Nordic Council of Ministers

Improving small water supplies in the Nordic countries

Achieving resilience through Risk-Based Management and Surveillance

Contents

This publication is also available online in a web-accessible version at:
https://pub.norden.org/temanord2026-505/

Foreword

Small water suppliers face different and relatively more challenges in delivering safe drinking water than are encountered in larger systems. Through this project we sought practical means to increase the resilience of small water supplies to contamination solutions appropriate to their variable and challenging contexts. Our detailed findings are described in these six scientific papers:

Paper 1 **Status of risk-based approach and national framework for safe drinking water in small water supplies of the Nordic water sector.**

Paper 2 **Implementing risk-based approaches to improve drinking water quality in small water supplies in the Nordic region – barriers and solution.**

Paper 3 **Water quality for citizen confidence: The implementation process of 2020 EU Drinking Water Directive in Nordic countries.**

Paper 4 **Small water supplies in Nordic countries: climate change effects, risks and contingency planning.**

Paper 5 **Lessons from Covid-19 effects on small Nordic water supplies: future resilience and vulnerability.**

Paper 6 **Surveillance structure and inspection challenges of small water supplies in the Nordic region.**

These papers are oriented towards understanding the situation as well as challenges to improve the situation. In this final report we summarize those findings and recommendations and synthesize the results to derive system-level responses involving relevant stakeholders, together with opportunities to improve the situation in an unavoidably resource-constrained environment.

The forerunner to this project was a joint study by University of Iceland and Lund University Sweden[1] which showed more frequent waterborne outbreaks and much higher non-compliance with fecal contamination occurring in small supplies than in the larger ones in the Nordic region. These finding initiated the project "***Improving drinking water quality at small water supplies in the Nordic countries***" presented here, with participation of all the eight Nordic countries: Åland (AX), Denmark (DK), Faroe Islands (FO), Finland (FI), Greenland (GL), Iceland (IS), Norway (NO) and Sweden (SE). The work has been supported by the Nordic Council of Ministers – Nordic Working Group for Microbiology & Animal Health and Welfare (NMDD) from 2019 to 2025, along with the affiliated institutions of the authors. The contributors are listed after conclusions.

The pictures show water intakes for two small water supplies with different approach to water safety. The one on the left had a waterborne outbreak some years back where about 100 people came ill whereas the one on the right has had a risk-based approach in place for over two decades and always compliant in drinking water quality.

1. Paper 1 – Status of small water supplies in the Nordic countries: Characteristics, water quality and challenges. (2017)

Executive summary

Small drinking water supplies across the Nordic region face disproportionate risks of non-compliance in faecal contamination and, of waterborne disease outbreaks, and lag in adopting risk-based approaches (RBA). The small water supplies, including a large number of very small and unregulated systems, serve around four and a half million inhabitants, or 17% of the Nordic population.

RBA improves drinking water quality and public health[2], is required in the EU Drinking Water Directive (EU DWD), and is recommended in World Health Organization guidelines[3]. Legal frameworks requiring RBA exist across the Nordic region but implementation in small systems is negligible in some regions. Emerging challenges to water suppliers to include climate change which is altering hazard profiles with increasing temperature and extreme weather events with an uncertain future trajectory that we found to be insufficiently reflected in RBA policy and practice. Similarly, lessons from COVID-19 and other recent pandemics confirm that preparedness should also be part of RBA. Our study revealed precarious staffing, delayed maintenance, surveillance disruptions, and supply chain dependencies during the pandemic, even though automation and digital communications supported continuity during the pandemic.

Official surveillance capacity - that is the day-to-day work of health inspectors and national administrations - is overloaded, especially for the small supplies. Most Nordic countries lack even the foundation of a comprehensive register that includes very small and unregulated systems where risks are greatest. Regular national statistics on water quality are not always available although required in some of the national drinking water legislations.

The finding show that small systems have specific challenges and are not managed as effectively as the large ones. However, the small systems should not be understood as downscaled large systems. Instead, small supplies should be helped with additional guidance and regulations that are, suitable for their specific, individual characteristic. The training of operators of small supplies is insufficient in some of the countries whereas training is legislatively required in others and typically the information provided to small system customers is inconsistent and difficult to access.

The new EU-DWD (2020/2184) states that RBA should be applied by all regulated water suppliers, including small water suppliers. Our work reveals that this remains to be done and that the substantial benefits, such as reducing incidents, raising

2. Gunnarsdóttir, M.J., Gardarsson, S.M., Elliott, M., Sigmundsdottir, G., Bartram, J. (2012).
3. WHO (2017) Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum.

compliance and enhancing resilience are unrealized and maybe beneficially achievable in all (including non-regulated) small systems. It was also found that achieving these through down-scaling approaches applied to larger systems is impractical and probably ineffective; and that an effective response requires both strengthening of support systems and strengthening of individual water supply systems.

Strengthening of the nation-wide support systems would be beneficial in most countries. This includes: the surveillance function, such as by strengthening inspector capacity; making RBA resources and activities small-system-fit and accessible in relevant languages; improving data accessibility and transparency to users; establishing or improving national registries of water supplies to include the numerous small (50-500 people) and smallest (<50 people) water systems, as well as requiring and enabling training for everyone involved in operating small systems. Involved stakeholders include central and local government, providers of education and training, those involved in emergency preparedness and response, and professional associations.

These support systems should collectively facilitate context-specific improvements tailored to the local circumstances of individual water supplies. Effective implementation is likely to be progressive and towards inclusion of the widespread very small systems, programmed to include all system types, and scheduled with deliberate lesson-learning and adaptation. We therefore recommend progressively extending risk-based management towards coverage of all small water supplies and developing the resilience of these systems through risk-based management, initially including adaptation to a changed climate and to pandemic resilience and ultimately towards establishing broad-based multi-threat resilience.

Our work reveals substantive opportunities for better use of existing knowledge and resources to improve small drinking water systems. It is crucial to deal with the small supplies both as indviduals and to provide support and guidance across them at scale. Our specific recommendations are practical and attainable; and together would substantively improve the resilience of small water supplies to diverse threats, across the Nordic region and enhance drinking water safety for many. The general lessons have widespread applicability beyond the region and arguably worldwide.

Based on our work on improving the drinking water quality and resilience in the small and very small water supplies in the Nordic region, our individual reports include the following specific recommendations:

Require Risk-based Approach (RBA) for all supplies and provide small-system-fit template in the local language such as a sanitary inspection form and implement a pilot case for learning and training to facilitate implementation for the small systems. Use the readily available WHOs guidelines and training material on the subject and adapt to local language and circumstances.

Include climate change and pandemic risks into RBA practice and manuals, and embed climate change, pandemic and other crisis scenarios into RBA followed by rehearsing plans. Prioritize automating the operation of the small water supplies.

Institutionalize and require operator training in legislation including water quality issues, where not in place. These should be targeted at the small water supplies while designing for their needs. Track completion and provide online delivery of training for remoteness, e.g., by online teaching and testing.

Strengthen surveillance by expanding inspector staffing and tools, standardize checklists with additional guidance for small-scale supplies, prioritize risk-based inspection frequencies and include auditing and regular inspection of RBA at all supplies, large and small alike, and adapt methods for remote areas.

Facilitate cooperation and collaboration between small-scale water supplies as is done in some of the Nordic countries, including Denmark and Finland where operators learn from each other and get guidance e.g., via online services

Complete national registries and regular reporting of all water supplies including currently unregulated supplies, and link to licensing and country reporting. Conduct regular national reporting of drinking water quality in a national summary that includes and separately analyses and report on the status and progress in small supplies.

Establish a national water quality database, if this is not in place, to increase transparency and thereby public confidence, and always include the small water supplies. This entails development of a central, publicly accessible, easily comprehensible and searchable database along with timely national reporting to meet EU DWD Article 17's expectations for regular, accessible, and comparable information for everyone.

Increase Nordic cooperation with shared templates e.g., guidance text, benchmarking, and joint pilot projects for small systems.

Methods

The methods used in this project were document analysis, and targeted interviewing. We collated information from published documentation on the structure, size and legislation pertaining to the drinking-water supply sector, with emphasis on small water supplies, status of preventive RBA in water safety management in the sector and training in how to secure drinking water quality.

We interviewed 53 selected key personnel in the initial interviews. Interviewees were from small water suppliers (n=27), associations of water suppliers or similar (n=5), and government authorities including surveillance agencies and ministries (n=21). The questionnaire for the interviews was in four sections: general questions, challenges to water quality, whether preventive risk-based approach was in place to managing water safety, and training - in total 34 semi-structured questions. Initial interviews were performed in the local languages during 2020–2021. Responses were analysed using qualitative research methods for coding and then analysing the answers. Because the initial interviews were conducted early on in the COVID-19 pandemic, we conducted 17 further 'hindsight' interviews with selected specialists with country-wide experience in 2023 seeking especially lessons learned during the pandemic.

Problem definition and objectives

That small water supplies are a weak link for water safety in the Nordic region was already revealed in the forerunning study published in 2017[4]. Between 2010 and 2014, 47 waterborne outbreaks with 57 thousand illnesses were registered in Denmark, Finland, Iceland, Norway and Sweden with more than 80% (39) of the outbreaks occurring in supplies serving less than 5000 people. The population-weighted average faecal contamination (*Escherichia coli*) incidence rate in the Nordic region was over ten times higher in smaller water supplies (<500 inhabitants) than in larger ones (>5000 inhabitants), see Fig. 1.

The European Union had already recognized a decade ago that small water supplies in Europe are less monitored and much less likely to meet the quality standards of the Drinking Water Directive compared to larger ones e.g., as described in a report on water quality for Europe 2008–2010[5]. Non-compliance related to exceedance of the microbiological criteria for *E.coli* and enterococci in water supplies serving less than 5000 people for this period was 5-10% in Denmark, 1–5% in Finland and <1% in Sweden, while the remaining Nordic countries did not provide data for this EU study.

In 2020, the then-new EU DWD (EU 2020/2184) introduced four relevant changes from the former (1998) Directive (EU/98/83) exact sampling frequeny for small and very small water supplies; requirement to implement RBA in all regulated systems; fulfilling Goal 6b of the UN's Sustainable Development Goals (SDGs)[6] ; and requiring access to up-to-date information to the public to increase citizens' confidence in the water suppled to them.

4. Paper 1 – Status of risk-based approach and national framework for safe drinking water in small water supplies of the Nordic water sector
5. European Commission (2014)
6. https://www.un.org/sustainabledevelopment/water-and-sanitation/

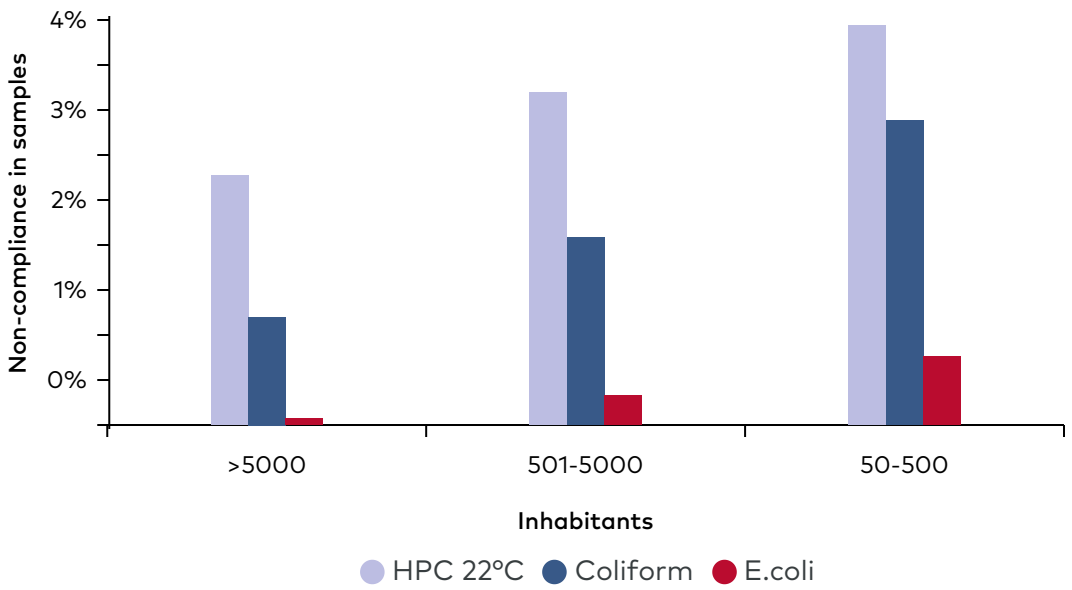

Figure 1 Non-compliance in microbial parameters in regulated Nordic water supplies (HPC = Heterotrophic Plate Count and *E.coli* = Escherichia coli)[7]

The objective of this project was to find solutions to improve water quality and resilience in Nordic small water supplies and enable them to adapt to the increased requirements in the 2020 EU DWD for the RBA, thereby fulfilling the SDG and the Right2Water[8] initiative by delivering safe water to all before 2030.

7. Gunnarsdóttir, M.J., Persson, K.M., Andradottir, H.O. & Gardarsson, S.M. (2017)
8. https://www.right2water.eu/

Nordic Water sector – status and safe water

Paper 1 – Status of risk-based approach and national framework for safe drinking water in small water supplies of the Nordic water sector.

Apart from Greenland and the Faroe Islands, the Nordic countries are part of either the European Union (Åland, Denmark, Finland and Sweden) or the European Free Trade Association EFTA (Iceland and Norway) which are jointly a part of the European Economic Area (EEA). The EFTA countries have to implement all EU directives that are part of the EEA agreement. All the Nordic countries that are EU members have already implemented the new DWD to some extent, whereas the EFTA countries, Norway and Iceland, are still in the process of doing so (December 2025). Although not mandatory in Greenland and the Faroe Islands those countries have implemented many of the retirements in the DWD e.g. to facilitate access to market for seafood products.

Number of water supplies and population

The population in the region in 2017 was 27 million inhabitants, of whom 91% is served by 16,500 regulated water supplies (Fig.2). The remaining 9%, or 2.3 million people, are assumed to be served by an unknown number of unregulated water supplies, mostly serving single or few households. Registration of these is largely lacking.

While 3,300 large- and medium size water supplies (serving more than 500 people) provide water to 83% of the population, 13,200 small regulated water supplies (less than 500 people) are serving 8% of the population or 2.2 million people and 9% unregulated serving 2.3 million people in the Nordic region. This means that approximately four and a half million people in the Nordic countries have drinking water that is subject to limited or no monitoring and surveillance.

Small is defined as 50–500 and very small less than 50 people served, however systems with commercial or public activity are always to be regulated. Small supplies rely often on a single operator/technician, who is in charge of every aspect of the operation. Many of the small supplies also serve temporary populations, such as those summer cottagers and tourist destinations, with many more users.

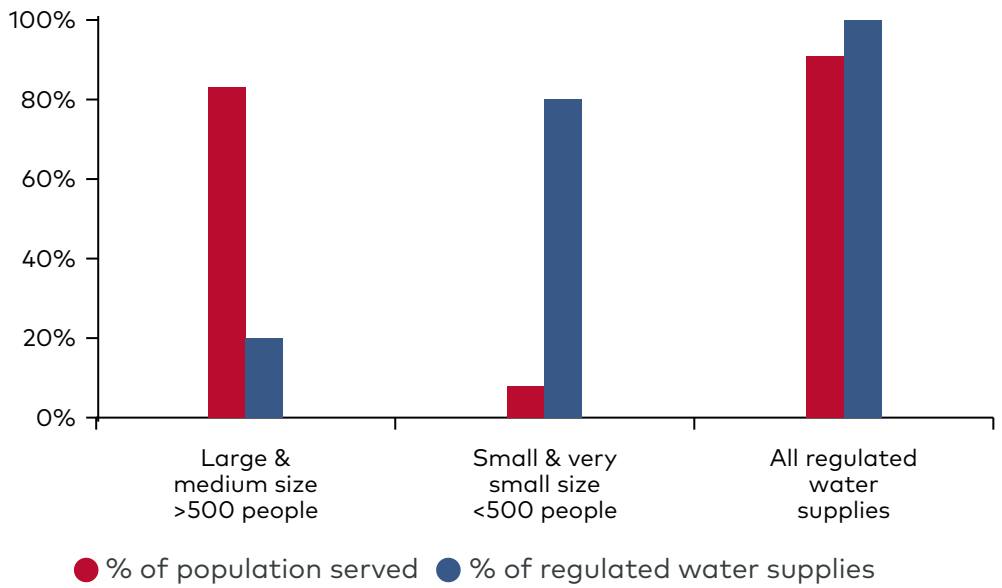

Figure 2 Population and regulated water supplies in the Nordic countries (%) (9% of the population is served by an unknown number unregulated water supplies)

The large and medium-sized water supplies are usually publicly owned, either by the municipality or the government (e.g., in Greenland where all supplies are owned and operated by Nukissiorfiit, a utility owned by the Government), whereas the smaller supplies serving less than 500 people are typically user-owned and often run as a cooperative.

Drinking water harnessing

The Nordic countries have a relatively similar cultural background and legal system, whereas their geography and geology vary widely which is reflected to some extent by the different challenges they face in harnessing drinking water.

Water harnessing varies both between large and small supplies and between countries. Overall, the water harnessing at all regulated water supplies in the Nordic region is 59% from groundwater and 41% from surface water[9]. Some countries use almost exclusively groundwater as a source for all supplies such as Denmark and Iceland; or almost exclusively surface water such as the Faroe Islands and Greenland. Whereas in the other countries the small supplies rely heavily on groundwater as a source and the large ones are using mainly surface water (Fig.3). Groundwater is considered safer than surface water because it is somewhat protected against microbiological contamination by the soil and strata above whereas surface water is more open to contamination and needs greater treatment.

9. Klöve, B., Kvitsand, H.M.L., Pitkänen, T., Gunnarsdottir, M.J., Gaut, S., Gardarsson, S.M., Rossi, P.M., Miettinen, I. (2017)

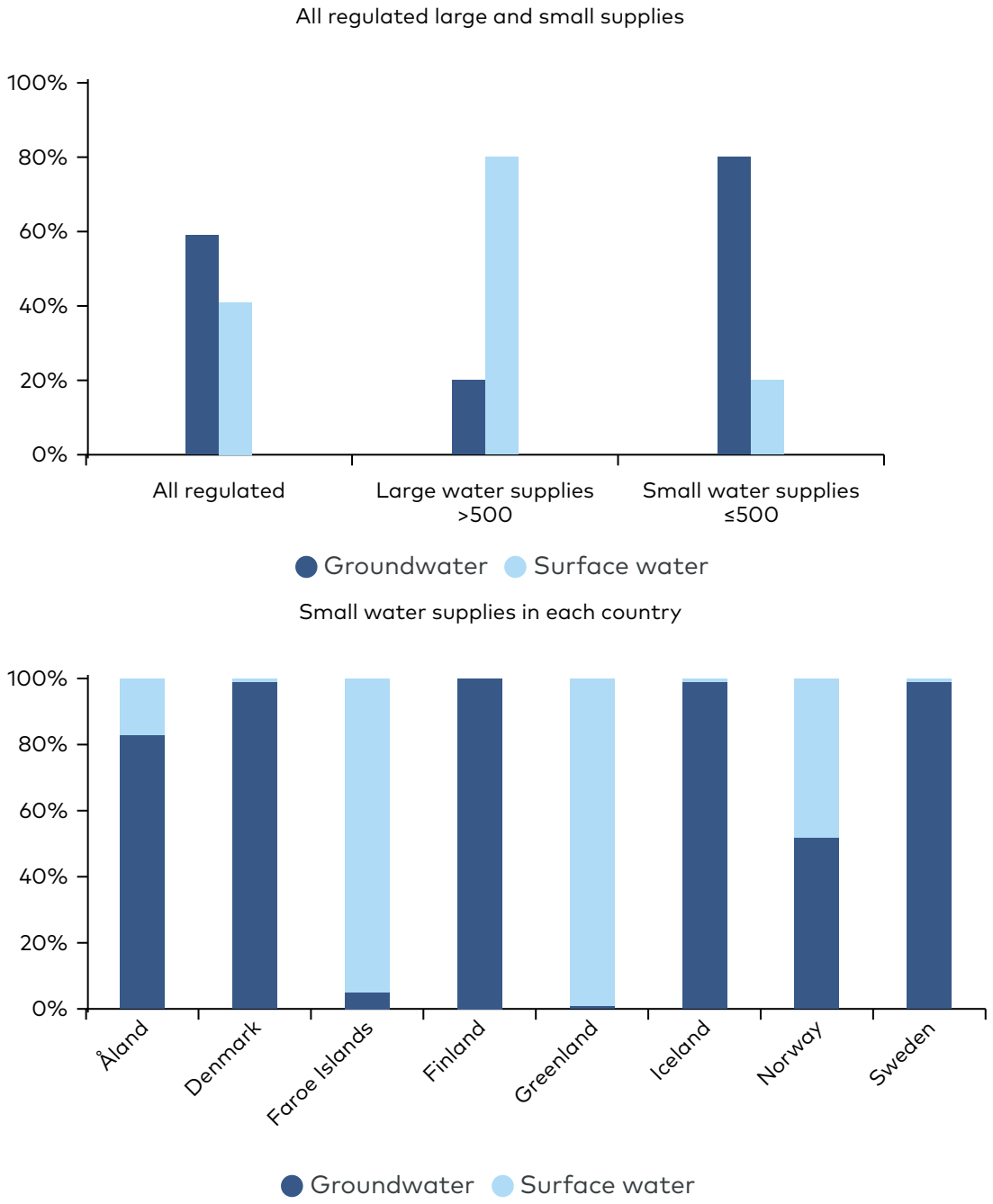

Figure 3 Water harnessing by the regulated water supplies in the Nordic countries [10]

10. Klöve, B., Kvitsand, H.M.L., Pitkänen, T., Gunnarsdottir, M.J., Gaut, S., Gardarsson, S.M., Rossi, P.M., Miettinen, I. (2017)

Non-compliance incidents[11]

In the 53 interviews we asked about incidents of contamination and how non-compliance was recognized. The two most reported route of detection was routine surveillance (sampling and inspection) by the authorities and water supply staff suspecting contamination e.g. due to extreme weather events such as heavy rain or prolonged drought, identification of changes when reviewing analytical reports, or on-line monitoring as in the case of two supplies interviewed in the Faroe Islands; user complaints (mostly related to change in colour); and suspected and sometimes confirmed waterborne illness (Fig. 4A)-

The most frequently mentioned causes for contamination incidents were surface water intrusion into groundwater sources, and system failures (Fig. 4B). Less frequently reported causes of non-compliance were chemical contamination, accidents such as contractors digging into pipelines, intensive farming and algal blooms. Incidents often can either be traced to surface water intrusion into groundwater during extreme weather events and consequential use of a reserve water source, or to treatment failures. This is in line with a past survey of small water supplies in Iceland where lack of maintenance or bad design of water supply intake was the most common cause of non-compliance in small supplies, waterborne outbreaks and boil advisory[12][13].

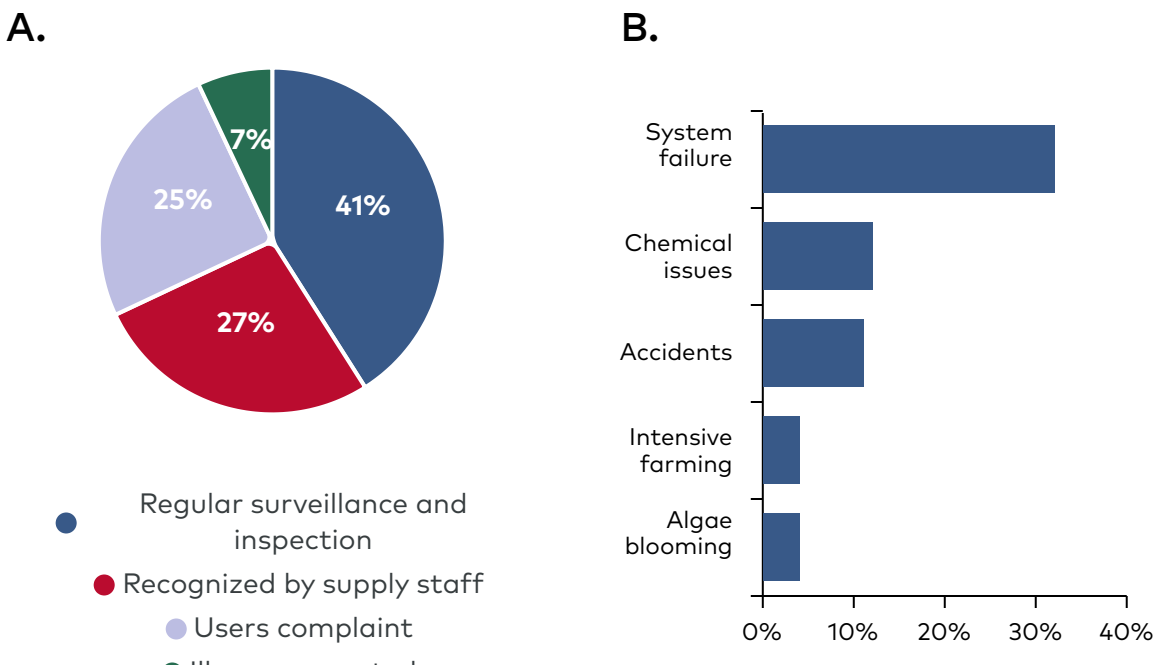

Figure 4 Non-compliance incidents: A) How contamination incidents were recognized (%) and B) What were the causes of these incidents given by the interviewees (%).

11. Paper 6 – Surveillance structure and inspection challenges of small water supplies in the Nordic region (2026)
12. King, R., Gunnarsdóttir, M.J., Narfason, T., Hjaltadóttir, S., Sigurðsson. S., Herschan, J., Gardarsson, S.M., McKeown, R.M., Pond, K. (2022)
13. Gunnarsdóttir, M.J., Atladóttir, A.S., Gardarsson, S.M. (2020)

Risk-based approach for safe water in small supplies

Paper 1 – Status of risk-based approach and national framework for safe drinking water in small water supplies of the Nordic water sector

Paper 2 – Implementing risk-based approaches to improve drinking water quality in small water supplies in the Nordic region – barriers and solution

Where a risk-based approach (RBA) had been implemented, it was perceived by interviewees as beneficial and a positive experience. According to one operator in a small water supply, "*RBA is just an advantage, control over ourselves and work practices.*" It improves documentation, emergency preparedness and resilience in crises.

RBA is required across the Nordic countries and have been in regulation for around ten years in all countries except Iceland where it has been in legislation for 30 years and practiced since 1997. WHO has been advocating the Water Safety Plan in its drinking water quality guidelines since 2004, which includes RBA. However, implementation of RBA is concentrated on larger systems and is seen as difficult to implement in small water supplies.

Around 40% of regulated water supplies were required to implement RBA under previous legislation, but implementation was lacking or progress unknown when studied in 2020. The 2020 directive (EU 2020/2184) with increased demand for RBA has only recently been implemented into legislation in several Nordic EU countries and the RBA progress in these countries is unknown. The main barrier for implementation in small supplies was considered by interviewees to be the lack of simple, context-appropriate templates and guidance. Other factors often mentioned were lack of staff; or relying on voluntary staff, insufficient knowledge and therefore little understanding of risk; and both lack of availability of courses and continuous training in risks to water safety. The requirement for training of water supply operators is found in the legislation in Åland, Denmark, Finland and Norway whereas it is lacking in the other Nordic countries. Lack of guidance, resources and support from the authorities to the small water supplies was also often referred to by interviewees.

Solutions emphasized by interviewees consisted of providing guidelines and support in plain-language; RBA templates specifically designed for small supplies and with a pilot project for demonstration; periodic training of staff; and support for cross-country cooperation and benchmarking among small supplies. Interviewees suggested that legislation should include a requirement for training and an external regular audit of the RBA by the surveillance authority.

Water quality information for citizen confidence

Paper 3 – Water quality for citizen confidence: The implementation process of 2020 EU Drinking Water Directive in Nordic countries.

The 2020 EU DWD, particularly Article 17, mandates the provision of public access to information on drinking water. The purpose of this improved information access and transparency is described as "*it should increase citizens' confidence in the water supplied to them, as well as in water services, and should lead to an increased use of tap water as drinking water, which could contribute to reduced plastic usage and litter and greenhouse gas emissions, and a positive impact on climate change mitigation and the environment as a whole.*"

Our study reveals the challenges of actively sharing water quality information with the public, because public information remains uneven both between the countries and according to size of supply. Only Denmark, Greenland and Finland have a national, central, publicly searchable database with water quality information in place. The Jupiter database serves Denmark and Greenland and Vesi serves Finland, but the other countries lack such resources. Jupiter is dependent on end-users' knowledge, and since the database is in Danish, its use in Greenland may be constrained by language barriers. Finland's collaborative database for water quality data is accessible, but there are concerns about its coverage of smaller systems. There is also limited relevance of Vesi in Åland, where the most commonly spoken language is Swedish, because of the language barrier.

Small supplies typically rely on SMS, social media or door-to-door bulletin for communication to users. National surveillance authorities, outside Finland, Denmark and Greenland using Vesi and Jupiter, usually have a website where microbiological and chemical results for large and medium size supplies are sometimes uploaded. Large supplies have their own websites with this information whereas such websites are rare for the smaller ones. For small supplies water quality information is mostly only available on request. Regular legal national reporting of water quality exists but is patchy in practice. Implementation of EU DWD Article 17 on information to the public has the potential to advance Sustainable Development Goal 6 by providing comprehensive information on water that is delivered to all end-users and fosters perceptions of supplier transparency, thereby increasing confidence in water.

Climate change — effects, risks and contingency planning

Paper 4 – Small water supplies in Nordic countries: climate change effects, risks and contingency planning.

Small supplies and surveillance authorities report increasing concerns regarding heavy rain and flooding, landslides, drought, glacier and permafrost processes, algal blooming in surface waters and risks of saltwater intrusion (Fig. 5). Most interviewees had not direct perceived effects, but hazard exposure is increasing. Both Iceland and Norway have experienced damage to water intakes in small water supplies following heavy rain, and landslides have been traced to melting permafrost. Wildfire after a long drought has contaminated a water source, though not permanently.[14] Toxic algae were recognized as an increasing problem in some countries, including the majority of regions in Åland and Greenland. Rising sea levels and their consequences were mentioned by water suppliers located close to shorelines. Low-lying areas and countries such as Denmark are especially concerned about this increasing saltwater intrusion into aquifers.

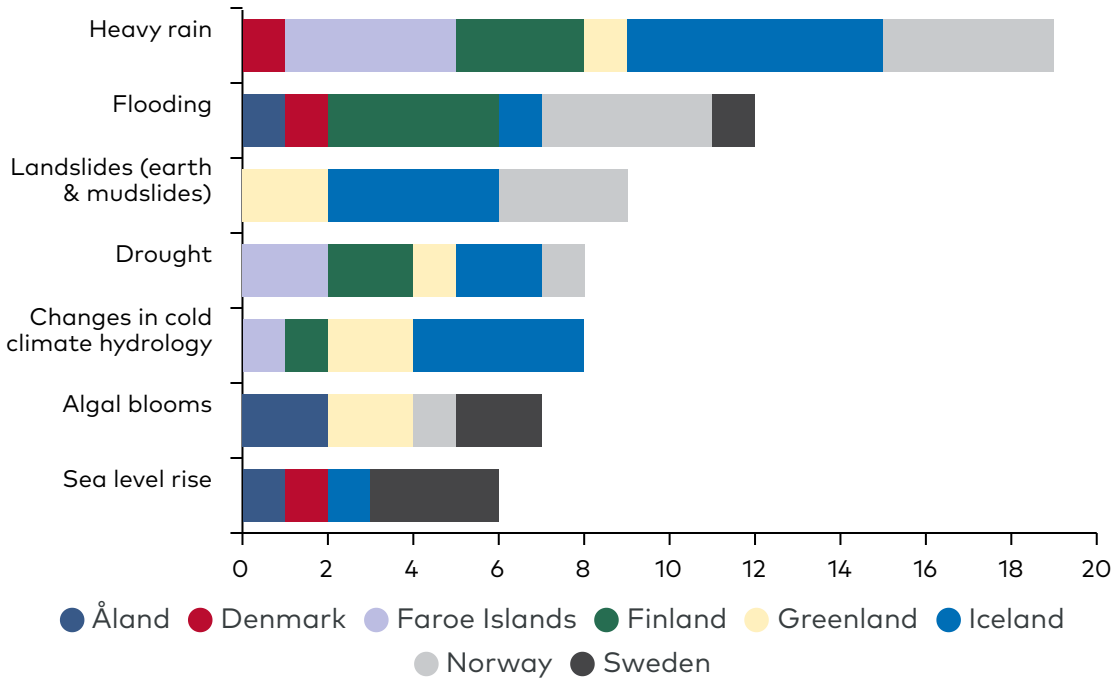

Figure 5 Climate change effects mentioned in the 53 interviews

14. Gunnarsdottir, M. J., Tómasdóttir, S., Örlygsson, O., Andradóttir, H. Ó., & Gardarsson, S. M. (2025)

Overall, the interviewees perceived that climate change is already causing consequential environmental changes and would be best addressed by integrating it into legislation and RBA guidelines along with contingency planning. National RBA guidance often lacks explicit climate modules whereas separate national tools exist in some countries, which over-burdens staff if not integrated into RBA.

One solution suggested by the interviewees is to make climate change an explicit element in guidelines but not a separate framework. Widespread experience indicates that the participation in development of RBA is critical to securing its benefits and thereby ensuring that guidelines are simple and easy to use with limited staff, while access to relevant pilot cases would assist in this. Improved preparedness of small water supplies has the potential to improve the management of risks arising from climate change and to enhance the protection of water and health more widely.

COVID-19 — lessons learned and future resilience

Paper 5 – Lessons from Covid-19 effects on small Nordic water supplies: future resilience and vulnerability

No immediate, widespread service failures in small supplies were attributed to COVID-19. During the COVID-19 pandemic the main challenges or problems reported by interviewees were vulnerabilities in staffing or system management, see Fig. 6. Among specific experiences reported by interviewees, one of the supplies interviewed, had a staff of two. Both had to quarantine because of COVID-19 but a recently retired employee took over with support from local contractors. The case illustrates strong local unity in the small settlements, which increases resilience but is often underestimated.

Problems experienced in COVID-19	Supports resilience in COVID-19
Staff related strain • Short of staff • More cleaning needed	**Contingency plan** • In place and tested for working
System managing • Reserve delivery problematic • Water patterns consumption changing	**Contextual support** • Assistance from authorities • National associations / local support
Sampling and monitoring • Problem in transport (less local traffic) • Inspection and sampling inhouse not allowed • Delayed maintenance	**Technical and management** • Automation of water supplies • Safe IT • RBA in place • Reserve equipments secured • Infrastructure in good conditions
Contextual factors • Support from authorities lacking • Less meeting attendance	

Figure 6 Problems experienced or anticipated in the COVID-19 pandemic, and factors expected to increase resilience against COVID-19, as mentioned in initial and hindsight interviews.

System management implications included delayed maintenance built up during the pandemic and constraints in delivery of spare part and other consumables. Contingency plans for a pandemic or epidemic were inconsistent in some countries and sometimes unworkable for small water supplier-level. Several operators complained about the contingency plan e.g., that the plan precluded two employees working together, but some repairs such as pipe failure could not be done by one person alone or relying on extra staff from a neighbouring water supply, was considered unrealistic, reasoning that system-specific knowledge is needed to operate it. There were also surveillance disruptions and difficulties in transporting samples to the laboratories. Automation and remote communication supported continuous system operation without human encounters; cyber-security challenges and supply logistics difficulties were evident (Fig. 6).

We interpret these findings as highlighting the value of integrating epidemic preparedness into RBA risk assessment and contingency planning; ensuring active support from the authorities, professional associations and locally in the sector; ensuring reserve equipment, and safe IT and prioritize automation of the water supply. Small settlements and their water systems have specific vulnerabilities that require appropriate planned responses.

Surveillance and inspection — role, reach, and constraints

Paper 6 – Surveillance structure and inspection challenges of small water supplies in the Nordic region

Surveillance structures vary, being placed on a governmental level (Åland, Faroe Islands, Greenland and Norway), or on a municipal level (Denmark, Finland, Iceland and Sweden). Countries that define drinking water as food (Faroe Islands, Iceland, Norway and Sweden) have the Food Agency as the main governmental institutes, otherwise it is either the Health Agency (Åland and Finland) or the Environmental Agency (Denmark and Greenland) that serve these supplies.

The size limit for regulated water supplies in legislation in some Nordic countries follows the EU DWD (10 m^3 per day or serving 50 people or commercial or public activity) with the exceptions of Denmark which regulates all water supplies except for supplies serving one household and Greenland, the Faroe Islands and Norway, all of which regulate all water supplies of all sizes, though sometimes with less surveillance for very small. Finland and Åland have a specific legislation for very small water supplies.

All the Nordic countries have mechanisms for enforcement in legislation in case of non-compliance, such as fines, closures, demanding improvements or calling on police assistance if needed. These mechanisms are very seldom used. The legislation and practice in some countries are unclear on when to involve the health authorities during non-compliance as the Chief Epidemiologist is to be the responsible authorities during pandemics.

In all the countries there is a requirement for valid official approval for regulated water supplies that has to be accepted by the surveillance authority before operation of the water supply. Legal preconditions for licensing are similar in all countries, requiring protection of the water source, evaluation of water quality and the infrastructure, and having an RBA in place. Åland and Finland require supply operators to have a valid working card confirming training, including training in water quality issues and in Denmark all regulated water supply operators are required to take courses and pass exams. Progress with licensing for operational permits or approval has been slow in some countries where many small supplies still lack such licensing.

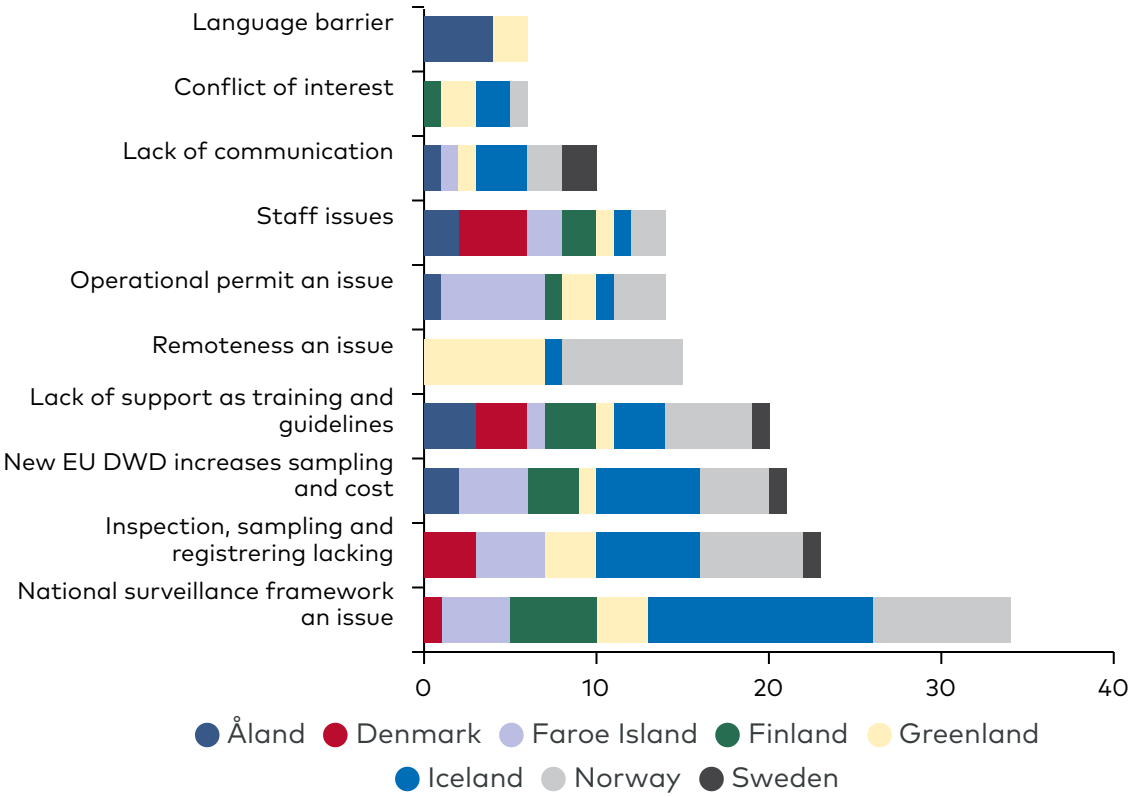

Figure 7 Surveillance constraints mentioned in the 53 interviews.

The interviews reveal some surveillance constraints that can be classified into ten categories as shown in Fig. 7. Some were mentioned in most countries, while others were only mentioned in few countries such as remoteness (Greenland, Iceland and Norway) and a language barrier (Åland and Greenland), that both translate official documents into the local language whereas training material and guidelines are less likely to be translated. The interviews highlighted interlinked challenges in drinking water surveillance such as national frameworks not working well for the small water supplies and that inspectors play a crucial yet under-resourced role in bridging the gap between regulation and local practice; infrequent inspection and sampling, especially in remote areas; increased costs associated with more frequent monitoring under the EU DWD for small supplies in some countries unless implemented with risk-based proportionality and targeted support; and insufficient technical support, training and competence requirements for operators.

Suggested solutions include strengthening inspection capacity; providing technical support to small supplies, and developing clear, adapted guidelines and easy to use training materials; improved communication channels from authorities to operators; and the publishing of monitoring results. By strengthening inspectors' capacity, supporting small supplies and embracing a risk-based approach the Nordic countries can ensure that all benefit equally from safe drinking water.

Conclusions

Our main conclusion is that the small (50–500) and very small (<50 people) water supplies are a weak link in providing safe water for all citizens of the Nordic region, as they have both higher rates of faecal contamination and waterborne outbreaks. The very small supplies are often lightly monitored or completely unregulated though serving 17% of the population. The RBA, which are required in the EU DWD, are sparsely implemented in the small supplies. The small supplies are not large supplies tailored down to small, so solutions have to be adapted to their needs. The Nordic region already has most of the pertinent legal concepts on paper. The challenge now is to make them practically workable for small systems.

Our core recommendations are to provide small system-fit templates in local languages, require and track operators training, with online options; and strengthen surveillance capacity and risk-based inspection, including auditing of RBA. This needs to be supported by cooperation between the small supplies and authorities. Climate, pandemic and other crisis risk modules must be embedded into standard RBA practice, while national registries must be completed, national water quality databases established and public reporting that include small supplies.

Our work reveals substantial opportunities to better use existing knowledge and resources to improve small drinking water systems. It is crucial to deal with them as both individuals and provide support and guidance across them at scale. Our specific recommendations are practical and attainable on the individual level and together would substantially improve the resilience of small water supplies to diverse threats, across the Nordic region and enhance drinking water safety for many. The general lessons have widespread applicability beyond the region and arguably worldwide.

Project contributors

Åland	Magnus Eriksson	Åland Environmental and Health Protection Authority
Denmark	Hans-Jørgen Albrechtsen	Technical University of Denmark
	Anna Charlotte Schultz	Technical University of Denmark
Faroe Islands	Kim Steve G. Bergkvist	Faroese Food and Veterinary Authority
Finland	Pekka M. Rossi	University of Oulu
	Riikka Matilainen	University of Oulu
	Björn Klöve	University of Oulu
	Ville Soininen	Environmental & Health Authority City of Kalajoki
	Virpi Lämsä	Environmental & Health Authority City of Kalajoki
Greenland	Lisbeth Truelstrup Hansen	Arctic DTU Sisimiut, Technical University of Denmark
	Pernille Erland Jensen	Arctic DTU Sisimiut, Technical University of Denmark
	Susanne Berglund	Ministry of Nature and Environment of Greenland
	Judith Maréchal	Arctic DTU Sisimiut
Iceland	María J. Gunnarsdóttir	University of Iceland **Project leader**
	Sigurður M. Garðarsson	University of Iceland
	Þorsteinn Narfason	Environment and Public Health Authority of West Iceland
Norway	Mette Myrmel	Norwegian University of Life Sciences
	Frida Celius Kalheim	Norwegian University of Life Sciences
Sweden	Kenneth M Persson	University of Lund
	August Bjerken	University of Lund
	Daniel Stensing	Region Gotland Municipal Authority
UK	Jamie Bartram	University of Leeds **Special advisor**
	Angela Bayona-Valderrama	University of Leeds

References

Paper 1: Gunnarsdóttir, M. J., Gardarsson, S. M., Schultz, A. C., Albrechtsen, H. J., Truelstrup Hansen, L., Bergkvist, K. S. G., Rossi, P. M., Klöve, B., Myrmel, M., Persson, K. M., Eriksson, M. & Bartram, J. (2020).
Status of risk-based approach and national framework for safe drinking water in small water supplies of the Nordic water sector. *International Journal of Hygiene and Environmental Health*, 230, 113627. https://doi.org/10.1016/j.ijheh.2020.113627

Paper 2: Gunnarsdóttir, M. J., Gardarsson, S. M., Eriksson, M., Albrechtsen, H. J., Bergkvist, K. S. G., Rossi, P. M., Matilainen, R., Hansen, L. T., Jensen, P. E., Maréchal, J. Y. A., Myrmel, M., Kalheim, F. C., Persson, K. M., Bjerkén, A. & Bartram, J. (2023).
Implementing risk-based approaches to improve drinking water quality in small water supplies in the Nordic region – barriers and solutions. *Journal of Water and Health*, 21(12), 1747–1760. https://doi.org/10.2166/wh.2023.088

Paper 3: Bayona-Valderrama, Á., Gunnarsdóttir, M. J., Rossi, P. M., Albrechtsen, H. J., Bergkvist, K. S. G., Gardarsson, S. M., Eriksson, M., Hansen, L. T., Jensen, P. E., Maréchal, J. Y. A., Myrmel, M., Persson, K. M., Bjerkén, A., Kalheim, F. C. & Bartram, J. (2024).
Water quality for citizen confidence: The implementation process of 2020 EU Drinking Water Directive in Nordic countries. *Water Policy*, wp2024013.
https://doi.org/10.2166/wp.2024.013

Paper 4: Rossi, P. M., Gunnarsdóttir, M. J., Myrmel, M., Gardarsson, S. M., Eriksson, M., Albrechtsen, H. J., Bergkvist, K. S. G., Matilainen, R., Truelstrup Hansen, L., Jensen, P. E., Maréchal, J. Y. A., Kalheim, F. C., Persson, K. M., Bjerkén, A. & Bartram, J**.** (2025).
Small water supplies in Nordic countries: climate change effects, risks and contingency planning. *Journal of Water and Health*, 23(10), 1286–1298.
https://doi.org/10.2166/wh.2025.113

Paper 5: Bartram, J., Albrechtsen, H. J., Gunnarsdóttir, M. J., Gardarsson, S. M., Eriksson, M., Bergkvist, K. S. G., Rossi, P. M., Matilainen, R., Hansen, L. T., Jensen, P. E., Maréchal, J. Y. A., Myrmel, M., Kalheim, F. C., Persson, K. M., Bjerkén, A. & Bayona-Valderrama, Á. (2026).
Lessons from Covid-19 effects on small Nordic water supplies: future resilience and vulnerability. *Submitted.*

Paper 6: Gunnarsdóttir, M. J., Gardarsson, S. M., Narfason, Þ., Eriksson, M., Albrechtsen, H. J., Bergkvist, K. S. G., Rossi, P. M., Soininen, V., Låmså, V., Hansen, L. T., Jensen, P. E., Berglund, S., Myrmel, M., Persson, K. M., Stensing, D. & Bartram, J. (2026).
Surveillance structure and inspection challenges of small water supplies in the Nordic region. *Submitted.*

European Commission (2014).
Report from the Commission – Synthesis Report on the Quality of Drinking Water in the EU examining the Member States reports for the period 2008–2010 under Directive 98/83/EC. Document 52014DC0363.

Gunnarsdóttir, M. J., Atladóttir, A. S. & Gardarsson, S. M. (2020).
Waterborne outbreaks in Iceland – analysis of scale and causes (In Icelandic). *The Icelandic Medical Journal*, 6/2020(106), 283–334.

Gunnarsdóttir, M. J., Gardarsson, S. M., Elliott, M., Sigmundsdottir, G. & Bartram, J. (2012).
Benefits of Water Safety Plans: Microbiology, Compliance and Public Health. *Environmental Science & Technology*, 46(14), 7782–7789.

Gunnarsdóttir, M. J., Persson, K. M., Andradóttir, H. Ó. & Gardarsson, S. M. (2017).
Status of small water supplies in the Nordic countries: Characteristics, water quality and challenges. *International Journal of Hygiene and Environmental Health*, 220(8), 1309–1317. https://doi.org/10.1016/j.ijheh.2017.08.006

Gunnarsdóttir, M. J., Tómasdóttir, S., Örlygsson, O., Andradóttir, H. Ó. & Gardarsson, S. M. (2025).
Impact of wildfires on the drinking water catchment for the capital area of Iceland – a case study. *Environmental Science: Advances*.
https://doi.org/10.1039/D4VA00352G

King, R., Gunnarsdóttir, M. J., Narfason, T., Hjaltadóttir, S., Sigurðsson, S., Herschan, J., Gardarsson, S. M., McKeown, R. M. & Pond, K. (2022).
Adapting sanitary inspections for the monitoring and surveillance of small drinking water supplies in Iceland. *Journal of Water & Health*, 20(5).
https://doi.org/10.2166/wh.2022.144

Klöve, B., Kvitsand, H. M. L., Pitkänen, T., Gunnarsdóttir, M. J., Gaut, S., Gardarsson, S. M., Rossi, P. M. & Miettinen, I. (2017).
Overview of groundwater sources and water-supply systems, and associated microbial pollution, in Finland, Norway and Iceland. *Hydrogeology Journal*, 25(4), 1033–1044. https://link.springer.com/article/10.1007/s10040-017-1552-x

WHO (2022)
Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda. Geneva: World Health Organization. Licence: CC BY-NC-SA 3.0 IGO. Available from: https://www.who.int/publications/i/item/9789240045064

About this publication

Improving small water supplies in the Nordic countries

Maria J. Gunnarsdóttir, University of Iceland
Sigurdur M. Gardarsson, University of Iceland
Magnus Eriksson, Åland Islands Environmental and Health Protection Authority
Hans-Jørgen Albrechtsen, Technical University of Denmark
Kim Gerlach Bergkvist, Faroese Food and Veterinary Authority
Pekka M. Rossi, University of Oulu, Finland
Lisbeth Truelstrup Hansen, Arctic DTU Sisimiut, Technical University of Denmark
Pernille Erland Jenssen, Arctic DTU Sisimiut, Technical University of Denmark
Mette Myrmel, Norwegian University of Life Sciences
Kenneth M. Persson, Lund University, Sweden
Jamie Bartram, University of Leeds, UK

TemaNord 2026:505

ISBN 978-92-893-8441-4 (PDF)
ISBN 978-92-893-8442-1 (ONLINE)
http://dx.doi.org/10.6027/temanord2026-505

Cover photo: Orhan Pergel/Pexels.com
Published: March 2026

Disclaimer

This publication was funded by the Nordic Council of Ministers. However, the content does not necessarily reflect the Nordic Council of Ministers' views, opinions, attitudes or recommendations.

Rights and permissions

The Nordic Council of Ministers

The Nordic Council of Ministers is the official body for inter-governmental co-operation between Åland, Denmark, Finland, the Faroe Islands, Greenland, Iceland, Norway and Sweden.

In 2019, the Nordic prime ministers presented a vision of the Nordic Region as the most sustainable and integrated region in the world by 2030. The work of the Nordic Council of Ministers is designed to pursue that goal by making the Nordic Region green, competitive and socially sustainable.

The Nordic Council of Ministers
Nordens Hus
Ved Stranden 18
DK-1061 Copenhagen
pub@norden.org

Read more Nordic publications on www.norden.org/publications