Agreements, instead there is a regulatory approach with binding administrative acts and sanctions.

LU: The grand ducal regulation of the 12 of April 2015[17] was implemented by the ministry of environment and the ministry of agriculture. Since 2015, farmers are not allowed to use metazachlore in the drinking water safeguard zones.

MT: The 2nd RBMP includes various measures which address the optimization of the management of water resources, particularly measures that protect water abstracted for drinking water, controls on artificial recharge or augmentation of groundwater bodies, the prohibition of direct discharge of pollutants to groundwater. This is together with supplementary measures such as the development of a nation-wide awareness campaign on water management issues, sector-specific awareness campaigns, the regulation of water supply operators, metering of private groundwater abstraction sources, reduction of losses in the municipal distribution system and the introduction of pilot projects on water demand management and supply augmentation measures.

NL: Examples given include:

- DAW (Dutch approach for agricultural water management)[18] and nitrate-based projects in the 2020 Nitrate Report[19];
- Board agreement between national government, provinces, water boards and agricultural sector from December 2017 for 34 vulnerable drinking water areas;
- Agreements with industrial sectors. Some further information on additional policy for drinking water areas is available[20];
- In the NLs the process of RBMP 2022-2027 was carried out with all responsible water organisations in the country. Soil has become an important factor on all work and policy levels. This had led to the “water+bodem sturend” (=water+soil steering) approach in NL (published on 25 Nov. 2022); and
- *Een benadering om het rendement van maatregelen voor grondwater te bepalen (rivm.nl)* (with English summary) describes an approach to determine the efficiency of measures for groundwater by linking local policy plans to RBMPs.

PT: The main pressure for groundwater bodies is agriculture. It is important to highlight the role of the Administration and the effort in the implementation of measures and awareness-raising activities for farmers.

RO: Measures to reduce nitrate pollution provided in particular by the Urban Wastewater Treatment Directive and the Directive on the protection of waters against nitrate pollution from agricultural sources have been implemented. The measures mainly concern the construction, modernization or extension of wastewater collection and treatment systems, as well as the implementation of the code of good agricultural practice and action programs for water protection.

SK: No data available yet.

SE: Unknown.

UK/EN: The farmers voluntarily entered into the Nitrate Sensitive Area agreements. The farmers were all then paid for their land use change actions. Elsewhere there has been voluntary actions used to reduce nitrate leaching but generally the nitrate reductions we see from voluntary schemes are much lower.

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[17] https://legilux.public.lu/eli/etat/leg/rgd/2015/04/12/n1/jo
[18] https://agrarischwaterbeheer.nl/content/task-force-agricultural-water-management
[19] https://www.rivm.nl/bibliotheek/rapporten/2020-0184.pdf
[20] https://www.rivm.nl/bibliotheek/rapporten/2020-0179.pdf

UK/EN/LI+NO: Regarding nitrate concerns, safeguard zones have implemented voluntary strategies to reduce agricultural inputs, while source protection zones have imposed legal restrictions on certain activities. Collaboration with farmers, agronomists, and organisations like the Maize Grower's Association, ADHB, ADAS, and anaerobic digestate plants has improved awareness and showcased effective measures for groundwater quality enhancement, soil health, and crop yields without high costs.

For addressing point source groundwater pollution, the Environmental Protection Act's Part 2A has been a key regulatory tool. It mandates the remediation of pollution impacting public water supplies, licensed abstractors, and surface waters. The water company, along with the primary beneficiaries of the intervention, are actively working to expedite a resolution.

UK/NI: n/a

UK/SC: -

Question 9.

Was a Payments for Ecosystems Services approach used (i.e. incentives to farmers or landowners in exchange for managing their land in an environmentally sound way)?

Summary of answers

Yes, in some countries it is reported that a Payments for Ecosystems Services approach is used (e.g., IT/LO, LU, NL, PT). These have included collaborative programs and cooperations have emerged to aid farmers in pesticide and nitrogen reduction, often accompanied by subsidies and support mechanisms.

Individual answers

DK: The "polluter pays principle" is used in DKs Environmental Protection Regulation. When stricter regulation is introduced with environmental regulations, this is most often done without compensation. However, there are exceptions where subsidy schemes are set up to encourage a particular development. Part of the EU grant for farmers is included in the single payment as a green grant (e.g., a higher subsidy per hectare can be obtained if complied with certain green initiatives).

FI: Some studies have been done on payments for ecosystem services but so far only instruments such as conditions related to the sustainable use of pesticides in agriculture and state aid on restoration of groundwater status exist. There are only very few cases where the polluter has been convicted and been liable for restoration.

DE/BE: No, since the agricultural impact is insignificant for our catchment areas and supply network.

DE/HE: Site specific supplementary measures have been identified in hotspot areas. Supplementary measures are more restrictive for farmers than basic measures and could lead to extra work for farmers or a loss in farmers earning. In practice, the local water supply and farmers agree on supplementary measures for sustainable agriculture and compensation for income loss. Compensation is provided by the water supply company, overseeing farmers' compliance with measures. An accepted expert consultant initiates, organizes, advises, and implements the cooperation. Average annual costs of local projects are approximately 14,000 €, ranging from 3,570 € to 80,100 €.

IT/LO: The rural development program of the Lombardy Region has already provided for the financing of the reconversion of agricultural practices towards more environmentally compatible models (for example integrated defense practices and more efficient management of fertilizers in addition to the financing of mitigation measures such as the creation of buffer strips and filter ecosystems).

LU: Regulation has been used to ban the pesticide in question. In the meantime, regional and local programs and cooperations were established to help the farmers with the reduction of pesticides and nitrogen use, including a catalogue of possible subsidies (e.g., targeted offers from agricultural consultants, purchases of shared mechanical weed control machines).

MT: The benefits of adopting an Ecosystems Services approach has become increasingly relevant in water scarce environments such as MT and will be adopted and implemented in the development of the PoMs for the 3rd RBMP.

NL: In 2012 an overview of payments was published by Rijkswaterstaat.[21] To promote sustainable water use, the WFD introduces the principle of cost recovery (KTW) of water services. KTW involves charging the costs of water services to the various water use sectors according to the polluter pays principle. The financial-fiscal structure for groundwater management is spread across various laws and administrative bodies. To be distinguished are several levies (e.g., groundwater levy province, water system levy water board and sewerage levy municipality).

PT: Yes, under cross compliance.

RO: There are given incentives to farmers and landowners for managing the land in an environmentally sound way.

SK: No data available yet.

SE: Unknown.

UK/EN: Yes, the Nitrate Sensitive Area Scheme effectively used a Payments for Ecosystems Services approach, and it worked well but was expensive.

UK/EN/LI+NO: No, the incentives come from a soil health and crop yield angle. Improved soil health leads to improved crop health – more disease and drought tolerance as well as better water retention and reduced erosion of soil. This all improves crop yields with less application of artificial fertilizer required, so reduces operational cost.

N/A for the point source pollution.

UK/NI: N/A

UK/SC: -

Question 10.

In what way was the trend reversal steered/influenced by the river basin management plan, the programme of measures or lower-level planning (e.g. management within water protection zones / safeguard zones)?

Summary of answers

Based on responses from the questionnaire, a couple of countries have reported that RBMPs and PoMs have had positive influences on trend reversal (DK, FI). However, the majority of respondents have not reported a clear link between the RBMPs and PoMs and trend reversal. A couple of countries have reported that more time is needed to fully understand the impacts of RBMPs and PoMs on trend reversal (LU, MT).

[21] https://iplo.nl/thema/water/beleid-regelgeving-water/financieel-economische-instrumenten/economische-aspecten-waterbeheer/economische/kostenterugwinning-0/

As whilst some countries have implemented various strategies to monitor and improve groundwater quality, the direct impact of these measures on trend reversal is not yet fully understood. However, results are expected to emerge in the future due to groundwater residence times. Despite challenges in linking specific measures to observed improvements, these initiatives will contribute to achieving water quality goals set by the WFD. Strategies include protection perimeters, passive sampling for monitoring, action programs to address trends, cooperation within WFD, comprehensive aquatic environment monitoring, and protective area regulations.

Individual answers

DK: DK started monitoring the aquatic environments in the 1980s, with the Water environmental plan I of 1987, with the primary goal to decrease the leaching of excess nutrients to the environment. The leaching of excess nutrients and pollutants have been closely monitored and regulated since. The RBMPs play a big part in the rules and regulations of nutrients and pollutants in the environment. Whilst this focus is mainly leaching in surface waters, the regulations benefit groundwater too.

FI: The RBMPs and POMs have increased the knowledge and the risks are now better anticipated and the protection measures needed are now well identified. State support on groundwater restoration has increased to some extent, as well as permit authorities' and municipalities' expertise and risk awareness.

DE/BE: For e.g. sulphate, the trans-regional RBMP for the river Spree restricts general concentration in the surface water. Regarding the other examples, RBMPs are not suitable, since the contaminations are local and affecting mostly selectively our production wells.

DE/HE: According to the German Code of Practice on Protective Areas for Groundwater (DVGW, W 101) groundwater protection areas provide an enhanced protection for drinking water supply. In Hessen, more than >30% of the state territory are drinking water protection areas (totalling 1,700 protection areas). Water protection areas are categorised based on nitrate concentrations in groundwater: below 15 mg/l, between 15 and 25 mg/l, and above 25 mg/l.

For the first two categories, "good agricultural practice" following EU Nitrate-Directive or national Fertilization Ordinance was prescribed to adhere to the non-deterioration principle of the WFD. For the third category as well as for polluted areas outside of water protection areas, requiring supplementary measures are needed to achieve good groundwater status.

IT/LO: The mitigation measures of contaminants such as nitrates and pesticides have been defined and applied starting from the monitoring and evaluations between status and gap to achieve the environmental objectives that are the basis of the RBMP.

LU: PoMs have not been in place for long and, due to the residence times in groundwater the first results are expected in the coming years. Results of the 2015 ban apparent in the meantime.

MT: The 1st and 2nd RBMPs aimed to enhance its groundwater quality through measures and protection zones. Linking observed trend reversal to specific RBMP measures is challenging due to groundwater's residence time. Yet, these measures will positively impact future trend reversals in line with the WFDs goals.

NL: The measures described in Q9 are part of the programmes of measures for the WFD. Within the RBMP, 34 vulnerable (drinking water) extractions were published. Measures to be taken until 2027 vary in the country and per region/province. The complexity of cooperation within the WFD was described in Wuijts et al.[22] The NL cooperated with 2 case studies in this survey.

[22] https://www.sciencedirect.com/science/article/pii/S0301479721003327?via%3Dihub

PT: The trend reversal was steered in the scope of Nitrates Directive, namely in the implementation of Action Programme.

RO: No data available.

SK: No data available.

SE: The SGU (Geological Survey of Sweden) has not had time to dig deep into the specific cases of trend reversal and to what extent the improvements directly can be connected to the measures outlined in the RBMPs that are drafted by the regional water authorities, or to the recommendations of physical measures that are outlined in the VISS database for each groundwater body.

UK/EN: No. This was because the nitrate sensitive area scheme started before RBMP in 1989/90.

UK/EN/LI+NO: Safeguard zones have been a very useful tool to target measures and raise awareness, as well as leverage to explain why additional mitigation might be needed for some activities (e.g., permitting materials to land for agricultural benefit). N/A for the point source pollution.

UK/NI: N/A

UK/SC: The RBMP is key to timely evaluate trends improvement, setting targets and take actions where the improvements are not shown.

Question 11.

How far can the positive experience be generalized and similar measures be taken in other cases?

Summary of answers

Based on the responses from the questionnaire, the extent to which positive experiences can be generalized and applied in other areas varies across countries and context. Effective monitoring, regulations, cooperative approaches, knowledge of best practice are key for addressing groundwater pollution challenges.

Individual answers

DK: To get better regulation and results, the inclusion of several environmental parameters is needed. In this case, the focus in DK is on rivers, lakes, and coastal areas, where the positive changes consequently improve the status of the groundwater. Effective monitoring of groundwater quantity and chemical status is crucial. Regulations play a key role in preventing deterioration, while consistent inspections and supervision ensure their enforcement and effectiveness.

FI: Risk awareness and knowledge of best practices has risen, which may help the implementation of measures in the future. Nevertheless, in those areas where the pressures of human activity are high, keeping the situation as good as it is would already be a good achievement.

DE/BE: For contaminated sites, there are always individual cases. Regarding trace organics from waste water treatment plants, there is a general approach for expansion the waste water treatment with advanced treatment technologies regarding trace organics (ozonation, adsorption); investigation and contact to indirect dischargers; contact and information of relevant pharmaceutical industry.

DE/HE: The cooperative approach used in drinking water protection areas (as described in question 10) has been partly adopted also in the PoMs where regions with nitrate concentrations of more than 25 mg/l are concerned. Case studies were also attached to the questionnaire response.

IT/LO: Some of them can be generalized.

LU: S-metolachlore was also banned in 2015 via the same above-mentioned regulation on the whole Luxembourgish territory. Due to the long groundwater residence times, a trend reversal is not yet observed but is expected to occur in the coming years. PoMs established in the meantime to circumvent further strict bans.

MT: The trend assessment exercise in MT developed as part of the RBMP revealed the importance of long-term planning for the protection of groundwater resources, and the need for innovative ways of measuring directly the impact of the adopted measures on the qualitative status of groundwater.

In this regard, in the 3rd RBMP cycle, nitrate levels in the annual recharge will be monitored through a Cohesion funded project using state-of-the-art technology, first of its kind in Europe, to provide information on fluxes and chemical compositions of water percolating in the unsaturated zone and also allow for the sampling of water percolating through the unsaturated zone.

NL: Similar measures, such as the DAW approach, could be applicable to other NW-European countries with similar soil and geology conditions in relation to groundwater aquifers. However, the voluntary nature of the DAW approach posed challenges, as it is not feasible for every farmer, leading to incomplete national coverage. Safeguard and spray-free zones offer notable benefits, but enforcing these measures while considering private land ownership along water bodies remains a challenge. In the NL, the classification of groundwater bodies is relatively broad, with only 23 distinct bodies for the entire country, although smaller bodies exist in specific regions like the Schelde area.

PT: Definition of perimeter for protection of groundwater abstraction for public supply - areas around the abstraction, delimited by hydrogeological studies, which sets public utility restrictions on the use and occupation of the land.

Passive Sampler-based searches allows for qualitative identification of emerging compounds, priority substances, and ultra-trace levels from watch lists, due to the prolonged exposure, minimizing the costs of monitoring.

RO: Farmers, industry or any other kind of activity that is potentially polluting the surface or ground waters should be informed and periodically checked by authorities. In RO there are national/local action plan for environmental compliance regarding used waters.

SK: No data available.

SE: Unknown.

UK/EN: The payments for ecosystem services model works well. Ideally long-term agreements should be entered into. Payments should only be made for activities that go beyond good practice. It can be tricky to work out what activities go beyond good practice and should therefore be funded by a payments for ecosystem services scheme.

UK/EN/LI+NO: The bulk of the trials and engagement work has targeted a single groundwater body, where the trends and nitrate concentrations were most concerning. The water company has however taken the evidence and case studies and shared this information across their area, which takes in the remaining three groundwater bodies failing for poor chemical status, and also to other groundwater bodies. The measures are applicable in any area as they focus on improving soil health and land management.

N/A for the point source pollution.

UK/NI: N/A

UK/SC: Nitrate vulnerable zones (NVZ) are reviewed periodically (every 4 years) based on analytical results and statistical analysis. This approach can extend or reduced the number and size of NVZ areas. This approach can be used where a large body of the economy (e.g. farmers in the nitrate diffuse pollution case) can be identified as the main contributor to the pollution problem and work with them to its resolution.

Question 12.

Do you have any additional remarks?

Individual answers

DK: No

FI: -

DE/BE: No

DE/HE: No

IT/LO: None

LU: No

MT: As part of the revamp of the qualitative and quantitative national monitoring network, additional monitoring stations will be included which will enable the sampling of groundwater from particular strata of the freshwater lens. Moreover, the mean sea level freshwater lens will be regularly profiled. A new real-time monitoring network will also be established to track groundwater level elevation, freshwater lens thickness, and the freshwater-saltwater interface thickness. This approach is particularly relevant for MTs aquifer systems.

NL: Questionnaire response referred to already published documents of the Netherland, so no restrictions occur concerning this given information.

PT: -

RO: The authorities should be more involved in environmental compliance regarding used waters, and they should manage expert teams to periodically check compliance regarding used waters.

SK: No

SE: -

UK/EN: In EN, water companies utilise catchment initiatives, combining voluntary and funded measures. They can sometimes employ an innovative reverse auction system for funding measures[23]. These schemes can be both efficient and effective. There are also Nitrate Vulnerable Zones, which are statutory zones where farmers must comply with a set of rules. There are also new statutory farming rules for water. These statutory schemes have typically not delivered the improvements needed to comply with the environmental objectives in the WFD.

[23] https://www.entrade.co.uk/

Environmental Stewardship schemes funded via the Common Agriculture Policy, although locally valuable they have not delivered the scale of improvement needed meet the environment objectives in the WFD.

UK/EN/LI+NO: No

UK/NI: No

UK/SC: -

Question 13.

What do you expect from the IMPEL project on trend reversal? What could be the most useful elements of an IMPEL guideline in this field?

Summary of answers

The responses highlight the need for practical guidance and examples of effective measures to reverse trends in groundwater pollution. Countries have expressed an interest in sharing experiences, methodologies, and successful approaches from other countries to establish best practice and lessons learnt.

Individual answers

DK: To be inspired how regulation is done in other countries and where good initiatives can be applied that suit DKs distinctive features. In addition, it is a desire for DK to inspire other countries on how DK handles challenges with groundwater.

FI: -

DE/BE: Water supply in Berlin is influenced very little by agriculture, but mainly influenced by urban activities. Nevertheless, the publication of the collected information within this project and questionnaire would give a valuable insight about relevant reversal trends all over Europe.

DE/HE: It would be helpful to establish a digital platform of all best case studies of the IMPEL project on trend reversal to continue the know-how interexchange and knowledge transfer between the IMPEL partners and as support for the farmers. Another important point will be the translation of the IMPEL guideline into German.

IT/LO: No additional remarks

LU: A guide of effective measures and their use in situ, both for known substances and with regard to the approval of new substances that could cause problems in the future. The comparison of similar problems and different solutions would further identify options for action.

MT: The Energy and Water Agency would welcome any guidance on how to link the observed trend reversal with the currently adopted measures and future planned measures, also as part of the development of the 3rd RBMP and would be interested in learning more about the approaches taken in other River Basin Districts for trend reversal assessment in groundwater bodies with long groundwater residence times.

NL: Share the common findings. These are expected to be different in Europe as much as the climate, soil, geology differ. It would be valuable to hear of great findings/approaches in other countries that have stimulated the reduction of diverse substances in groundwater. Also, advisory guidelines e.g. with best (and bad) practices of certain regions can help the Member States further in order to cope better with groundwater quality in future.

PT: An evaluation of the methodologies to be applied in trend reversal analysis and an indication of the method that should be used is considered very useful. Some concrete measures accordingly the different pressures typology to be implemented to reverse the trend should also be very interesting.

RO: IMPEL should be able to bring in the foreground the role that has to be played by authorities in regarding used waters.

SK: To get new information how measures be taken in other countries.

SE: It would be useful to see examples of cost-effective measures and cooperation that successfully has dealt with groundwater pollution. Especially for PFAS that will be a concern for the chemical status of many groundwater bodies in SE, but also for other pollutants that cause poor status or upward trends (e.g., organic contaminants, pesticides, metals, nutrients, saline intrusion).

UK/EN: Practical guidance notes and presentations via zoom to the groundwater community.

UK/EN/LI+NO: -

UK/NI: It would be useful to hear and understand examples of where trend reversal has taken place and what methods were used. Examples relating to different scenarios would be great. E.g., saline intrusion and agri-related chemicals. Also, advice on realistic timelines for trend reversals in groundwater.

A generalized approach for the steps which should be considered (when groundwater pollution is identified and a trend needs to be reversed), specifically detailing what sort of things should be given due consideration e.g., 1. Identify source, 2. Stakeholder engagement etc.

UK/SC: -

Annex II . Survey Tables

Table 1. IMPEL Project: "Trend reversal in groundwater pollution" Q1-Q5

Country and (national/regional/local) area of competence.	*What is the chemical status of groundwater in your area?*	*What is the trend regarding pollution of groundwater in your area?*	*Which chemical substances cause trends in groundwater pollution in your area (e.g. nitrate, pesticides, solvents, hydrocarbons, PFAS) and where do they come from?*	*Which methods are used to measure/assess trends in groundwater pollution?*
Denmark (national) - Response is focused on nitrates	In Denmark, groundwater is distributed across 2050 groundwater bodies. With regards to nitrate pollution, of these, 1345 gwb are classified as "good". 22 are classified as "poor" and 683 as "unknown" (based off analysis from RBMP 3, published in 2019)	Both increasing and decreasing trends with nitrates between 2016-2019 - Slow improvement might be due to groundwater age and infiltration time Pesticide metabolite 2,6-dichlorobenzamide reported to have been declining for the last 20 years	Noted they are not able to comment on trends of other chemical substances than nitrate as data isn't published - so pesticides is commented on instead: The Danish groundwater monitoring programme from 1989-2019 Pesticide metabolites 2,6-dichlorobenzamide, chloridazon desphenyl, chloridazon methyl desphnyl, N, N-dimethylsulfamide and 1H-1,2,4-Triazole	Three types of monitoring initiatives in DK: - The Groundwater Monitoring Initiative (GRUMO) - The Agricultural Catchment Monitoring Programme (LOOP) - The Waterworks' Well Monitoring Programme Collected data is made available on the database JUPITER. Data is analysed annually at GEUS for a Danish groundwater status report The Danish trend analysis is calculated by means of yearly means across different monitoring periods.
Finland (national)	Approx. 3,900 GW areas (approx. 3,600 are classified GW bodies), in 2019, 95 GW areas/bodies in less than good status - A total of 380 GW areas are considered risk areas - Approx. half of the groundwater areas in less-than-good chemical status are in Southern Finland (approx. 40 in less-than-good out of 1 000 gw bodies).	Compared to the previous assessment in 2013, the chemical status of groundwater areas has remained almost the same, but the number of risk areas has increased in about 30 areas (+ 9%). The status of groundwater is at risk especially in the areas where there are a lot of human activity nearby. For example, the number of groundwater areas in less-than-good chemical status increased by 6 (+35%, 17à24) compared to the previous assessment in the Region of Uusimaa (county around Helsinki).	Chloride, solvents, old pesticides that are no longer in use, and ammonium Increasing pressures from PFAS, various pharmaceuticals and microplastics (this has not been extensively studied in Finnish GW) Sources: antiskid treatment/de-icing of traffic, transport of dangerous substances, polluted land areas, agriculture, industry and soil extraction	Monitoring programmes for WFD and GWD Monitoring of water pollution from agriculture and forestry. Mandatory monitoring related to environmental permits
Berlin (Germany)	Chemical status is reported "poor" except for nitrate and pesticides. The poor status is due to ammonium and sulphate.	Increasing trend in emerging trace organics. Likely due to higher prescription and consumption of pharmaceuticals, stronger thresholds and increased analysis sensitivity Slight decrease in trends contaminated sites (e.g. vinyl chloride, MTBE, phenazone)	Main pollutants: - Trace organic compounds (e.g. pharmaceuticals and transformation products) from treated wastewater - Substances of contaminated sites (aniline, PFAS, vinyl chloride, phenazone - Sulphates in surface water from opencast mining - Humic substances in geological background	Analysis of trace organics include HPLC-MS-MS and GC-MS, with extraction methods including ion chromatography, conductivity, photometric determination, organic sum parameters such as TOC, DOC Non-target screening with high resolution HPLC Monitoring of the observation and production wells as wells

			- Ammonia due to former fields irrigated with sewage	
State of Hessen (Germany)	For 29 out of 127 groundwater bodies within the State of Hesse the chemical status is classed as "poor".	Significant and sustained upward or downward trends of nitrate concentrations in Hessian groundwater could only be detected in very few monitoring sites. The majority (64%) of monitoring sites did not show any significant and sustained upward or downward trends of nitrate concentrations. The proportion of groundwater monitoring sites with falling trend (23 %) is well above that with rising trend (13 %).	The major pollutants in Hessen's groundwater are nitrate, pesticides, ammonium and chloride. The first three substances are emitted mainly by agriculture; the chloride comes from saltwater discharge by the potash industry in some Eastern areas of Hessen.	Deeper groundwater wells naturally have lower nitrate concentrations than shallow wells. Analysis of NO3- and Nmin (mineralized nitrogen) across soil horizons and time periods is necessary. Calculating the N-balance at the farm level helps estimate N-surplus. Trend assessment for groundwater pollution uses a linear regression test, considering all monitoring points and raw concentration data from surveillance and operational monitoring.
Lombardy region (Italy)	The chemical state in 2019 of groundwater bodies with good status at 35.71% 64.29% of groundwater bodies were reported with poor status	The trend in the quality of groundwater has been reported to improve over the last three years The chemical state in 2017 was good for a percentage of 28.57%, groundwater bodies and increased to 32.14% in 2019 (with percentage of groundwater bodies in poor status from 71.43% to 64.29%) Nitrates have had a decrease in average concentrations (between 2012-2015 vs 2016-2019) across 177 monitoring points - 34% of monitoring points a decrease in nitrates - 42% of monitoring points in a stable condition - 23% of monitoring points have an increasing trend The distribution of monitoring points show an increasing trend in nitrate concentrations mainly localised in Vulnerable Zones or in areas where there are potentially more sources of pollution from nitrogen sources	In 2018 (where 61% of groundwater bodies are in a poor state) the chemicals were: trichloromethane (25%), ammonium ion (21%), arsenic (18%), bentazone (11%), summation of trichlorethylene and tetrachlorethylene and the summation of phytosanitary drugs (7%), nitrates and summation of organohalogenated compounds and zinc (4%) - Arsenic and ammonium ions also exceeded thresholds Nitrates and PFAS also found in groundwater bodies Sources of pollution: industrial and agricultural, Lombardy is a densely populated region.	The legislation that regulated groundwater and protects it from pollution in Italy is done by Legislative Decree 152/2006 (Directive 2000/60EC) and Legislative Decree 30/2009 (implementation of European Directive 2006/118/EC) The Higher Institute for Environmental Protection and Research (ISPRA) has issued guidelines for assessing the upward and reversing trends (Mann Kendall is used for pollutants in groundwater)
Luxembourg (national)	WFD period (2015-2020) chemical status: - Three groundwater bodies in good - Three groundwater bodies in bad	One downward trend identified for one groundwater body ('Devon') for metazachlor-ESA	Metazachlor-ESA, which is a chemical is a transformation product of Metazachlor, a herbicide used in agriculture	The Wilcoxon-Test - median concentrations in first two and two years of the reference period are compared for each monitoring station - carried out per groundwater body

Malta (national)	2nd RBMPs Out of 15 identified GW bodies, 12 were found to be of poor status	Nitrates: - 2 of the 15 GW bodies showed a significant increase from the 1st RBMP to the 2nd RBMP - 1 showed a significant decrease - There was no significant trend for the remaining 12 GW bodies. Chloride: - 6/15 GW bodies showed a significant increase from 1st to 2nd RBMP - No significant trend for the remaining 9 GW	Poor chemical status in the groundwater bodies mostly is the result of the presence of nitrates (resulting from anthropogenic sources, e.g. arable agriculture and animal manure) and chlorides (resulting from the intrusion and mixing of seawater as a result of the increased vulnerability for intrusion of the floating lens aquifer system of the Maltese islands).	In the trend assessment process in the development of the 2nd RBMP, assessments for significant trends were undertaken using the Mann-Kendall assessment method at 95% confidence level for each monitoring station.
Netherlands (national)	The chemical status of the groundwater bodies in: https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/stroomgebiedbeheerplannen-2022-2027/ Poor status is reported for: - Phosphorus in dune areas in the west of the Netherlands - Chloride on the islands in the north of the Netherlands Nitrate in the south of the Netherlands in the loess region	No trends reported for groundwater bodies (see https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/stroomgebiedbeheerplannen-2022-2027/) - In individual filters, increasing trends reported for arsenic, chloride and phosphorus Nitrate - decreasing trends in groundwater (more details can be found in https://www.rivm.nl/bibliotheek/rapporten/2020-0184.pdf)	Poor status for phosphorus in dune areas (west of NL) and chloride on the islands (north of NL) and nitrate (south NL in the loess region) In drinking water a diversity of substances found with increasing trends including chloride, bentazon, nickel and arsenic (https://www.rivm.nl/bibliotheek/rapporten/2020-0044.pdf)	Standard protocol used to assess GW pollution (prepared within the implementation of the WFD) - Assessing trends and trend reversal (https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/grondwater/grondwater-krw/protocol-toetsen/) - Assessing trend analysis in groundwater bodies (https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/kaderrichtlijn-water/grondwater/grondwater-krw/krw-achtergrondrapporten/@237288/rhdhv-2020-trendanalyse-grondwaterkwaliteit/) - Assessing trend analysis in drinking water areas (https://www.rivm.nl/bibliotheek/rapporten/2020-0044.pdf)
Portugal (mainland)	Third cycle of RBMPs 28% of groundwater bodies in less than good chemical status	Almost the 28% of groundwater bodies show stability in the trend.	Nitrate, total phosphorus, ammonia, pesticides (including terbuthylazine, desethylterbuthylazine, metolachlor, tebuconazole and desethylsimazine) from agriculture hydrocarbons (toluene, xylene, acenaphthene, fluorene, phenanthrene and pyrene) from the oil refinery industry Chloride comes from high groundwater extraction in coastal zone, in the south region	Mann-Kendall method with the Sen slope

Romanian	143 GW are delimited - 110 are GW bodies and 33 are deep GW bodies 15 are not in good chemical condition due to nitrates and/or ammonium	Due to the dynamics of groundwater and the time required for the measures to take effect (longer residence time of groundwater), the impact on water chemistry, will not be visible instantly, but after a few years or even decades.	Nitrates	At the national level, the Water Law no. 107/1996 ensures that direct discharges of wastewater into groundwater are prohibited In protected areas for drinking water intakes, measures have been imposed to prohibit 23 activities and to use the land with restrictions (to prevent contamination)
Slovakia (national)	GW in 2020, 75 GW bodies were evaluated: - 11 GW in poor chemical - 64 GW in good chemical Good chemical status indicated in 85.7% of GW bodies Poor chemical status indicated in 14.3% of GW bodies Most important area of GW in SK is Žitny Island (the largest reservoir of GW in middle Europe) - also most endangered area of GW	Groundwater of Žitný ostrov: increased concentrations of total iron, manganese and ammonium ions, increased content of oxidized and reduced forms of nitrogen in the water Increased concentrations of arsenic (20 times) and lead (1 time), no exceedance of other monitored trace elements were recorded (in monitoring period of 2019 and 2020)	Sulphates, arsenic, lead In 2020: Atrazine, desethylatrazine contributed to GW contamination Other pesticides that exceeded limit concentrations included: promethrin, terbutrin and tebuconazole For Polyaromatic hydrocarbons: In 2019 and 2020, concentrations of naphalene was most often exceeded - Other monitored indicators in this group that exceeded limit values included phenanthrene, acenaphthene, benzo (b) fluoranthene, benzo (k) fluoranthene, chrysene, phenanthrene, fluoranthene, fluorene, naphthalene, pyrene Volatile aliphatic hydrocarbons: vinyl chloride exceed limit values	SK has a national monitoring program since 1982 (led by the Slovak Hydrometeorological Institute) Between 1995-2006, groundwater quality were assessed in 26 water management areas Since 2007 groundwater quality has been monitored as part of basic and operational monitoring
Sweden (national)	See national database for WFD implementation in Sweden: https://viss.lansstyrelsen.se/ or information on WISE	See page: https://viss.lansstyrelsen.se/	Upward trends: chloride and conductivity Downward trends: nitrate and pesticide Pesticide, PFAS and main reasons for poor status Most common stated reason for poor status on chloride seems to be road salt - Some GWBs with poor status and risk for chloride based on salinization from seawater/high abstraction	Mann-Kendall and Theil-Sen statistical methods.
England	Net decrease in the number of GW bodies meeting good chemical status 2009: Poor (42%), good (58%) 2015: Poor (47%), good (53%) 2019: Poor (55%), good (45%)	Nitrate the most common cause of GW failure - Failure of trend test due to nitrate: 2015 (25.5%), 2019 (26.9%) - Failure of any test due to nitrate: 2015 (36.9%), 2019 (39.8%)	Substances causing failure for 2019 across all tests and GW bodies: - Nitrate (108) - Orthophosphate (36) - Copper (35) - Chloride (35) - Zinc (34) - Sulphate (34)	We analyse all of the data across our Groundwater Quality Monitoring Network once every River Basin Planning Cycle. Trend assessment was performed using the R programming language and software to determine significant upward trends using the Sen's and Mann-Kendall statistical tests. These tests were selected as the most appropriate

			- Iron (34) - Manganese (33) - Nickel (22) - Ammoniacal Nitrogen (14) - Other (87)	statistical methods for the available groundwater data.
Lincoln and Northamptonshire (England)	- 5/20 of groundwater bodies are poor chemical status 15/20 of groundwater bodies are good chemical status	4/5 of failing groundwater bodies are from agricultural nitrate impacts - Trends are either increasing or plateauing - Reductions not observed yet due to the lag time between implementation of measures and effects 1/5 failing groundwater body was due to pesticide pollution	4/5 - agricultural diffuse nitrate application 1/5 - pesticides (e.g. mecoprop, metaldeyhe) from a historic landfill	Ongoing representative groundwater monitoring
Northern Ireland	- As of 2020 63 groundwater bodies are at good status and 12 are at poor status based on draft classification	Variable. Some areas are improving, some are consistent and some are deteriorating	• Chlorine – saline intrusion in one area and unconfirmed source in another area • Aluminium – unconfirmed source • TCE – historical contamination • Lead – unconfirmed source • Nitrate – agriculture • Arsenic- unconfirmed source	Trend analysis completed within classification tests. The methodology is available at: https://www.daera-ni.gov.uk/publications/groundwater-classification-methodology-trend-assessment-and-points-trend-reversal-2015
Scotland	- Generally Good Status with some exceptions, 43 out of 403 groundwater bodies are at Poor Status for chemical tests.	Generally stable with some improving trends however variable depending on the determinants teste	The chemical status failure is due to several determinants linked to different anthropic activities such as agriculture, mining, land contamination etc. Nitrate, due to diffuse pollution from agriculture use of fertilizers	Groundwater sampling and analysis, statistical assessment of analytical results including maximum, average, trends, projections. The results from single monitoring locations are assessed within the groundwater body group to evaluate trends over large areas.

Table 2. IMPEL Project: “Trend reversal in groundwater pollution” Q6-11

Country and (national/regional/local) area of competence.	*Are there positive examples of reversing upward trends in groundwater pollution in your area? Which parameter(s), to what extent, and in which period of time was trend reversal achieved?*	*How was the trend reversal in this case / in these cases accomplished? Which actors were responsible and what instruments did they use?*	*In particular: What was the role of voluntary agreements and/or binding administrative acts and sanctions in this context? What role was played by economic stakeholders (farmers, industry etc.), water suppliers, local government, NGOs and the general public?*	*Was a Payments for Ecosystems Services approach used (i.e. incentives to farmers or landowners in exchange for managing their land in an environmentally sound way)?*	*In what way was the trend reversal steered/influenced by the river basin management plan, the programme of measures or lower-level planning (e.g. management within water protection zones / safeguard zones)?*	*How far can the positive experience be generalized and similar measures be taken in other cases?*
Denmark (national) *- Response is focused on nitrates*	Ammonia emission in Denmark has dropped by 42% between 1990-2015 - Nitrate discharge to aquatic environment has halved since the mid-1990s - National phosphorus surplus has reduced by 75% between 1990-2016 Reductions in direct discharges of livestock manure and organic matter	Denmark has a long history of measures introduced since the 1980s to reduce pollution of water bodies. Examples include: - A series of Aquatic Environmental Plans - For livestock farming in Denmark, a number of measures have been implemented (e.g. rules on storage capacity on livestock farms, handling and use of livestock manure)	Voluntary agreements not thought to have had the biggest impacts in Denmark, noted that they have seen examples of water supply facilities buying farming areas and forests to keep the GWB from deteriorating, by not applying pesticides and manure. Many municipalizes are also announcing the end of using pesticides on their areas, to protect the GWB, but also to improve biodiversity and organic areas.	Denmark follows the "polluter pays principle" - E.g. when stricter regulation is introduced with environmental regulations (No. 6), this is often done without compensation. However, there are exceptions where subsidy schemes are set up to encourage a particular development. Part of the EU grant for farmers is included in the single payment as a green grant. A higher subsidy per hectare can be obtained if complied with certain green initiatives.	Denmark started monitoring the Danish aquatic environments in the 1980s, with the Water environmental plan I of 1987. - The leaching of excess nutrients and pollutants have been closely monitored and regulated since The RBMP plays a big part in rules and regulation of nutrients, pesticides and other pollutants into the environment.	To ensure better regulation and results, several environmental parameters are required. - E.g. whilst the focus in Denmark is on surface waters, the positive changes consequently improves the status of the groundwater. Good monitoring of quantification and chemical status in GWB and regulation is key to ensure status doesn't deteriorate - Regular inspections and supervision are important for the upkeep of this
Finland (national)	The number of groundwater areas in less than good chemical status decreased by three areas compared to the previous assessment in 2013 in both the Region of Häme and in the Region of Southwest Finland (38%, 8-->5, in both regions).	It was reported that the positive trend in both the Region of Häme and in the Region of Southwest Finland was achieved through more detailed information, implemented measures or natural recovery.	-	Finland reported that some studies have been done on payments for ecosystem services but so far only instruments such as conditions related to the sustainable use of pesticides in agriculture and state aid on restoration of groundwater status exist. Only very few cases where the polluter has been convicted and been liable for restoration.	The RBMPs and POMs have had the benefits of increasing knowledge and the identifying and understanding the risks and the protection measures required There has been an increase in state support on groundwater restoration to some extent, as well as permit authorities' and	Risk awareness and knowledge of best practices has risen, which may help the implementation of measures in the future. However in areas where pressures of human activities are high, keeping the situation as good as it is would already be considered a good achievement.

					municipalities' expertise and risk awareness.	
Berlin (Germany)	Several positive examples including: - Methyl tert-butyl ether (MTBE) - Mecoprop: decreasing trend in last 10 years - Vinyl chloride: decreasing trend since 2016 - Phenazone - decreasing trend since 1997 - Ammonia - decreasing trend in last 10 years - Arsenic - decreasing trend since 2006	Responsible bodies: Berliner Wassbetriebe, with local and federal authorities. Trend reversal achieved via: - MTBE: restriction of groundwater withdrawal, monitored natural attenuation - Mecoprop: implementation of groundwater treatment facility in 2000 - Vinyl chloride: local restrictions in groundwater withdrawal of drinking water, pump and treat, implementation of groundwater treatment facility - Phenazone - groundwater restrictions since 1997, implementation of groundwater treatment facility - Ammonia - local restrictions in groundwater withdrawal, implementation of groundwater treatment facility in 2010 - Arsenic - encapsulation of contamination source in 1999	Voluntary agreements had little effect, binding administrative acts and sanctions were noted as more effective	No, as agricultural impact is insignificant for the catchment areas and supply network in this area	Trans-regional RBMPs for the river Spree restricts general concentrations of sulphate in surface water Other examples in RBMPs noted as not suitable, as contaminations are local	Contaminated sites tend to always be individual cases A more general approach for expansion on treatment can be taken for trace organics from wastewater treatment plants, including advanced treatment (e.g. ozonation, adsorption). Also investigations into indirect discharge and communication with relevant pharmaceutical industries.
State of Hessen (Germany)	Links to annexes and case studies	Links to annexes and case studies Many of the groundwater bodies used for the public water supply are protected by local ordinances issued (in Hessen) by the regional authorities and the establishment of water	The government of the State of Hesse favours a two state approach, focusing on binding administrative instruments (1st stage) and supplementary measures, especially voluntary agreements between the farmers and local public water supply companies (2nd stage) Command and control policies are challenging to implement in the agricultural context, the government of Hessen has supported the	Yes - an example regarding supplementary measures in the WFD, site specific supplementary measures have been identified for hotspot areas, these can be more restrictive for farmers and can lead to a loss of farmers earning. To address this, with the local water supply company and the	According to the German Code of Practice on Protective Areas for Groundwater (DVGW, W 101) groundwater protection areas provide an enhanced protection for drinking water supply. In Hessen: >38% of the state	The cooperative approach has been used for drinking water protection areas has been partly adopted also in the programme of measures, where regions with nitrate concentrations of >25 mg/L

		protection areas The Fertilization Ordinance is the national instrument in Germany to implement the EU Nitrate Directive, this introduces further measures, especially in the nitrate-polluted areas - with the aim of reducing or avoiding nitrate inputs from agriculture into the environment Pesticides are governed by EU regulations and by Germany's Plant Protection Act	introduction of voluntary agreements between farmers and water utilities	farmers conclude an agreement on the measures and the compensation for losses of farmers income. The compensation is paid by the local water supply company who has to control that the farmers implement the supplementary measures according to the contract The average of the annual total costs of the local co-operation projects is €14,000 (range: €3,570 and €80,100)	territory are drinking water protection areas, the number of protection zones is about 1,700. All water protection areas are categorised by the NO3 concentration. For NO3 concentrations <15 mg/L or between 15-25 mg/L, the concept of "good agricultural practice" should be applied (e.g. the EU Nitrate Directive of the national Fertilisation Ordinance) has to be implemented in all areas of the water protection zones. For drinking water protection areas that have NO3 concentrations >NO3, supplementary measures are required. >158 cooperation agreements between farmers and public water supply companies exist in Hessen, with aims of reducing nitrate concentrations	
Lombardy region (Italy)	Due to the latency times and absorption capacity of the soils and the depth of the aquifers, trend reversals with groundwater pollutants is challenging to identify Noted that for surface waters, pesticides observed a decrease to beyond the limits of quantification	Example given for pesticides in surface waters: Italy has adopted a National Action Plan, which has the objectives, measures, times and indicators for the reduction of risks and impacts from the use of plant protection products etc. Various measures introduced, for example implementing a control system, regulation and maintenance of sprayers in the Lombard territory and increasing the network of stations for the detection of agro-meteorological data	Voluntary agreements have mostly been made with regards to surface waters, however with regards to groundwater there is currently no experience of voluntary agreements, regulatory approach binding administrative acts and sanctions	The rural development program of the Lombardy Region has provided for the financing of the reconversion of agricultural practices towards more environmentally friendly practices (e.g. more efficient management of fertilisers)	The mitigation measures of contaminants (e.g. nitrates and pesticides) have been defined and applied, starting from the monitoring and evaluations between status and gap to achieve the environmental objectives that are the basis of the RBMP	Reported that some can be generalised (no further detail provided)

Luxembourg (national)	Metazachlore-ESA reported a downward trend in the groundwater body 'Devon'. This trend reversal is based on the period 2015-2020.	The use of the active substance metazachlore was banned in drinking water safeguard zones with the implementation of the grand ducal regulation of the 12 of April 2015.	The ban on the active substance metazachlore in drinking water safeguard zones was implemented by the ministry of environment and the ministry of agriculture. Since 2015, farmers are not allowed to use metazachlore in the drinking water safeguard zones.	In the case of metazachlore, regulation was used to ban the pesticide in question. There are also regional and local programs and cooperations where established to help the farmers with the reduction of pesticides and nitrogen use, including a catalogue of possible subsidies (e.g. targeted offers from agricultural consultants, purchases of shared mechanical weed control machines,..)	Due to the long residence times of groundwater, and as the programs of measures have not been in place for long, the impacts of these measures results are expected in the coming years. However, the results of the 2015 ban apparent in the meantime.	S-metolachlore was also banned in 2015 via the same regulation as metazachlore. However, again due to the long groundwater residence times, a trend reversal is not yet observed but is expected to occur in the coming years. Programs of measures established in the meantime to circumvent further strict bans.
Malta (national)	Between the 1st RBMP cycle to the 2nd: Nitrate concentration observed a downward trend in 2/14 monitored stations in the Malta Mean Sea Level, and 1/7 monitored stations in the Gozo Mean Sea Level. In all other monitored stations in both aquifer bodies, no significant trend was observed For the Comino Mean Sea Level and Victoria-Kercem Perched aquifers, monitoring reported a downward trend of nitrate concentration (due to small size of aquifers, monitoring is carried out in one station) Chloride content - 1/14 monitored stations in the Malta Mean Sea Level observed a downward trend, 7/14 showed no significant trend	During the 2nd RBMP, additional measures were put in place to address nitrate and chloride pollution. The quantity of monitoring stations where trend reversal was achieved cannot be directly related to one or more measures that have been implemented as part of the 2nd RBMP. Monitoring of trend reversal in the Malta River Basin District is complicated due to long groundwater residence times in the main sea level aquifers Due to these long residence times of groundwater, the direct effect of such measures can only be observed at a later date	The 2nd RBMP includes measures which address the optimization of the management of water resources, particularly measures that protect water abstracted for drinking water, controls on artificial recharge or augmentation of groundwater bodies, the prohibition of direct discharge of pollutants to groundwater, together with supplementary measures such as the development of a nation-wide awareness campaign on water management issues, sector-specific awareness campaigns, the regulation of water supply operators, metering of private groundwater abstraction sources, reduction of losses in the municipal distribution system and the introduction of pilot projects on water demand management and supply augmentation measures.	Malta will be adopting and implementing an Ecosystems Services approach in the development of the programme of measures for the 3rd RBMP.	Again due to long residence times of groundwater in Malta, it is not possible to directly link observed trend reversal with any of the measures in the 1st and 2nd RBMP. However measures adopted as part of the 1st and 2nd RBMP have aimed to protect the water environment and positive impacts of the measures will likely influence the reversal of trends in years to come.	Malta's trend assessment exercise undertaken as part of the RBMP has highlighted the importance of long-tern planning for the protection of groundwater resources, and the need to be able to directly measure the impact of adopted measures on the qualitative status of our groundwater In the 3rd RBMP cycle, nitrate levels in the annual recharge will be monitored through a Cohesion funded project using state-of-the-art technology. This will provide information on fluxes and chemical compositions of water percolating in the unsaturated zone and also allow for the sampling of water percolating through the unsaturated zone.

Netherlands (national)	Nitrate concentrations are reported to decrease since the late nineties. See chapter 5.2 in this report Agricultural practices and water quality in the Netherlands: status (2016-2019) and trends (1992-2019) (rivm.nl).	The Nitrate Action Programme describes the national policy.	Stakeholders involved: - DAW (Dutch approach for agricultural water management) - Board agreement between national government, provinces, water boards and agricultural sector from 2017 for 34 vulnerable drinking water areas - Agreements with industrial sectors - RBMP 2022-2027 was carried out with all responsible water organisations in the country, soil has become an important work factor.	An overview of payments was published by Rijkswaterstaat in 2012 The WFD introduces the principle of cost recovery (KTW) of water service, this involves charging the costs of water services to various water use sectors according to the polluter pays principle The financial-fiscal structure for groundwater management is spread across different laws and administrative bodies, several levies to be distinguished: For livestock farming in Denmark, a number of measures have been implemented - Groundwater levy province - Water system levy water board - Sewerage levy municipality	There are a series of measures in the programme of measures for the WFD. Within the RBMP, 34 vulnerable (drinking water) extractions were published. Measures to be taken until 2027 vary in the country and per region/province.	Similar measures (e.g. DAW) might be possible in other countries of NW Europe which have similar soils/geology related to groundwater aquifers - Limitation with the DAW approach was voluntary action, which was not feasible for every farmer, so sufficient or national coverage wasn't reached Safeguard zones and spray-free zones can have positive impacts - Challenge is how to enforce this measure in relation to (private) ownership of the land
Portugal (mainland)	Reported that there is likely a delay between the implementation of measures and the observation of trend reversal in the data on monitoring networks. However, some positive indicators examples are in Nitrate Vulnerable Zones in karst media	It has been important the implementation of Action Programme in the scope of Nitrate Directive.	The main pressure for groundwater bodies is agriculture. The role of the Administration and the effort in the implementation of measures and awareness-raising activities for farmers is therefore important.	Yes, under cross compliance.	The trend reversal was steered in the scope of Nitrates Directive, namely in the implementation of Action Programme.	The definition of perimeter for protection of groundwater abstraction for public supply - areas around the abstraction, delimited by hydrogeological studies, which sets public utility restrictions on the use and occupation of the land. Search with Passive Sampler qualitative detection of emerging compounds, priority substances to minimize the costs of monitoring.

Romanian	2019: All groundwater bodies have good quantitative status Between the 1st and 2nd RBMPs, reported a slight increase in the proportion of water bodies with good chemical status (93-98%) 56% of water bodies still classified with low level of confidence IN 2nd RBMPs, significant pressures are identified and addressed through a series of measures Some measures have been completed since the 1st programme of measures	Romania has a revised action program for the implementation of the Nitrates Directive, the revised legislation has resulted in significant improvements compared to the previous action program Romania has taken a "whole territory approach" instead of designating areas vulnerable to nitrates and have modified some measures in the national action program	To reduce nitrate pollution - measures provided by the Urban Wastewater Treatment Directive and the Directive on the protection of waters against nitrate pollution from agricultural sources have been implemented	There are incentives to farmers and land owners for managing the land in a environmentally sound way.	No data available	Farmers, industry or any kind of activity that is potentially polluting water bodies should be informed and periodically checked by authorities. In Romania we have a national/local action plan for environmental compliance regarding used waters.
Slovakia (national)	No data available yet	No data available yet	No data available yet	No data available yet	No data available	No data available
Sweden (national)	*See attached file for downward trends.* Trend reversals (i.e. groundwater bodies with previous upward trends that have been broken) are not possible to read out from VISS or the files directly.	Reported that it is not possible to easily read out from the information in VISS for the specific GWB's. It is thought that the decreasing concentrations of pollutants for some groundwater bodies are likely due to measures for increased water protection, decreased use of fertilizer, pesticides and road salt above/around groundwater bodies, better treatment of wastewater and remediation of polluted sites.	Not known	Not known	The Geological Survey of Sweden (SGU) has not had time to identify specific cases of trend reversal and to what extent the improvements directly can be connected to the measures outlined in the RBMPs that are drafted by the regional water authorities, or to the recommendations of physical measures that are outlined in the VISS database for each groundwater body.	Not known

		Decreasing salt and sulphate concentrations can be a result of decreasing water abstraction in the area.				
England	Reported there are a small number of examples of trend reversal in England - E.g. Nitrate Sensitive Area Scheme in 1990, in a fast responding spring source there was a rapid decrease in nitrate concentrations	In the Nitrate Sensitive Area Scheme - farmers were paid to make land use changes Measurements from 22 Nitrate Sensitive Area Scheme introduced in 1994/5 showed an overall 34% decrease in the nitrate concentration of water leaching from soils from 115 mg/l (1994/5-1995/6) to 76 mg/l (1998/9-1999/2000)	For the Nitrate Sensitive Area scheme, farmers voluntarily entered and were paid for their land use change actions Noted that in general for voluntary action schemes to reduce nitrate leaching, the nitrate reduction tends to be lower	The Nitrate Sensitive Area scheme did use Payments for Ecosystems Services approach, and whilst it was reported as effective it was also noted as expensive	No, due to the Nitrate Sensitive Area scheme started in 1989/90 and so before the first RBMPs	Reported that the payments for ecosystem services model works well, and that long term agreements are preferable.
Lincoln and Northamptonshire (England)	Nitrates - no decreasing trend yet, but likely due to time it takes to observe change at the groundwater body scale - early positive signs are rising trends slowing down or plateauing Pesticide pollution - Downward trend of contamination	Nitrates - Intervention in high nitrate areas, e.g. the Environment Agency and water company have undertaken a series of partnership projects to trial and promote land management interventions with local farmers (e.g. cover crops, fertilizer application timing, changes to farm machinery) and raising awareness of risks and impacts Pesticides - Groundwater remediation efforts, a pump and treat plant has been operating for 15 years (managed by the Environment Agency) - The Environment Agency is working with water company's to accelerate remediation effects and to target the source of pollution	Nitrates - Safeguard zones have targeted voluntary measures to reduce agricultural inputs - Source protection zones have a statutory restriction on certain activities - Anglian water work with farmers, agronomists and other organisations (e.g. Maize Grower's Association, ADHB, ADAS) and local anaerobic digestate plants to raise awareness and provide case studies of effective measures Point source groundwater remediation - Part 2A of the Environmental Protection Act was the main regulatory tool - The water company is involved too as the main beneficiaries of the intervention	No, incentives come from soil health and crop yield angle - Improved soil health leads to improved crop health (increased disease and drought tolerance as well as better water retention and reduced erosion of soil) - This improves crop yields with less application of artificial fertiliser, so reduces operational cost N/A for point source pollution	Safeguard zones have been effective as a tool for targeting measures and raise awareness N/A for point source pollution	Bulk of trials and engagement work have been targeted on a single groundwater body where trends and nitrate concentrations were concerning - Water companies have taken evidence and case studies and shared information across their area - Measures are though to be applicable in any area as focus on improved soil health and land management

Northern Ireland	No examples available	-	-	-	-	-
Scotland	Reversing trends are not observed in groundwater at single monitoring location scale or groundwater body scale. High nitrate concentration areas have observed a lowering trend >12 year period in the Strathmore groundwater body group	Lowering trends are observed in Nitrate Vulnerability Zones (NVZ), this is likely attributed to the introduction of NVZ but this cannot be confirmed as groundwater monitoring started after their introduction	-	-	RBMPs are noted as key to evaluate trends and improvements, and taking actions where improvements are not shown	NVZ are reviewed every 4 years, the approach is flexible to extend or reduce the number and size of NVZ areas. This approach can allow specific pressures to be identified and allow appropriate action to be taken (e.g. farmers in the nitrate diffuse pollution case)