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The quality of sources of drinking water in the Netherlands

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Bridging Science to Practice

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1 Introduction

1.1 Reason and purpose

In its most recent inspection report, the Dutch Human Environment and Transport Inspectorate [Inspectie Leefomgeving en Transport (ILT)] argues that the quality of drinking water meets the quality standards in 99.9% of the samples, but that the development of the quality of the sources of drinking water is a reason for concern (ILT, 2018). However, these concerns are hard to specify and prioritise, as most summary reports are prepared on a themed level so that the information that is available about the quality of the sources is highly fragmented. The lack of a summary overview of the information available about the quality of sources of drinking water also makes it difficult to gain insight into the urgency and effectiveness of various policy and management options. In order to be able to properly look after the drinking water interests in water quality management and policy, Vewin asked KWR to gather information about the quality of sources of drinking water.

The purpose of this report is to bring together the most important information about the quality of sources of drinking water and to present it coherently. It discusses existing bottlenecks, as well as projected developments. As such, the report offers an extensive picture of the facts of the current condition of the sources of drinking water in terms of water quality. This summary enables the drinking water sector to address and prioritise bottlenecks in water quality issues. It can also serve as a basis for drafting the agenda and be used for looking after the drinking water interests in the water quality policy for the next few years.

1.2 Scope

The scope of this report concerns an overview of the current condition of sources of drinking water in terms of water quality, including the present risks of contamination of the water sources (environment). However, the condition of the sources is also determined by the availability of sufficient freshwater (quantity) and the possibility to protect water resources. These aspects are not dealt with in this report. This report provides a general picture of the chemical condition of the sources of drinking water and it was composed on the basis of factual information from public reports. Therefore, new insights have emerged only by presenting available information in coherence. This report is not based on any new research.

It runs parallel to the final assessment of the second generation of drinking water protection files by the National Institute for Public Health and the Environment. The report of this final assessment is expected at the end of 2019.

1.3 Strategy

This report offers an overview of the current quality of the sources of drinking water based on available factual material from the themed reports. We make a distinction between surface water, groundwater and riverbank groundwater as sources of drinking water. One reason for making this distinction is because the quality requirements for these sources are subject to different laws and regulations. The other reason is that these sources substantially differ in terms of sensitivity regarding the impact of external quality effects.

The water quality for every type of water source is described for a number of themes. For the definition of these themes, we have broadly followed the classification of the first evaluation of a series of drinking water protection files (Wuijts et al., 2014). "Salinisation" has now also been included in this report. The "emerging substances" theme is divided into "emerging substances" and "pharmaceutical residues". For the individual themes, we then consulted summary reports that were published after Wuijts et al. (2014). The most topical information has been summarised and is coherently presented in the individual chapters of this report. We also discuss a number of new threats in this report for which no summary reports are available with regard to the quality of sources of drinking water. In the concluding chapter, we use synthesis to present a coherent overview of the chemical condition of the various types of sources of drinking water.

1.4 Acknowledgements

The content of this report is based on a review of, largely, public summary reports. In addition, a large group of representatives from the drinking water sector, from Vewin (the Dutch association of water companies), RIWA (the Association of River Waterworks) and drinking water companies has provided feedback for multiple draft versions of this report. As such, this document is also the result of the knowledge of various persons from different drinking water companies and organisations such as Vewin and RIWA.

1.5 Reader's guide

Chapter 2 provides a definition of the various types of sources of drinking water. This information is important in order to understand the sensitivity of the water quality to external influences. Chapter 3 then describes the various benchmarks for water quality. It discusses the way in which standards are set, partially ensuing from European legislation and how this relates to the way in which water quality data is collected. In the next chapters, these benchmarks are used to describe the chemical condition of the sources of drinking water. The following themes are discussed, respectively: nitrate and related parameters (Chapter 4), pesticides (Chapter 5), salinisation (Chapter 6), soil contaminants (Chapter 7), pharmaceutical residues (Chapter 8) and emerging substances, including industrial substances (Chapter 9). Chapter 10 discusses a number of other threats to the water quality, namely microplastics, nanomaterials, antimicrobial resistance, drugs waste and subsurface energy storage. The concluding synthesis brings the information about these themes together and briefly discusses perspectives for action.

2 Drinking water sources in the Netherlands

2.1 Introduction

Water for the production of drinking water is abstracted from a total of 221 locations in the Netherlands (Figure 2-1). In this report, these abstraction sites are subdivided on the basis of the type of source, namely surface water (rivers, lakes and streams), groundwater and riverbank groundwater. This distinction can also be seen in the way in which the water quality is described. These three types of water sources are specified further down in this chapter.

2.2 Surface water

About 40% (500 million m^3/year) of the annual quantity of Dutch tap water is abstracted from surface water (Vewin, 2017). The intake points for surface water (nine of them) can mainly be found in the west of the country. About 40% of the surface water taken in is immediately treated to achieve drinking water quality. The rest is transported to western coastal dunes after pre-treatment. The water is infiltrated in the dunes and abstracted again after retention in the subsoil. It concerns a total of 11 infiltration abstractions (Vewin, 2017).

The majority of surface water is abstracted from the Rhine and the Meuse (both rivers) and the IJsselmeer (a lake). These rivers are fed by precipitation and groundwater from Dutch soil, as well as by the supply of surface water from Germany and Belgium, which to some extent originates from Luxembourg, France, Switzerland, Liechtenstein, Austria and Italy. Due to the larger size of the river basin and the contribution of meltwater, the Rhine by nature has much higher and more stable drainage than the Meuse. On the other hand, the drainage of the Meuse is to a large extent regulated by weirs, which means the river discharge is currently less variable than it would be by nature. The Rhine's summer discharge is roughly 100 times larger than that of the Meuse. This difference in drainage characteristics manifests itself in the sensitivity to quality change; on balance, the Meuse is more sensitive to this than the Rhine.

Waterbedrijf Groningen abstracts water from the Drentsche Aa, a stream that is fed by both rainwater and groundwater. Because of the small size of the river basin (200 km^2), discharge is diluted to a small extent only. As a result, quality effects from land use and site discharge have a big impact on the quality of the abstracted surface water. These quality effects are reduced to the greatest possible extent through rewilding and agreements with farmers.

The quality of surface water is directly affected by river discharge, discharges via sewage treatment plants and industrial wastewater treatment plants, atmospheric deposition, drift and runoff. Depending on the extent of dilution by the river's drainage, this may result in a temporary failure to meet the quality requirements for the production of drinking water. In that case, drinking water companies may impose a temporary suspension of surface water intake. They will rely on buffer stock in reservoirs, the infiltration dunes or on alternative sources. Compared to groundwater, the quality of surface water demands intensive treatment technologies in order to be able to produce water of drinking water quality. The Water Framework Directive (WFD, see Chapter 3) makes it mandatory for Member States to prevent the deterioration of the water quality and, as such, to reduce treatment intensity.

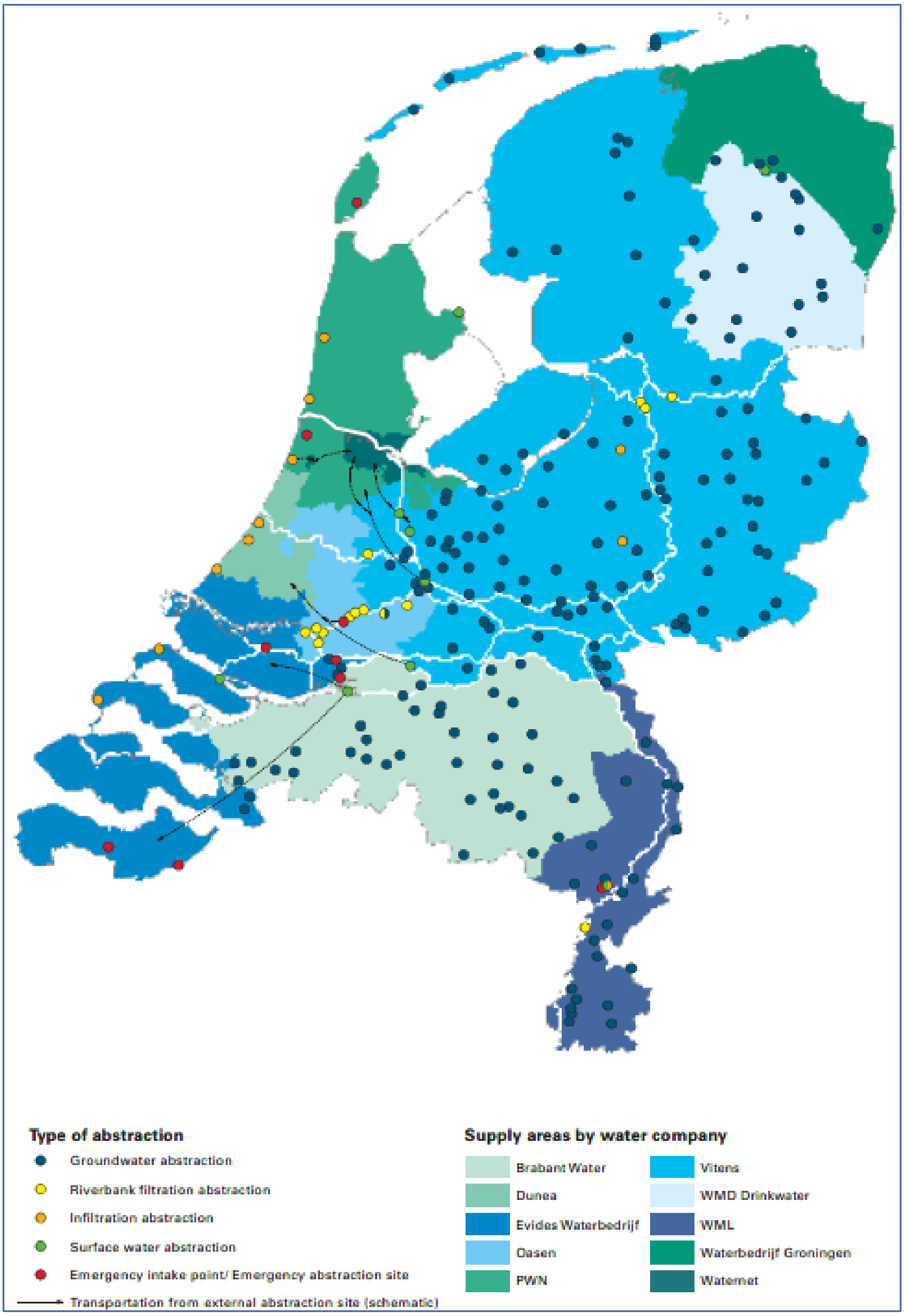


Figure 2-1: Water abstraction for the drinking water production in the Netherlands (source: Dutch Drinking Water Statistics 2017, Vewin).

Surface water is also used in infiltration abstractions, mainly in the dunes in the west of the country, where pre-treated surface water is infiltrated. As such, the dunes are one step in the treatment process. In a distant past, it was relatively easy to abstract water from the dunes, without this affecting freshwater reserves. At one point, however, demand for water started to exceed the natural replenishment in the dunes, requiring measures in order to prevent the depletion of freshwater reserves. Since the 1950s, pipelines have taken pre-treated surface water to the dunes where it is infiltrated. These days, the majority of dune-abstracted water from infiltrated surface water originates from the Rijn, the Meuse and the IJsselmeer. In order to be able to infiltrate water in the dunes, the water quality has to meet the standards of the Infiltration (Soil Protection) Decree, as well as those of the WFD (Chapter 3). The aim of the Infiltration (Soil Protection) Decree is to prevent soil contamination as a result of infiltration with contaminated surface water. The quality of the surface water used for infiltration abstraction also has to meet the WFD criteria. These criteria have been drawn up in order to maintain 'a sufficient surface water quality for the aquatic ecosystem for dune water with WFD targets'.

2.3 Groundwater

In the Netherlands, 55% of the drinking water is produced from groundwater (Vewin, 2017). This groundwater is abstracted from approximately 200 sites, mainly in the east and south of the Netherlands (Figure 2-1). The groundwater that is pumped up there can be a couple of years or decades old, but also centuries or even millennia. This means quality effects of activities and emissions in the surrounding areas have a delayed impact on the quality of the abstracted groundwater. Also, the effects of contaminants attenuate due to mixing of groundwater of varying ages and origin at the abstraction wells, and because of degradation or conversion in the subsoil during transport towards the wells. The extent to which contaminants are degraded or converted depends on the characteristics of the contamination, the characteristics of the subsoil and the characteristics of the abstraction and, therefore, it differs from location to location. We do see a couple of patterns, however. For instance, a lot of groundwater abstractions are vulnerable to activities at the ground surface. Unconfined aquifers that are not protected by a natural, poorly permeable layer (such as clay) are particularly vulnerable, that is, there is a relatively high risk of contamination because the protective, poorly permeable layer is missing. Groundwater that is abstracted from confined aquifers is better protected against the impact of activities or emissions at ground level. On the other hand, these abstractions can also affect activities underneath the poorly permeable layer (such as mining) and they are characterised by a large infiltration or risk area. Also, groundwater from confined aquifers may be of sub-optimal quality for drinking water production, for instance, due to high concentrations of natural substances such as iron, methane, manganese and arsenic.

Because of these attenuation mechanisms of the impact of quality effects, groundwater, especially compared to surface water, is of a more constant (level) quality, with only minor fluctuations on a scale of hours to days. In general, the quality of groundwater changes slowly, taking years to decades. This means that once a contaminant has entered the abstracted groundwater, it will often remain there for a long time. To date, the quality of the abstracted groundwater in many locations is insufficient in order to be able to produce drinking water on the basis of relatively simple treatment (aeration and sand filtration). In 2017, the Water Advisory Committee indicated that the quality of groundwater is under increasing pressure. Again, the use of sophisticated technologies is one of the options, but this opposes the provision of the Water Framework Directive to aim for a reduction of treatment intensity (see Chapter 3).

2.4 Riverbank groundwater

In the Netherlands, 5% of drinking water is produced from riverbank groundwater, which is abstracted at 14 sites (Vewin, 2017). This means that groundwater is abstracted from the immediate surroundings of rivers, thereby indirectly instigating the infiltration of surface water. This infiltrated surface water is pumped up after a short residence in the subsoil and is treated to become drinking water. In contrast with direct intake of surface water, a selective intake of surface water during riverbank groundwater abstraction is not possible. On the other hand, whilst making their way through the subsoil, concentrations are levelled due to mixing and degradation. Nevertheless, the quality of riverbank groundwater strongly depends on the quality of surface water.

3 Policy, legislation

3.1 Introduction

Water, and water quality in particular, is dealt with in our legislation in various ways. All administrative bodies of the government: the central government, provinces, local authorities and water authorities, have a shared responsibility,. Many European policies, such as the European Water Framework Directive also extend to Dutch legislation. Apart from specific water-related legislation, we also have legislation about, for instance, (industrial) activities and the admission and use of certain substances. This chapter provides an overview of the most important legislation, paying specific attention to the benchmarks for assessing the water quality defined therein.

3.2 Water management

The Dutch Drinking Water Act imposes a duty of care on all authorities that are directly or indirectly involved in the supply of drinking water. Apart from infrastructure, this duty of care also relates to the sources of drinking water. This duty of care is partly structured in the form of statutory regulations, but it also serves as a starting point for the formulation of a policy where there are no rules. This enables authorities to structure the duty of care in various ways. Under the Dutch Drinking Water Act, drinking water companies also have a duty of care when it comes to protecting their own abstractions. This means that drinking water companies are obliged to tackle the bottlenecks in order to protect the sources and to help the authorities responsible implement the protection policy.

Under the Dutch Drinking Water Act, the central government is responsible for a national strategy. Within that framework, the central government draws up the National Water Plan, for instance, setting out the main features of the national water policy, with aspects of the national spatial policy. This system will change after the implementation of the Dutch Environment and Planning Act, which combines 26 acts in the fields of spatial zoning and the environment.

The Dutch Drinking Water Act explains the executing tasks of water management authorities. It also stipulates which party is responsible for the various bodies of surface water. In practice, this means that the water authorities are responsible for regional water systems and the central government for the main water system.

Responsibility for groundwater management is more fragmented. The responsibilities and powers are linked to specific subsoil activities in the subsoil (Sterk Consulting & Colibri Advies, 2012). The Dutch Environmental Management Act makes it mandatory for provinces to protect the groundwater. For instance, this act stipulates that the province determines the policy for regional water quality in a regional water plan. The groundwater protection policy for areas where groundwater is abstracted for the production of drinking water is also set out in provincial environmental by-laws. In principle, these by-laws offer the provinces the opportunity to impose additional bans, restrictions on use or measures within protection zones in, for instance, water abstraction areas, groundwater protection areas and/or drilling exclusion zones. The provinces tackle some cases, such as pesticides, mainly through awareness-raising, education and incentive programmes (Swartjes et al., 2016).

Local authorities also have duties when it comes to water management, primarily concerning the precipitation and groundwater duty of care. Sewer management also forms part of the duties of the local authorities, as set out in the Dutch Environmental Management Act.

3.3 European policy and effects

European policies have an impact on Dutch legislation. The National Water Plan, for instance, sets out the implementation of various European directives, such as the Floods Directive and the Water Framework Directive (WFD). Elements include the River Basin Management Plans, the Marine Strategy Set of Measures, the North Sea Policy Memorandum and the Flood Risk Management Plans. The most recent National Water Plan sets out the main features of the national water policy and the associated aspects of the national spatial policy for a period of six years (2016-2021) (Ministry of Infrastructure and Water Management, 2015). The preparations for the third National Water Plan are already in full swing.

The WFD is one of the most important directives with regard to assessing water quality. The WFD (2000/60/EC) and its "daughters", the Groundwater Directive (2006/118/EC) and the Priority Substances Directive (EU Directive 2013/39) are of direct significance for the quality of drinking water sources. Other important directives in connection with the water quality of sources of drinking water are the Nitrates Directive (91/676/EC), the Industrial Emissions Directive (2010/75/EU) and the Urban Waste Water Treatment Directive (91/271/EC).

In the field of pesticides or crop protection agents[1], the European Regulation concerning the placing of plant protection products on the market (1107/2009/EC) and the Directive concerning the sustainable use of pesticides (2009/128/EC) are of significance. Such legislation in respect of the admission and use of substances, as well as the REACH legislation (1907/2006/EC), has a direct or indirect impact on Dutch legislation. Other directives may be related to water management in the Netherlands, but they do not specifically focus on the contamination of drinking water sources. Examples include the Marine Strategy Framework Directive (2008/56/EC), the Bathing Water Directive (2006/7/EC), the Directive on the quality required of shellfish waters (79/923/EC) and Natura 2000. On a closing note, the (European) Common Agricultural Policy contains guidelines for best agricultural practices aimed at, among other things, reducing the burden on groundwater and surface water caused by fertilizers and pesticides.

The European Drinking Water Directive (98/83/EC) serves to protect public health against contaminants that reach us through drinking water. The Drinking Water Directive sets out quality requirements that apply specifically to drinking water. The quality of the sources of drinking water is one of the determining factors to realise these quality requirements.

3.3.1 Requirements under the Water Framework Directive (WFD)

In order to reach the targets of the WFD, water has to meet certain requirements. For that reason, the WFD not only specifies ecological targets but also chemical water quality targets for the condition of bodies of groundwater and surface water. Article 7 of the WFD specifically deals with the quality of the bodies of water and abstraction for human consumption. Following on from Article 7.1, the sites in the Netherlands where water is abstracted for the production of drinking water are listed in a register for protected areas (Informatiehuis Water, 2019). At these sites, the water quality has to meet agreed quality requirements, which directly follow from the WFD, the Priority Substances Directive and the Groundwater Directive.

Article 7.2 of the WFD also stipulates that the Member States have to achieve the ecological and chemical objectives to such extent that it is possible to produce drinking water that meets the requirements set out in the Drinking Water Directive (98/83/EC). To that end, additional quality requirements and protection zones may be implemented. These so-called environmental quality requirements are listed in the next paragraph (3.3.2).

On a closing note, Article 7.3 explains that the Member States have to protect the bodies of water intended for the production of drinking water in order to prevent a deterioration of the water quality to such extent that the level of treatment required for the production of drinking water can be lowered in time. The relevant monitoring and verification methods are detailed in paragraph 3.3.3.

[1] This report refers to 'pesticides' (in Chapter 5, for instance), while legislation also uses the terms 'crop protection agents' for, largely, the same group of substances. 'Crop protection agents' are substances used in agriculture, while pesticides also include substances that are used outside the agricultural sector ('biocides').

3.3.2 Water quality requirements

The most specific requirements for groundwater and surface water are listed in the appendices of the Water Quality Requirements and Monitoring Decree 2009. For instance, Appendix I of this decree lists the European environmental quality requirements for water for priority substances and certain other contaminants. Appendix II of the decree specifies the European groundwater quality standards for the healthy chemical condition of bodies of groundwater. These have been stipulated on a European level for nitrate and the active ingredients of pesticides. This appendix also sets out the Dutch threshold values for chloride, nickel, arsenic, cadmium, lead and total phosphorus. For chloride, arsenic and total phosphorus, a distinction is made between freshwater and salt water. Appendix III of the decree includes the specific (European) environmental quality requirements derived from surface water that is used for the production of drinking water.

The underlying 'WFD drinking water sources monitoring and verification protocol' (or the 'Protocol') provides more information about monitoring. This specifically implements the way in which the quality of groundwater, riverbank groundwater and surface water is monitored on the basis of the requirements set out above (Dutch National Groundwater Task Force, 2013). The Protocol also prescribes the way in which the abstraction status is verified (Helpdesk Water, 2019).

Riverbank groundwater is a separate category in this respect, for that matter. The Protocol argues that in the case of riverbank groundwater abstraction, groundwater is abstracted that predominantly consists of surface water that has reached the abstraction wells through soil passage. The groundwater manager uses the results of the monitoring carried out by the surface water manager as early warning information. The risks of exceeding values in the abstraction wells are assessed on the basis of how long the water remains in the soil (based on signalling values). This is how both the quality of the abstracted groundwater and the quality of the infiltrating surface water are assessed (Helpdesk Water, 2019).

3.3.3 Treatment intensity (Article 7.3 of the WFD)

The Protocol offers a reference for the verification of the regulation to aim for reduced treatment intensity in accordance with Article 7.3 of the WFD. After all, in the case of regulated substances in the Drinking Water Decree, the signalling value for groundwater in the Protocol is equal to the standard, while the assumption for new substances for which no standard exists is 0.1 µg/l. This value is based on the target values from the European River Memorandum (ERM), which serves as an international reference for the drinking water sector for simple treatment and which, in general, is used as a precaution for so-called 'anthropogenic substances' (i.e. substances that end up in the environment due to human action). As the signalling values from the Protocol are linked to a simple treatment method, the extent to which the quality development of the drinking water sources corresponds with the WFD targets is thus verified.

In the event of an environmental quality requirement being exceeded or in the event of a deterioration of quality, the water manager is obliged to take measures. A best-efforts obligation applies to improving quality with a view to reducing treatment intensity. The Protocol also stipulates that when a signalling value is exceeded, the water manager has to take follow-up measures, because this may be an indication that the quality of the drinking water sources does not correspond with Article 7.3 of the WFD. The follow-up measures mentioned in the Protocol are intended to find an unambiguous definition of the problem and to determine the best way of dealing with identified problems and risks. Following on from the impact on surface water, this still needs to be brought into operation for groundwater, however (Helpdesk Water, 2019).

3.3.4 Standards for other substances

This report predominantly uses the standards from the WFD, but there are also standards for substances that do not fall under the WFD. They include substances, for instance, for which values are derived when an application for a discharge permit is made, and substances with standards that were derived for water managers in order to assess their water quality (pesticides, mostly).

3.4 Quality control

3.4.1 General
Collecting water quality data and the quality control of bodies of water are primarily the responsibility of the water managers. The Directorate-General for Public Works and Water Management [Rijkswaterstaat] is primarily responsible for quality control of the Rhine, the Meuse and the IJsselmeer, while the water authorities are responsible for smaller, regional bodies of water. The provinces are responsible for strategic groundwater management, realising the WFD/Groundwater Directive targets and granting abstraction permits for groundwater abstraction for drinking water, among other things. They do not have implementing instruments, for which they have to rely on the water authorities and the local authorities.

This quality control is often carried out in close consultation with the drinking water companies. Drinking water companies do not only carry out measurements by virtue of their obligation under specific drinking water legislation in connection with groundwater and surface water (see the paragraphs below), but they also carry out measurements in the interest of business operations and in order to be able to act proactively on the basis of up-to-date information. The drinking water companies play a role in the early detection of threats, monitoring the water quality of the drinking water sources and looking for ways to improve the monitoring method.

3.4.2 Groundwater: early warning and source protection
In order to monitor the quality of groundwater, drinking water companies and the provinces use a measuring network with observation wells at various depths in the vicinity of most abstraction sites. An early warning measuring network is currently under development, for which shallow measuring filters will be assigned or installed as set out in, for instance, the WFD drinking water sources monitoring and verification protocol (Helpdesk Water, 2019). These measuring networks are used to collect information about the contaminants that enter groundwater abstraction sites. This information can be used to take specific measures so as to improve the quality of groundwater (source-specific measures) or to safeguard the quality of drinking water (effect-specific measures). Examples of such measures include capturing contaminant plumes from point sources by means of interception wells, relocating wells, mixing various raw water streams or, in extreme cases, temporarily increasing treatment intensity.

Apart from this legislation, the Dutch Soil Protection Act is also of importance for groundwater quality, because this act regulates discharges into or on the soil and the clean-up of contaminated soil and groundwater. The Soil and Subsoil Agreement (2016-2020) is of importance for the quality of the subsoil because it contains agreements about the implementation of the clean-up task for urgent sites.

3.4.3 Groundwater: signalling value
Following on from the aforementioned basic principles and because the treatment at groundwater abstraction sites for drinking water is often limited, the Dutch National Groundwater Task Force agreed to check the water quality of abstracted groundwater (raw water) against the standards of the Drinking Water Decree for the purposes of the WFD task (Dutch National Groundwater Task Force, 2013). These working agreements have been confirmed in the Protocol that prescribes that the quality of abstracted groundwater has to meet the standards of the Drinking Water Decree. However, this Protocol uses the term 'signalling value' rather than 'standard'. Signalling values are not environmental quality requirements that force the water manager by law to take measures in order to achieve the required water quality. They are tools to verify to what extent the quality development of drinking water sources corresponds with the WFD targets for water for human consumption (Article 7 of the WFD). In order to be able to provide a reference during testing, the extent of a signalling value is based on a value that corresponds with the application of simple treatment. Signalling values are also used to describe the condition and the determination of the target gaps in the drinking water protection files.

3.4.4 Surface water: early warning and intake policy
Under drinking water legislation, drinking water companies play a highly active role in the quality control of the surface water abstracted for the production of drinking water. Apart from mandatory monitoring systems at the intake points of surface water for the production of drinking water, the drinking water companies also have additional monitoring systems in place that continuously monitor the water quality. These systems can differ, depending on company and intake site, and they consist of organic monitoring (e.g. by using water fleas or mussels) and/or a semi-continuous chemical analysis of the water quality (e.g. by means of HPLC-UV, high-performance liquid chromatography separation method and a detection method that uses UV light (van Wezel et al., 2010). If these measuring results deviate from the normal pattern, the water company will study this and may decide to suspend or adjust the intake process. When the intake is suspended, drinking water can

temporarily be produced from alternative (backup) intake points or buffers such as reservoirs in the Biesbosch or the infiltrated water reserves in the dunes. Drinking water companies supplying each other is also an option.

3.4.5 Surface water: a rise in exemptions

Drinking water legislation has been offering the option of exemption since 2011. If statutory monitoring shows that the value of an identified substance is higher than permitted (quality requirement or signalling value from the Drinking Water Regulation), the drinking water company has to report it to ILT. If contamination concentrations are higher than the standard or the detection method for more than 30 days and if the drinking water company still has to take in water, it can ask ILT for an exemption. This is also necessary when drinking water companies expect exceeding standards to last more than 30 days. The Netherlands National Institute for Public Health and the Environment (RIVM) checks an exemption for any risks to public health. In 2015, three Dutch drinking water companies were granted a temporary exemption to take in river water that contained pyrazole, an emerging substance. In 2016, another drinking water company was granted an exemption for melamine, another emerging substance. The year 2017 saw a rise in the number of exemptions applied for and granted: six drinking water companies were granted a temporary exemption for 16 substances. In 2017, the inspectorate granted a total of 22 exemptions, a sharp rise which ILT believes is a sign that the quality of surface water as a raw material for drinking water remains a point for attention (ILT, 2018). Please note that this rise in the number of exemptions can partially be attributed to clearing backlogs. The data for 2018 was not yet known at the time this report was written.

3.4.6 Drinking water legislation

In Dutch legislation, the European Drinking Water Directive has an impact on the Drinking Water Act, the Drinking Water Decree and the Drinking Water Regulation. This legislation attaches requirements to drinking water quality and monitoring of drinking water and the water to be abstracted, to be implemented by the drinking water companies. Every year, the drinking companies carry out a total of more than one million water quality measurements, 620,000 of which form the basis for the annual ILT reports (see, for instance, ILT, 2018). One important detection parameter in the Drinking Water Regulation is the group of 'other anthropogenic substances' for the timely detection of increasing concentrations of potentially hazardous substances. The Drinking Water Regulation sets a value of 1.0 µg/l, and this applies to drinking water companies. In the Protocol that applies to water managers, the value of this detection parameter is a factor 10 lower (namely 0.1 µg/l). The reason for this is that water managers can implement the precautionary principle and contaminants can be detected early. For that matter, the Protocol signalling values for all hazardous substances are equal to the standard for drinking water in the Drinking Water Decree.

Acceleration tables and the Water Quality Delta Strategy

In part following a call from the Second Chamber, the Minister for Infrastructure and Water Management took the initiative to set up the Water Quality Delta Strategy, a strategy in which all the players in the water chain bundle their initiatives to tackle water quality-related bottlenecks. At the end of 2016, the parties involved signed a letter of intent to that effect. At the start of 2018, the Minister for Infrastructure and Water Management worked actively to come to administrative agreements. In the revamped set-up (autumn of 2018), so-called acceleration tables were set up with the aim of reaching specific agreements to further improve water quality, also aimed at vulnerable functions such as drinking water sources (Figure 3-1).

The Water Task Force gave the instruction for the Water Quality Delta Strategy. In order to achieve the desired acceleration, two administrative acceleration tables were proposed: Nutrients and pesticides ("agriculture") and emerging substances and pharmaceutical residues ("substances"). There is also an administrative table called Comprehensive Delta Strategy for overlapping themes. The aim of the acceleration tables is to give the priorities of the Delta Strategy a boost and more depth. The parties, both authorities and chain partners, organise the mandate and the agreement in which administrative agreements are set out.

3.5 Water Quality Delta Strategy

Apart from the aforementioned legislation, 2016 also saw the start of the Water Quality Delta Strategy. The aim of the Delta Strategy is to speed up the realisation of the WFD targets so that the necessary measures will have been taken by 2027. The governance structure of the delta strategy is shown in Figure 3-1.

The Delta Strategy lists threats to the sources of drinking water as a priority. It specifically concerns fertilizers, pesticides, pharmaceutical residues and emerging (industrial) compounds. The Minister for Infrastructure and Water Management has indicated that he wants to make administrative agreements about the measures that will actually improve water quality. To that end, administrative acceleration tables were started at the end of 2018 (see inset). The aforementioned contaminants will be discussed in the next few chapters.

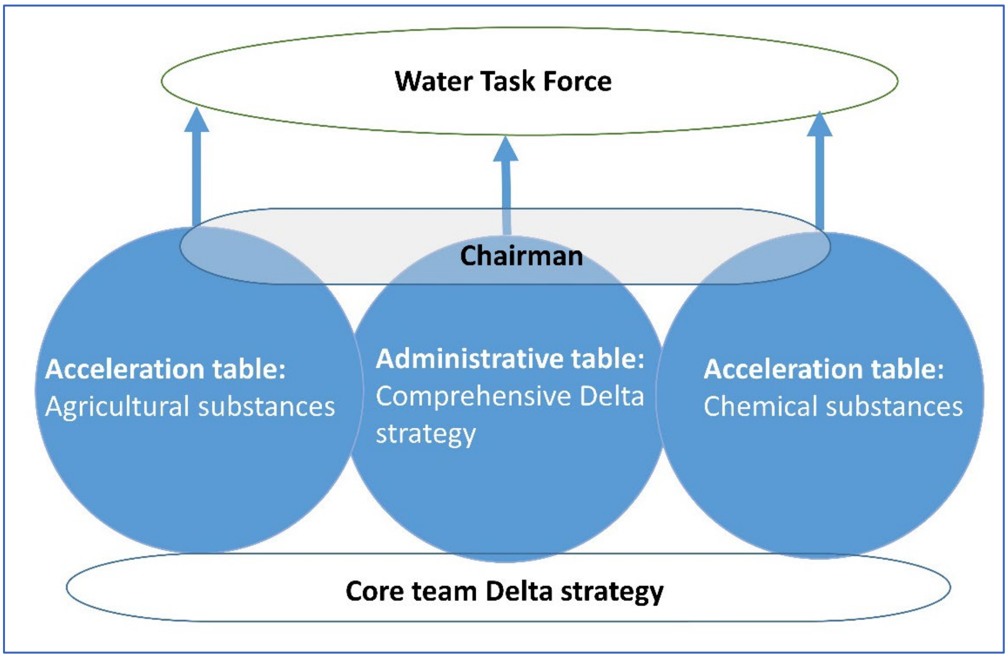


Figure 3.1: (New) governance structure for the Water Quality Delta Strategy

4 Nitrate and related parameters

4.1 Introduction

In the Netherlands, it is mainly fertilizers such as phosphorus and nitrogen that negatively affect water quality. Issues with phosphorus (phosphate) mainly occur in surface water, while problems with nitrogen (nitrate) mostly occur in groundwater. So far, phosphate is not yet an issue for the quality of surface water taken in that is used for the production of drinking water, because this substance is removed from the production process at an early stage. One of the ways to do this is through iron dosing before the intake point. Nitrate is among the substances that pose a risk to the production of drinking water from groundwater.

4.2 National picture of nitrate leaching

Since the 1990s, the Dutch government has been pursuing an active fertilizer policy through regulation of the use of fertilizers in the agricultural sector. To that end, the Netherlands has been divided into different regions on the basis of the most prevalent type of soil. This policy has helped to strongly reduce nitrate leaching from agricultural areas. As a result, average nitrate concentrations in water that leaches into groundwater underneath agricultural land in the sand region have fallen from about 200 mg/l in 1991, to 50 mg/l since 2012. The reduction of nitrate concentrations in the sand region has stagnated since 2012 (Fraters et al., 2016).

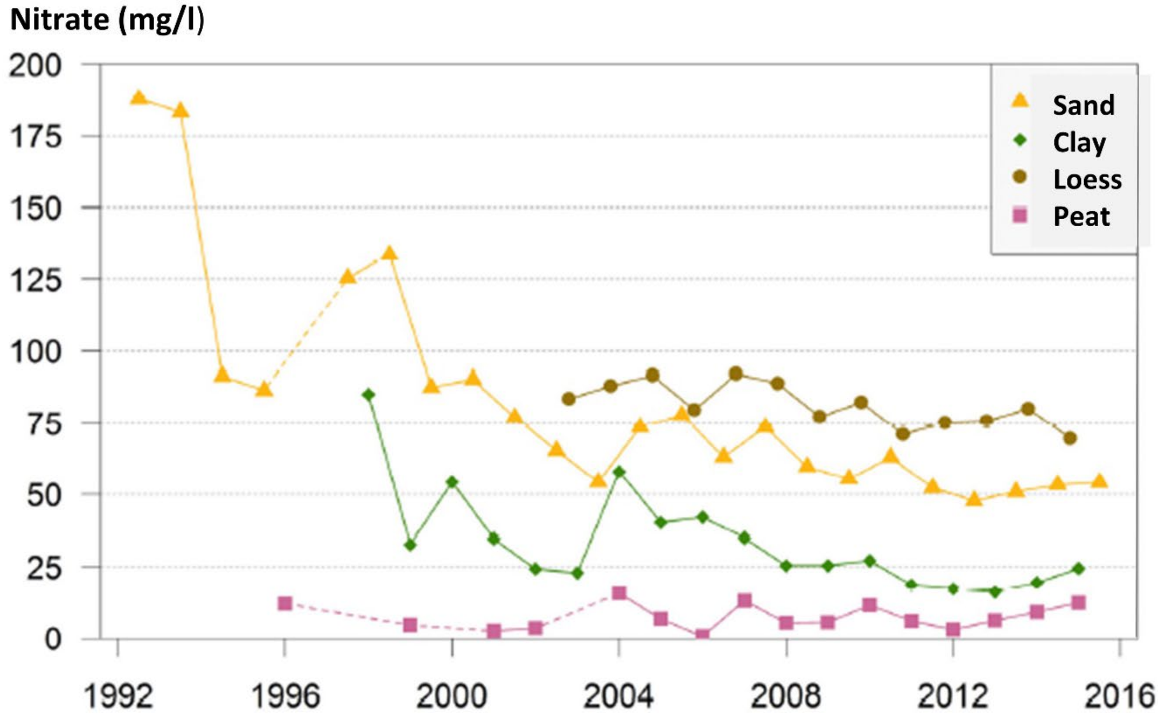


Figure 4-1: Nitrate concentrations in the water that leaches from the root zone on farms per region between 1992 and 2014. Annual averages of measured concentrations. Source: Fraters et al., 2016.

To date, the fertilizer policy in the loess region has been less successful. Average nitrate concentrations in leaching water have fallen to approximately 75 mg/l in 2015 (Figure 4-1, Fraters et al., 2016). An interim evaluation conducted by the PBL indicates that nitrate leaching from farming land on loess land has declined during the past few years and that the nitrate targets are now in sight for those areas too (Environmental Compendium, 2018). The next few years will prove if the reduction of nitrate leaching is structural and to what extent it will improve the quality of groundwater. Dry summers such as 2018 may result in, among other things, a temporary rise in nitrate concentrations in shallow groundwater underneath farming land as a result of a reduction in crop intake, an accelerated breakdown of organic matter and a reduced dilution from precipitation excesses.

Most groundwater abstraction sites for the production of drinking water can be found on dry land and, as such, the most vulnerable parts of the sand region. This means nitrate concentrations in leaching water in the groundwater protection areas are often higher than the average concentrations for the region as a whole (Van Loon & Fraters, 2016). Depending on the characteristics of the abstraction and the subsoil, leaching water in groundwater protection areas will end up in groundwater abstractions within a number of years to decades. In the meantime, all kinds of conversion processes can take place, resulting in increased concentrations of, for instance, sulphate and nickel in deeper groundwater and hardness may increase due to liming and the supply of acids (Figure 4-2).

Limited conversion of nitrates takes place near 10 to 15 shallow groundwater abstractions from oxic aquifers, which means nitrate concentrations in deep groundwater and in abstracted groundwater are higher than the standard of 0 mg/l (Van Loon & Fraters, 2016). In this situation, future nitrate concentrations in abstracted groundwater will be about the same as the current average nitrate concentrations in leaching water in the area around the abstraction site.

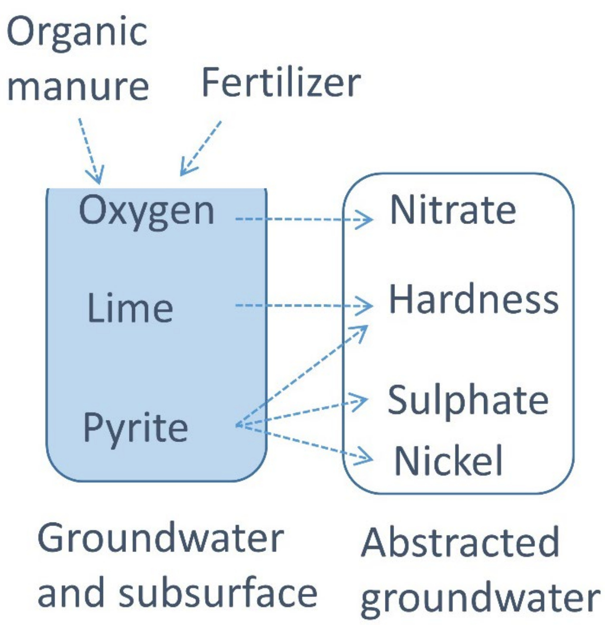


Figure 4-2: conceptual representation of the impact of fertilizer toxins on a number of chemical parameters that determine the quality of pumped-up groundwater.

4.3 Quality requirements

The Drinking Water Decree provides the most significant benchmark for the assessment of nitrate and related parameters in abstracted groundwater. In addition, the Groundwater Directive and the Nitrates Directive contain standards for nitrate in groundwater. In these directives, the standard for nitrate in groundwater and abstracted groundwater has been set at 50 mg/l. Furthermore, the Drinking Water Decree contains standards for a number of parameters that are often, but not always, related to manure (Table 4.1). Strictly speaking, the Drinking Water Decree only relates to the chemical quality of drinking water (clear water). As the treatment at groundwater abstraction sites is often limited, the Dutch National Groundwater Task Force agreed to check the water quality at groundwater abstraction sites against the standards of the Drinking Water Decree for the purposes of the WFD task (Dutch National Groundwater Task Force, 2013). In addition, the WFD prescribes a best-efforts obligation in order to reduce treatment intensity (see Chapter 3).

Table 4.1: Raw water standards for nitrate, sulphate and nickel in accordance with the Drinking Water Decree.

Substance	Standard
Nitrate	50 mg/l
Sulphate	150 mg/l
Nickel	20 µg/l

4.4 The condition of sources of drinking water

4.4.1 Non-compliance with standards

Since the 1990s, the manure surplus in the agricultural sector has fallen sharply. Nevertheless, the standards for the parameters that are often related to nitrate leaching are exceeded in the abstracted groundwater at many abstraction sites on high sand grounds and in the loess area (in individual abstraction wells, Van Loon & Fraters, 2016). Depending on the characteristics of the abstraction process and the subsoil, the effects of nitrate leaching manifest themselves in, among other things, increased concentrations of nitrate, sulphate and nickel and an increase in the total hardness of raw water (Figure 4-3). According to Van Loon & Fraters (2016), non-compliance with standards for these parameters in individual raw water (in pumping wells) was discovered in one or more abstraction wells of 86 groundwater abstraction sites across the south and east of the Netherlands between 2000 and 2015. At eight groundwater abstraction sites, the standard for nitrate was exceeded, that for nickel at 11 and that for sulphate at two, that for high hardness at 33 and for several of these parameters at 35 (Van Loon & Fraters, 2016). In a number of cases, the non-compliance with standards is not (just) the result of nitrogen leaching. Drainage, old soil contaminants, infiltrating surface water, salinisation and acid depositon may also have contributed to this. This does, in any case, applies to the non-compliance with standards for nickel in the abstracted groundwater at three abstraction sites on the Frisian Islands and to the high hardness in the abstracted groundwater at six abstraction sites in the province of Friesland.

4.4.2 Nitrate leaching in groundwater protection areas

The non-compliance with standards for parameters that are often related to nitrate leaching in the abstracted groundwater on dry sand and loess are, to some extent, related to the high historical burden which, as a result of the decades it takes groundwater to travel to the groundwater abstraction sites, now manifests itself in the water quality of the abstractions. However, calculations made by Van Loon & Fraters (2016) and Claessens et al. (2017) indicate that the generic fertilizer policy for about forty groundwater abstraction sites is insufficiently effective to be able to prevent non-compliance with standards for parameters that are often related to nitrate leaching in the pumped-up groundwater in the future. According to the calculations made by Claessens et al. (2017), the average nitrate concentrations in shallow groundwater within the groundwater protection areas will, in the long term, exceed 40 mg/l (Figure 4-3). The nitrate standard of 50 mg/l in shallow groundwater in these areas may already be exceeded under the current fertilizer policy. Claessens et al. (2017) also calculated that in 53 other groundwater protection areas, nitrate concentrations in shallow groundwater have risen (NO_3 > 25 mg/l) due to nitrate leaching from agricultural land.

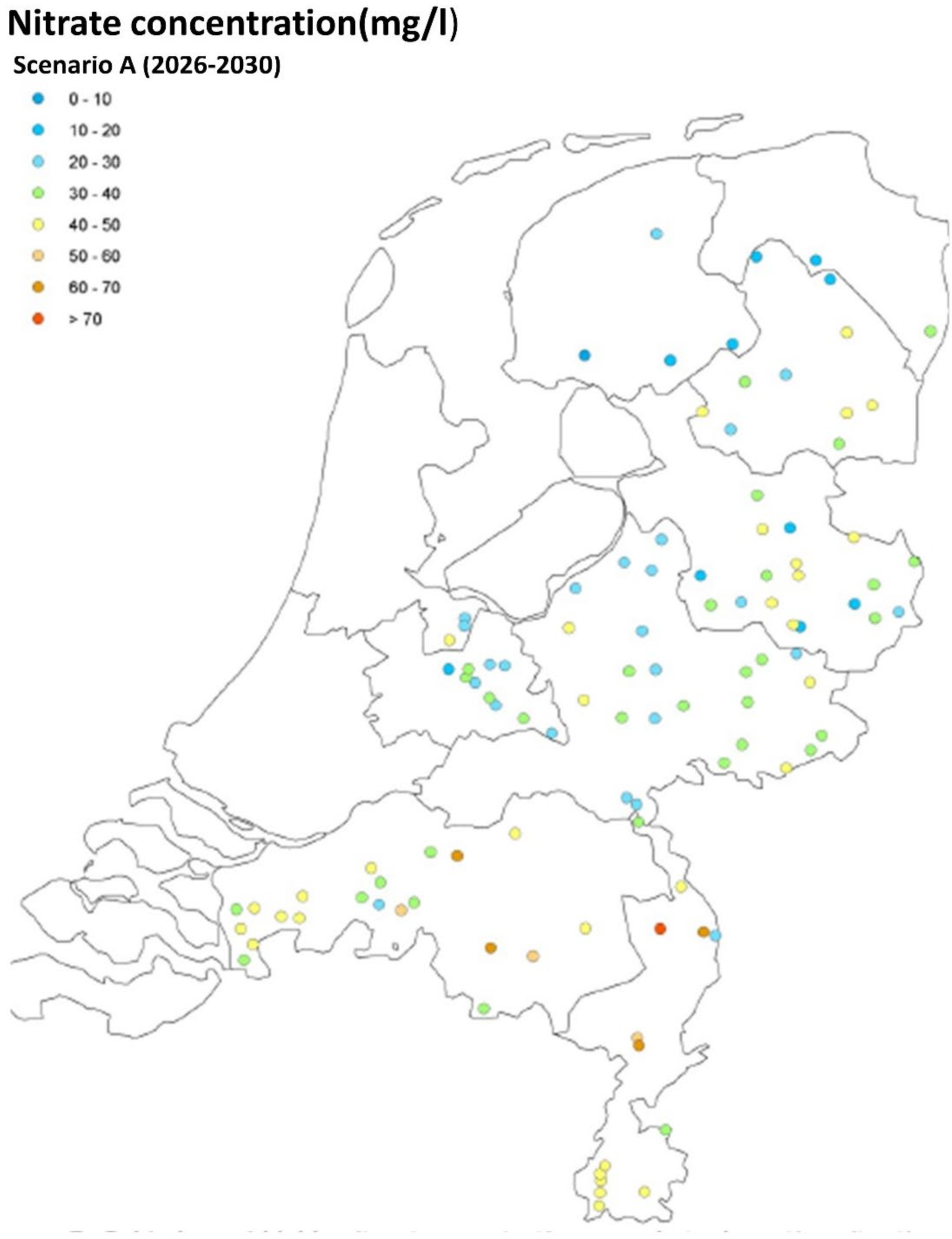


Figure 4-3: Area-average nitrate concentrations for vulnerable groundwater protection areas under the system of standards of use of the fifth Action Programme 2014-2017, calculated by means of STONE (Claessens et al., 2017)

4.5 Outlook

In 2017, an administrative agreement was concluded between Vewin, IPO, the Ministry of Agriculture, Nature and Food Quality, the Ministry of Infrastructure and Water Management and the Dutch Federation of Agricultural and Horticultural Organisations. Under this agreement, arrangements were made about voluntary measures in the 34 most vulnerable groundwater protection areas. The aim is to take measures within the term of the current (sixth) Nitrates Directive Action Programme in order to structurally get average nitrate concentrations in leaching water within groundwater protection areas below the standard of 50 mg/l as soon as possible but within the term of the next (seventh) Action Programme. To that end, the provinces, the water company and the regional agricultural organisation in question have concluded implementation agreements. If interim evaluations show that the suggested strategy offers insufficient perspective of achieving the target in time, mandatory measures may be an option.

The nitrate concentrations in groundwater in the groundwater protection areas of dozens of other groundwater abstraction sites may be below the standard, but they are raised as a result of nitrate leaching from agricultural land. By virtue of Article 7.3 of the WFD, water managers in these areas are obliged to take measures if nitrate concentrations in groundwater rise (in that case, the quality of groundwater drops). These measures should result in a quality improvement of abstracted groundwater in the medium to long term, while treatment intensity can be reduced. This is done via the drinking water protection files and the programmes of measures of the River Basin Management Plans.

In a number of areas with a pyrite-rich subsoil, so far, there have not been any cases of non-compliance with standards for parameters that are often related to nitrate leaching in abstracted groundwater. This can be attributed to denitrification under the influence of pyrite. The nickel found in these abstractions may be a precursor for problems with other metals such as cadmium, copper, zinc and arsenic. These metals also occur when pyrite oxidises, but they are less mobile than nickel due to a partial bond with the soil matrix, which means it will take some time for any problems to manifest themselves. Research into the long-term effects of nitrate leaching on the quality of abstracted groundwater is needed in order to determine their relevance to the policy.

5 Pesticides

5.1 Introduction

Among other things, pesticides are used to protect crops, public parks and gardens against fungi (fungicides), insects (insecticides) or weeds (herbicides). Pesticides form a highly diverse group of substances that develops continuously in terms of quantities and properties of permitted substances. In 2018, for instance, a total of 1001 substances and 1654 biocides were admitted to the Dutch market. A number of them are offered as alternatives for substances that were already excluded from the Dutch market (Board for the Authorization of Plant Protection Products and Biocides, 2019).

Depending on the use and method of application, such as spraying, scattering, rendering or submerging, leaching may cause the active ingredients to end up in groundwater and, particularly through runoff and drifting, in surface water. During transport to the abstraction or intake point, full or partial degradation may occur. This may generate degradation products (metabolites) that are also undesirable in water taken in for the production of drinking water.

When admitting pesticides, the vulnerability of groundwater is also taken into account. As the average groundwater protection areas are more vulnerable to leaching of pesticides than other (agricultural) areas in the Netherlands, the admission policy for groundwater protection areas applies a stricter safety factor in the assessment of new substances than is the case for groundwater outside these areas.

5.1.1 National picture of the use of pesticides

Between 1985 and 2002, sales of pesticides halved in the Netherlands (in terms of volume), while sales have been stable or rising slightly during the past ten years (de Snoo & Vijver; 2012; van Loon et al., 2019; Statistics Netherlands, 2019). Some of the substances that are banned in the Netherlands have now been replaced with alternative substances that do meet the criteria of the admission policy. As the admissions are often based on data provided by the manufacturer, leaching may, in practice, turn out differently than initially presumed during the admission procedure. This is why a process is in place to also include the monitoring data from water managers and drinking water companies during the admission assessment. From now on, this data will be collected and evaluated in the Pesticides Atlas for Groundwater, which is similar to the Pesticides Atlas for Surface Water.

Since 2016, professional use of pesticides on paving and in public parks outside agriculture has been banned (Second Sustainable Crop Protection Memorandum). Alternatives for weed control used by local authorities and other site managers include fire, weeding or the use of hot water. There is no ban on the use of pesticides by private individuals. The Second Sustainable Crop Protection Memorandum tells us that the Green Deals for Recreation, Sports Fields and Private Use have had a limited effect.

5.2 Quality requirements

5.2.1 Abstracted groundwater

In this report, the benchmark for the quality of groundwater as a source of drinking water is the signalling values from the WFD drinking water sources monitoring and verification protocol. The value is equal to the standards of the Drinking Water Decree (see paragraph 3.4.3) and the Groundwater Directive.

For active ingredients of pesticides and human toxicology-relevant metabolites, the value in the sources is 0.1 µg/l. For metabolites declared not human toxicology-relevant by the RIVM, a higher signalling value of 1.0 µg/l applies. Among other things, this concerns the metabolites AMPA, desphenyl chloridazon, BAM, metazachlor, metolachlor and N,N-Dimethylaminosulfanilamide.

In addition, a sum value of 0.5 µg/l applies for the sum of individual active ingredients with a concentration that exceeds the detection limit.

5.2.2 Surface water taken in

For surface water abstraction, the quality of the surface water taken in is checked against the signalling values or standards from the Water Quality Requirements and Monitoring Decree, the Drinking Water Regulation (Appendix V) and the Infiltration Decree from 1993. This means a value of 0.1 µg/l for active ingredients and their human toxicology-relevant metabolites, 1.0 µg/l for human toxicology-irrelevant metabolites and a sum standard of 0.5 µg/l. When these standards are exceeded, the government has a best-efforts obligation to improve the water quality in the surface water body and following on from the WFD, the targets must have been achieved by 2027. When a standard is exceeded for a maximum of 30 days, the water company is obliged to report this to the Human Environment and Transport Inspectorate. If the exceedance persists for more than 30 days, the intake of surface water is subject to an exemption (see paragraph 3.5.1).

The Protocol indicates that in the case of riverbank groundwater, both the quality of the abstracted groundwater and the quality of infiltrated surface water must be checked (see Chapter 3), so that also applies to the concentrations of pesticides.

5.3 The condition of sources of drinking water

5.3.1 Groundwater abstraction

Van Loon et al. (2019) took stock of exceedances of the standard in the groundwater abstraction wells for the production of drinking water between 2010 and 2014. It was found that in 70 of the 99 (71%) phreatic groundwater abstractions (the abstraction of groundwater from an aquifer that is not entirely covered by a layer of clay), traces of pesticides or degradation products were found at least once. In half of these abstractions, one or more exceedances of the signalling values for one or more substances were observed (Figure 5-1). In the abstraction wells of 19% of non-phreatic groundwater abstractions (the abstraction of groundwater underneath a layer of clay), traces of pesticides or degradation products were found, 9% of them above the signalling value. This picture is in line with the results from the evaluation of the first-generation drinking water protection files (Swartjes et al., 2016). According to this report, it is mainly herbicides that are found in abstraction wells and a number of substances of these are still permitted.

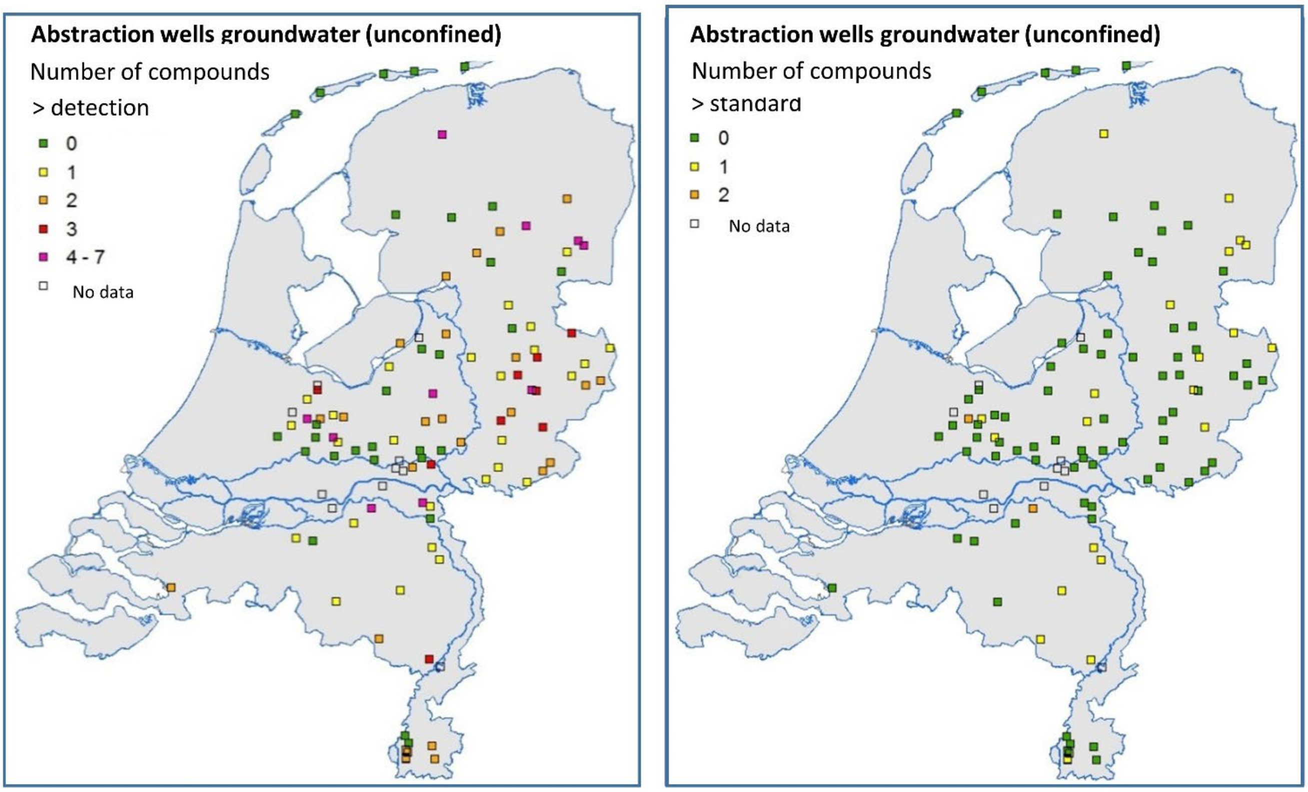


Figure 5-1: pesticides or degradation products that were found at least once in one or more abstraction wells at 99 phreatic abstraction sites between 2010 and 2014. Left: the number of substances found that exceed the detection limit. Note: the detection limit is the lowest quantity of a substance that can be detected within a given reliability limit. Right: the number of substances found that exceed the signalling value (pesticides ≥ 0.1 µg/l, degradation products ≥ 1 µg/l). Source: Van Loon et al., 2019.

Van Loon et al. (2019) also took stock of observations of pesticides and degradation products in observation filters in the surrounding area of the phreatic groundwater abstraction sites. This showed that groundwater near 36 of the 58 (62%) listed groundwater abstractions showed one or more pesticides or degradation products. These are observations above the reporting limit and in some cases, observations above the signalling value. It should be noted that the existing measuring networks of drinking water companies are not yet fully geared to quality monitoring in shallow groundwater. The list of Van Loon et al. (2019) also lacked data for limestone abstractions in southern Limburg. This means the shallow groundwater around groundwater abstraction sites will be contaminated with pesticides on a larger scale than shown here.

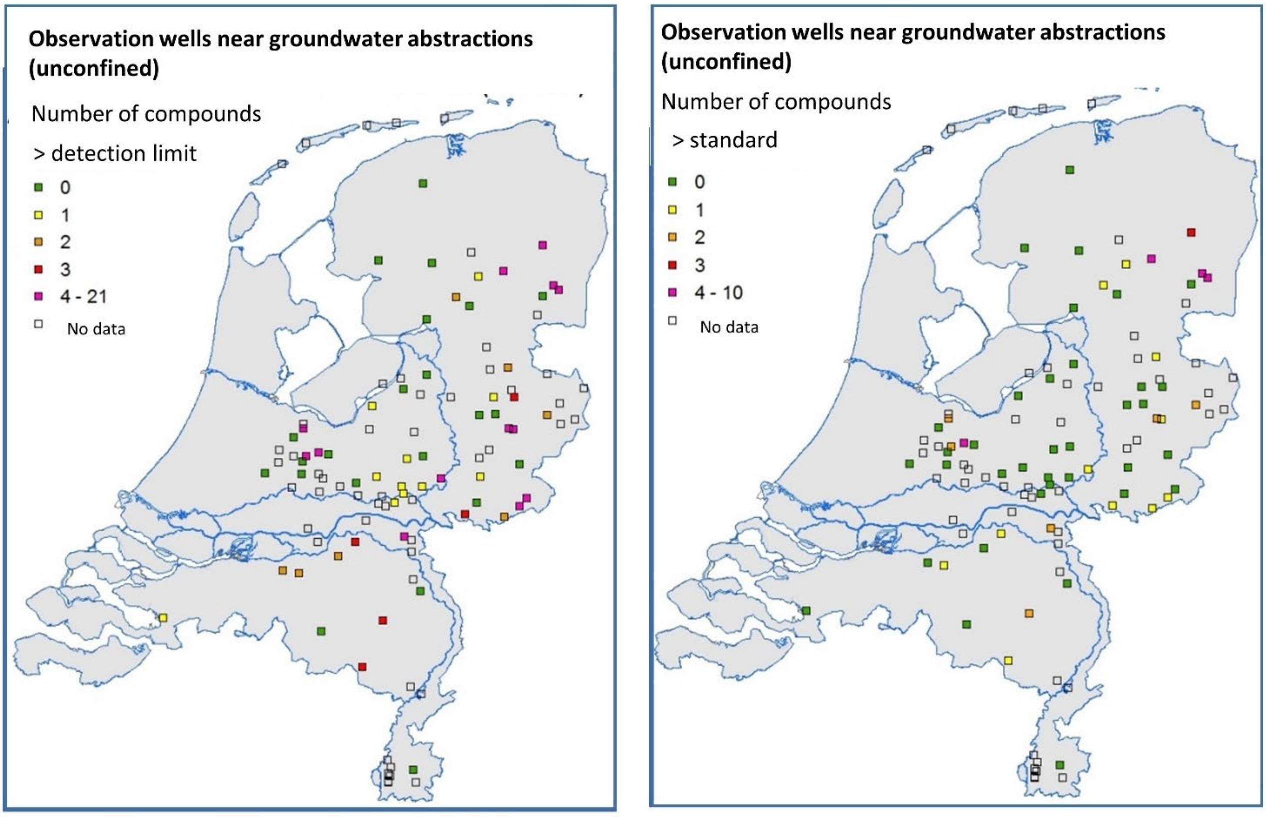


Figure 5-2: pesticides or degradation products found between 2010 and 2014 in the observation filters of 99 groundwater abstraction sites that are not protected by a covering layer of clay. Left: the number of substances found that exceed the detection limit. Right: the number of substances found that exceed the signalling value (pesticides ≥ 0.1 µg/l, degradation products ≥ 1 µg/l). Source: Van Loon et al., 2019.

5.3.2 Provincial groundwater measuring network

These results are very much in line with a study of pesticides and degradation products in the provincial groundwater measuring networks, which cover the groundwater protection areas for only a limited part (Sjerps et al., 2017b). It emerged that half of the groundwater samples are contaminated with pesticides. This reinforces the idea that a number of pesticides and metabolites are reaching increasingly deeper layers and that they may end up in groundwater abstractions sooner or later. This also applies to bentazone, glyphosate, BAM (a metabolite of dichlobenil) and desphenyl chloridazon (a metabolite of chloridazon).

5.3.3 Surface water abstraction

The Association of River Waterworks (RIWA) has been collecting water quality data of the Rhine and the Meuse for years now. The measuring data from 2017 shows that not one pesticide permanently exceeds the checks in the Meuse. However, in the Meuse water taken in, the ERM target values were exceeded by a total of 14 pesticides, biocides and/or degradation products (Bannink & van der Ploeg, 2018) (for an explanation of the ERM values and the link with the signalling value, see 3.3.3). Among other things, they included the herbicide glyphosate and AMPA (a degradation product of glyphosate), glufosinate-ammonium, carbendazim and propyzamide.

In the Rhine, five substances exceeded this value, including glyphosate, AMPA (a degradation product of glyphosate), metolachlor and N,N-Dimethylsulfonamide (DMS, a degradation product of tolylfluanid) (Stroomberg et al., 2018). It should be noted that the exceedances of the target values were mostly limited in scope and that they were of an occasional nature.

Another study into substances at intake points and reservoirs of surface water abstraction sites showed that between 2010 and 2014, pesticides were found at least once (Figure 5-3; Van Loon et al., 2017). Furthermore, in 75% of the locations, the standard was found to have been exceeded once or more often. Pesticides or degradation products were found in all dune and riverbank infiltration abstractions, with the standards being exceeded in more than 70% of the abstractions. The contamination of dune and riverbank groundwater abstractions is predominantly connected with the large portion of infiltrated surface water. Glyphosate was found most often in the surface water taken in and in the reservoirs. Bentazone was found most often in the collected groundwater that had been abstracted from dune and riverbank infiltration sites.

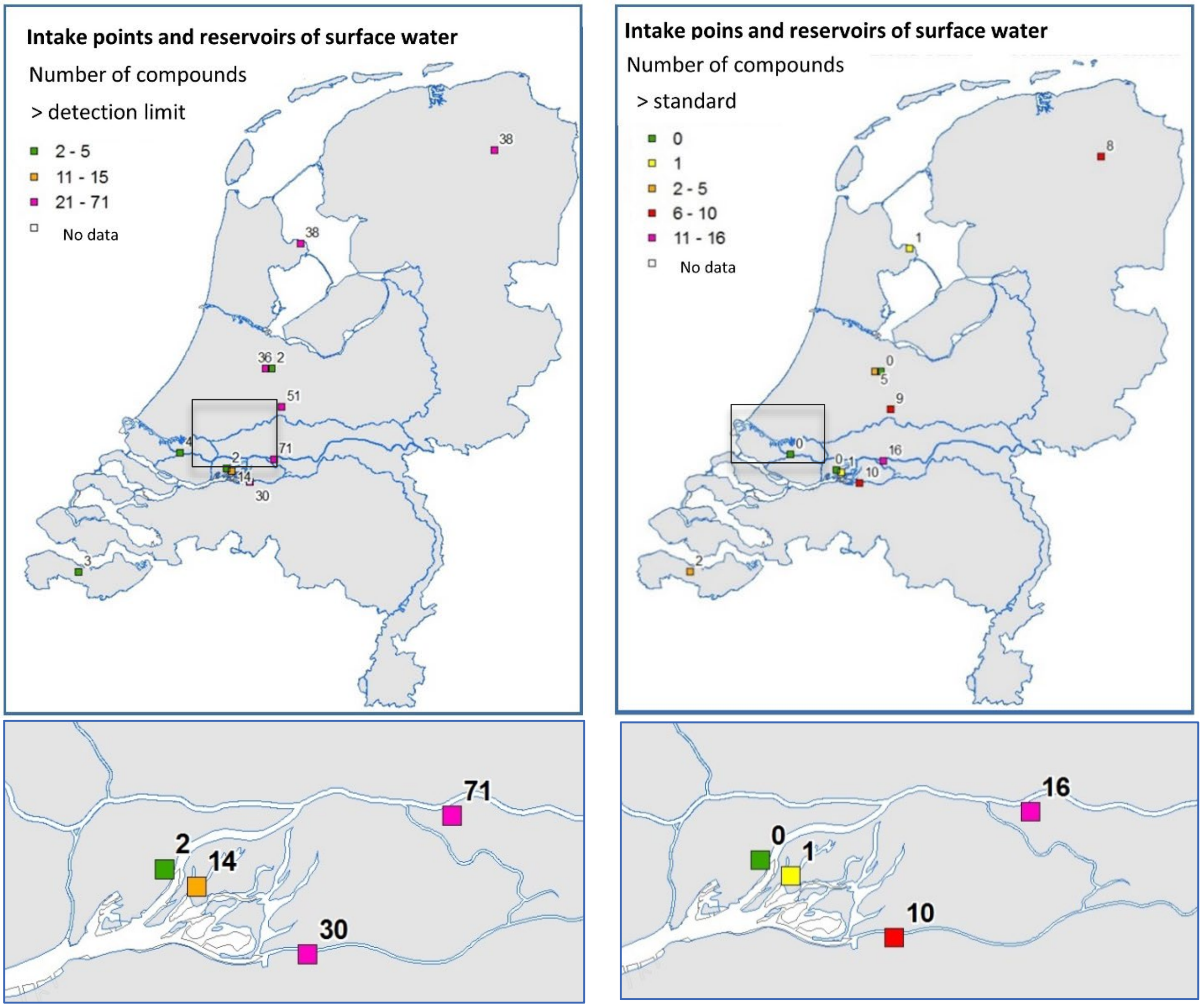


Figure 5-3: The number of pesticides and degradation products found between 2010 and 2014 in the reservoirs and in the surface water taken in at 15 surface water abstraction sites in the Netherlands. Left: the number of substances that exceed the reporting limit. Right: the number of substances that exceed the standard. Source: Van Loon et al., 2017.

5.4 Outlook

The development of the surface water quality is in part determined by international measures in the river basin of the Rhine and, to a stronger extent, in the river basin of the Meuse. In accordance with the scope of this report, this paragraph focuses on national developments that affect bottlenecks in the quality of sources of drinking water in terms of pesticides.

The Second Sustainable Crop Protection Memorandum (2013-2023) sets the target of complying with all international legislation in the fields of the environment and water by 2023. The specific target for surface water that is intended for the production of drinking water is as follows:

- 2018: a reduction of 50% compared to 2013 of the number of exceedances of the drinking water standard in surface water that is intended for the production of drinking water;
- 2023: a reduction of 95% compared to 2013 of the number of exceedances of the drinking water standard in surface water that is intended for the production of drinking water (hardly any transgressions).

This policy memorandum does not contain any specific targets for groundwater, so there is no specific policy process to realise the standards for pesticides in groundwater. Reference is, however, made to Article 7 of the Water Framework Directive with regard to preventing the degradation of the quality of water that is intended for human consumption. In order to combat the issues with groundwater quality, most reference is made to a strategy through the provinces. Collaboration between social partners is one aim, for instance. This has resulted in a number of Green Deals (Recreation, Sports Fields and Private Use) to limit the use of pesticides outside agriculture or switch to more environmentally-friendly alternatives. Also, since 2014, professional users of pesticides have been obliged to use integrated crop protection. The emphasis is on preventive measures, thus limiting the use of chemical agents to the greatest possible extent. On a closing note, a number of bans have been imposed, such as the professional use of pesticides outside agriculture on paving in the public space and in public parks and gardens.

Thanks to the admission policy, pesticides are increasingly excluded from use in groundwater protection areas. This unintentionally has also resulted in a stagnation of the replacement of the range of agents that pose a low environmental risk. Consequently, the older agents that had already been admitted and that often pose a higher environmental risk, remained. The Green Deal for Green Crop Protection Agents that was closed in 2014 is supposed to promote the admission of low-risk agents of natural origins. Under the admission policy, efforts are made to improve access to measuring data of pesticides in groundwater and surface water, making it possible to get a better picture during the admission assessment of the risks of leaching and runoff. These developments contribute to reducing the risks posed by the use of pesticides for drinking water sources, but the impact thereof is unknown.

Through awareness, incentive and information programmes, the provinces and drinking water companies encourage the responsible use of pesticides (Swartjes et al., 2016). Often, these programmes are aimed at several target groups, with farmers, greenspace managers and citizens being the most significant. In practice, incentive programmes for sustainable agriculture appear to be effective when it comes to reducing the use of pesticides (Vliet et al., 2017). On that basis, the quality of the abstracted groundwater is expected to improve in the medium to long term where pesticides are concerned. However, this effect is not yet visible in the measuring data because these projects have not progressed far enough for that. This means we do not yet know exactly to what extent the existing control elements used will be sufficient to prevent bottlenecks in drinking water sources in the future. One contradictory development is that the use of pesticides is still rising and that the limits of voluntary participation are nearly reached.

The continuous development of the pesticide market challenges policymakers and drinking water companies to timely anticipate on new insights into the risks related to the use of pesticides, including their degradation products, for the benefit of drinking water supplies. This is confirmed by a study undertaken by Sjerps et al. (2017c). These authors wrote a report about a one-off measurement of 24 new pesticides. This measurement has indicated that substances that were admitted fairly recently can also be found in surface water sources. The continuous development of the pesticides market requires a regular reflection of the efforts made in order to permanently safeguard drinking water sources.

Specifically in the case of groundwater, pesticides that were leached in the past now reach increasingly greater depths and they have already reached a large number of phreatic groundwater abstraction sites (without a protective layer of clay). Pesticides or degradation products have now also been found in a number of non-phreatic groundwater abstraction sites (with a protective layer of clay). The presence of pesticides in abstracted groundwater as described in paragraph 5.4.1 in combination with the continuous burden of groundwater indicates that the effects of pesticide application in the past will manifest themselves in the abstracted groundwater to a greater extent during the next years. On the other hand, it shows that measures are needed in order to be able to meet the quality requirements for groundwater - that is intended for the production of drinking water - in the medium to long term.

The interim evaluation of the Second Policy Memorandum for Sustainable Crop Protection by the Netherlands Environmental Assessment Agency (PBL) shows significant progress in many areas in the past five years. However, the PBL also argues that the total amount of chemical agents used by growers is not declining. The report mentions the operational target, namely that non-compliance with standards in surface water for the production of drinking water must be reduced by 95% by 2023 compared to 2013. The interim target to reduce non-compliance with standards by 50% by 2018 was not achieved. On average, non-compliance with standards was 25.7 between 2011 and 2013 and 28.7 between 2015 and 2017 (PBL, 2019). Also, the Green Deals for Recreation, Sports Fields and Private Use appear to have had limited effect so far (PBL, 2019).

In April 2019, the Minister for Agriculture, Nature and Food Quality sent the Crop Protection Future Vision 2030 to the Second Chamber, aiming for a considerable reduction of emissions to zero by 2030, among other things. The next step is to prepare an implementation programme that defines the perspectives for action for the short, medium and long terms, with the organisations involved indicating their contribution in order to bring the vision closer.

6 Salinisation

6.1 Introduction

Salinisation of surface water mainly occurs in the west of the Netherlands due to advancing seawater caused by a temporary rise in sea levels due to tidal effects and wind force or in the case of low river discharge. Onshore sources of chloride can also contribute to this. Salinisation can be enhanced by climate change, land subsidence and interventions in the water system, such as the construction of ports and locks and deepening waterways (such as Nieuwe Waterweg) (Deltares, 2018). The IJsselmeer, for instance, will experience salinisation because the water level difference on both sides of the Afsluitdijk causes a groundwater flow from the Wadden Sea towards the IJsselmeer (dike seepage) (Deltares, 2018). The mouths of the rivers in the west of the Netherlands are expected to salinify every year for a prolonged period of time (Deltares, 2018).

Salinisation of groundwater at groundwater abstraction sites is often related to attracting salt groundwater that has been present in the subsoil for a long period of time. A rise in abstractions, changes to water management, climate change and rising sea levels may cause salinisation of groundwater to increase.

6.2 Quality requirements

Salinisation may pose a threat to the water quality due to an increase in chloride and non-compliance with the standards in drinking water and the springs. This standard is mainly based on flavour and operational conditions, not on health concerns. The Water Quality Requirements and Monitoring Decree 2009 lists the European environmental quality requirements for surface water that is intended for the production of drinking water, with an average annual standard of 150 mg of chloride/l.

6.3 The condition of sources of drinking water

The evaluation of the drinking water protection files from 2014 shows that in 11 of the 215 inspected abstractions, chloride was found in one or more abstraction wells in concentrations that exceed the standard (Wuijts et al., 2014). For another eight abstractions, chloride concentrations in the water taken in exceeded 75% of the standard, which means chloride is a potentially hazardous substance in those locations. This concerned both groundwater and surface water. A total of 16 of these 19 abstraction sites with (imminent) non-compliance with the standard are groundwater abstractions; this mainly concerns the abstraction of saltier groundwater at greater depths. High chloride concentrations in the three riverbank groundwater and surface water abstraction sites were caused by discharges, the discharge of salt polder water, salinisation from the sea and/or a reduced discharge from the rivers (Wuijts et al., 2014).

The summer of 2018 showed the significance of the consequences of low river discharge in combination with salinisation from the sea for long periods of times. Measuring data from 2018 from the Directorate-General for Public Works and Water Management clearly shows that chloride concentrations rose to 149 mg/l at Wijk bij Duurstede and to 365 mg/l at Kinderdijk (information provided verbally by Gertjan Zwolsman, no data was shown).

Chloride concentrations were particularly high in the IJsselmeer, which means the annual standard for chloride could not be met at the Andijk intake point. A year before that, in 2017, PWN also reported non-compliance with the standard of the average annual salt levels (156 mg/l instead of 150 mg/l) to the Human Environment and Transport Inspectorate (PWN, 2018). Exactly what caused this rise is not yet known.

6.4 Outlook

A study conducted in 2008 already predicted increased concentrations of chloride for the IJsselmeer, partially based on the dry summer of 2003 (Zwolsman, 2008). In a comprehensive study from 2018, Deltares explained that salinisation from the sea will be more prevalent (and for longer periods of time) as a result of rising sea levels, ground subsidence and climate change (Deltares, 2018). During the summer of 2018, these climate forecasts already turned out to be reality, as described above.

The evaluation of the first-generation drinking water protection files shows that bottlenecks with salinisation appear mostly on the Rhine and the Lek (Wuijts et al., 2014). Model calculations from Deltares show that in the case of fast climate change, chloride concentrations at Lobith may exceed 150 mg/l by 2050 (assuming the current contaminant load of the Rhine). Annual average chloride concentrations in the Lek, in the west of the country, will exceed the standard during dry years in the case of fast climate change (Wuijts et al., 2013; Sjerps and Huijting, 2017a). The potential salinisation of the Lek is relevant because Dunea has an intake site here (Bergambacht). Model projections indicate that chloride concentrations at this location may exceed the standard of 150 mg/l for longer periods of time when river discharge is low (Hydrologic, 2018), see also Table 6.1. Therefore, expectations are that this will occur on a more frequent basis.

Table 6.1: The top 10 of salinisation events (periods with chloride concentrations in excess of 150 mg/l) in the WHdry climate scenario in Bergambacht (copied from Hydrologic, 2018). The duration of the salinisation period determines the ranking order from 1 to 10.

No.	Year	Number of consecutive days of salinisation
1	1976	152
2	1964	116
3	2003	110
4	1971	97
5	1962	77
6	1991	69
7	1990	65
8	2009	54
9	1972	43
10	1985	41

6.4.1 Demand for water

Apart from the salinisation of surface water, Deltares' future projection also shows that with a management adjustment, the deep, large freshwater lenses underneath the dunes in the provinces of Noord-Holland and Zuid-Holland should be able to cope with rising sea levels in the next 100 years, as long as the dunes are large and high enough. In an even longer term - beyond 2200 - the freshwater volume will, ultimately, drop considerably when sea levels rise particularly fast, down to 40% of the original volume. In this term - beyond 2200 - all medium-sized freshwater lenses on the Frisian Islands, in the provinces of Friesland and Groningen, in the north-west of the province of Noord-Holland and near Hoek van Holland and Katwijk will, in any case, disappear if sea levels are that high. The larger freshwater lenses are likely to shrink to such an extent that they can no longer be functionally used for drinking water supplies (Deltares, 2018).

6.4.2 The east and south of the Netherlands

Salinisation caused by climate change will have the biggest impact in the west and the north of the Netherlands. Still, climate change and changes in water demand may also play a role locally at groundwater abstraction sites in the east and south of the Netherlands (both in terms of quantity and quality).

7 Soil contamination

7.1 Introduction

Soil contaminations predominantly concern the 'old' soil contaminations that were often the result of past activities, such as dry cleaners, petrol stations and industry. The policy in question defines historical soil contaminations as having originated before 01 January 1987. The remediation task for these old contaminations is known. During the past few years, the contaminant sources that require attention most urgently were mapped out and a risk-oriented strategy was chosen, the so-called “emergency location strategy”. The local authorities with remaining problem sites are responsible for tackling soil contamination and have to make a choice between remediation or controlling the contamination.

Within this context, Chapter 3 mentions the Dutch Soil Protection Act and the Soil and Subsoil Agreement. The Soil and Subsoil Agreement sets out agreements in order to control the risks of all contaminated locations with unacceptable risks to man, ecology and distribution before 2020. This concerns the soil contaminations that are both serious and urgent according to the criteria set out in the Dutch Soil Protection Act. When this is not possible for financial reasons, the unacceptable risks must be mapped out and the implementation of measures against them should be scheduled.

Point contamination also results from more recent activities, such as rubber grains on sports fields, thermally cleaned land, the dumping of drugs waste and the presence of PFAS in relatively low quantities (Progress soil contamination task 2018; Subsoil, Soil and Groundwater Task Force, 2019). A number of these contaminations will be discussed in the other chapters.

7.2 Quality requirements

In view of the threat that soil contamination poses to water quality, the first-generation drinking water protection files identified hazardous substances and potentially hazardous substances (Wuijts et al., 2014). Hazardous substances were defined as non-compliant with the standards on one or more occasions, while *potentially* hazardous substances were defined as contaminations that fail to comply with 75% of the standard or with the parameters that exceed the assessment framework of the drinking water sector itself. The value is derived from the Water Framework Directive, which asks Member States to identify and list the concentrations of substances in water bodies that show such a trend that non-compliance with the standard may occur at the end of a next plan period. The threshold is a value of 75% of the standard, while it was noted that this value of 75% has not been implemented in the Water Quality Requirements and Monitoring Decree in the Netherlands (Wuijts et al., 2014).

7.3 The condition of sources of drinking water

The study into the evaluation of the drinking water protection files (Wuijts et al., 2014) offers the most recent national overview of soil contamination in relation to the sources of drinking water. Out of the 215 reported abstraction sites, 40 show substances in the abstracted water that could relate to the presence of 'old' soil contaminations in quantities that do not comply with the standard. During this study, a total of 72 abstraction sites were found with concentrations of 'old' contaminations that exceed the signalling values. It concerns 57 groundwater abstraction sites and 15 surface water and riverbank groundwater abstraction sites. In the latter group, the riverbank groundwater abstraction sites prevail. This analysis was conducted on the basis of a test in accordance with the Dutch Drinking Water Act, using the signalling values that are lower than those set out in the Dutch Soil Protection Act. At 31 groundwater abstraction sites, the drinking water standard is not complied with. The RIVM study says that 11 of these cases will be dealt with via the process of urgent sites from the Dutch Soil Protection Act.

This report focuses on the condition of the sources of drinking water. However, soil contaminants that are intersected by drinking water pipes may also pose a direct threat to the quality of drinking water because these contaminants may permeate through plastic drinking water pipes. The RIVM and the KWR have set up a step-by-step plan about how to deal with this issue. It is expected that this will make it clearer if substances from soil contaminations can, indeed, directly contaminate drinking water and if suitable measures can be taken (RIVM, 2016).

7.4 Outlook

The current Soil Agreement from the authorities runs until 2020 and regulates the remediation and/or control of the most urgent sites. The monitoring figures from 2018 show that out of the 1,383 urgent sites that were identified at the time the agreement was concluded, 210 still have to be put into operation. Timetables for only 26 of those sites have been prepared for implementation after 2020. The other sites are currently in progress (700 sites) or have been completed (473 sites) (Subsoil, Soil and Groundwater Task Force, 2019).

However, this concerns complex groundwater remediation projects whose implementation and monitoring will not have been completed until after 2020 and the final risk control will continue until far beyond 2020 or may even last for centuries (Subsoil, Soil and Groundwater Task Force, 2019). The progress report, for that matter, does not specifically deal with the sites in relation to drinking water, while it is unclear for these sites who will be responsible and how urgent sites will be dealt with on the basis of distribution risks. What *is* clear is that the management of historical contaminations will involve substantial costs beyond 2020 too. In addition, 'old' soil contaminations near groundwater abstraction sites will still have to be monitored for a long time to come in order to identify and anticipate problems.

One of the concerns of the drinking water companies is that during the transition to the Dutch Environment and Planning Act after 2020, only the urgent sites that originate from before 1987 fall under transitional law. This means that responsibility for non-urgent sites, as yet undiscovered historical soil contaminations and recent soil contaminations (after 1987) will more and more shift to the party that caused them. For that reason, these sites will no longer be controlled or to a lesser extent, resulting in a growing risk of distribution towards groundwater abstraction sites. In addition, the companies are concerned about the continuation of monitoring of soil contaminations because when the targets of the urgent sites strategy have been realised, the central government will no longer contribute. The issue with new contaminants such as PFAS leads to a need for a new perspective for action and the progress report from the Subsoil Task Force mentions a larger (financial) undertaking than anticipated when the agreement was concluded (Subsoil, Soil and Groundwater Task Force, 2019). All in all, while the 'old' contaminations still raise concerns, the 'new' contaminations may pose a threat to the quality of sources of drinking water.

8 Pharmaceutical residues

8.1 Introduction

This report defines medicines as all chemical substances that are used for the benefit of human health (human medicines) or animal health (veterinary medicines). Residues of a number of medicines such as antibiotics, beta blockers, cytostatics (cancer medicines), painkillers, anti-depressants, anti-diabetics, anti-epileptics and blood thinners may end up in groundwater and surface water. Hormone-disrupting substances also fall under the category of pharmaceutical residues if they originate from the contraceptive pill or other hormone preparations. Pharmaceutical residues tend to dissolve in water well, which is why they easily distribute themselves throughout the environment. We also know that because of their specific effects, they can cause undesirable environmental effects, even at low concentrations (Moermond, 2016).

Officially, X-ray contrast agents are not pharmaceutical residues, although they are included in this chapter because they are used in the medical sector. X-ray contrast agents and MRI contrast agents are not only persistent, but they are also mobile in the water chain (polar). After all, these substances need to be absorbed fast and they need to disperse in our tissue, after which they are excreted via our urine within a short time after consumption. These properties promote diagnostic use in patients, but they are relatively hard to remove, which is why they often end up in drinking water.

Residues of human medicines end up in wastewater mainly through the urine and faeces from households, care institutions and hospitals. An estimated minimum of 140 tonnes of pharmaceutical residues and 30 tonnes of X-ray contrast agents are discharged into our surface water via sewage treatment plants (or overflow points) (Moermond, 2016). No figures are available for the river basins of the big rivers outside our country. The use of medicines by those living in the river basins of the Rhine and the Meuse, upstream of the Netherlands, is similar or even a little higher, as a result of which considerable quantities end up in the Netherlands from abroad (ter Laak et al., 2010; ter Laak et al., 2014; Coppens et al., 2015). Also, an unknown quantity of these substances ends up in the groundwater via leaking sewers, landfills and infiltrating surface water. Ter Laak et al. (2010) calculated that up to 70% of consumed medicines can end up in the environment, some of them in groundwater or surface water.

During the past few years, increasing attention has been paid to the occurrence, the risks and reduction of the emissions of human medicines into our water. So far, veterinary medicines receive less attention than human medicines. We have no clear picture of the veterinary use of any medicines and the same applies to the distribution in groundwater, because no measuring data is available. Residues of veterinary medicines mainly end up in animal manure and may be discharged into surface water or groundwater when farmland is being fertilized or grazed. The amount of measuring data is relatively limited (Moermond, 2016; Lahr et al., 2018).

The use of antibiotics in the agricultural sector in the Netherlands is an estimated 200 to 225 tonnes per year (Moermond, 2016; ter Laak et al., 2017). An unknown quantity thereof is discharged into surface water or groundwater, depending on excretion by the animal, environmental factors and substance properties. It is not exactly known how large this fraction is, but we *do* know that some medicines do not or poorly degrade, and that they distribute easily in groundwater and surface water (Rougoor et al., 2016). One striking result from a study into the relationship with the use of slurry is that concentrations of a large number of antibiotics, anti-parasites, coccidiostats and natural hormones were detected in all samples (Lahr et al., 2018).

Not all medicines that are used are analysed. In the Netherlands, for instance, approximately 260 active ingredients have been registered as veterinary medicines and approximately 2,000 substances on the market have been registered as human medicines. A study conducted by the RIVM in 2016 showed that water managers checked approximately 80 active ingredients to see if they do, indeed, occur in surface water (Moermond et al., 2016).

Measurements of metabolites or degradation products of medicines are even more scarcely available, because measuring methods are not readily available, even though these degradation products probably cover a multitude of the number of parent substances. Therefore, it is not clear if these substances are present in surface water and/or groundwater and if so, to what extent. However, if certain medicines are detected, residues of other medicines and metabolites or degradation products are also likely to be present in the water (Moermond, 2016). Studies by ter Laak and de Jongh, for instance, show that these conversion products appear in various streams and rivers in similar or even higher quantities than their parent substances (de Jongh et al., 2012; ter Laak et al., 2014; ter Laak et al., 2016b).

8.2 Quality requirements

There are no standards for pharmaceutical residues in sources of drinking water, but the Drinking Water Regulation does mention a detection parameter of 1.0 µg/l for drinking water companies while the Water Quality Requirements and Monitoring Decree 2009 mentions a signalling value of 0.1 µg/l for sources of drinking water. Chapter 3 sets out the policy and legislation in more detail.

8.3 The condition of sources of drinking water

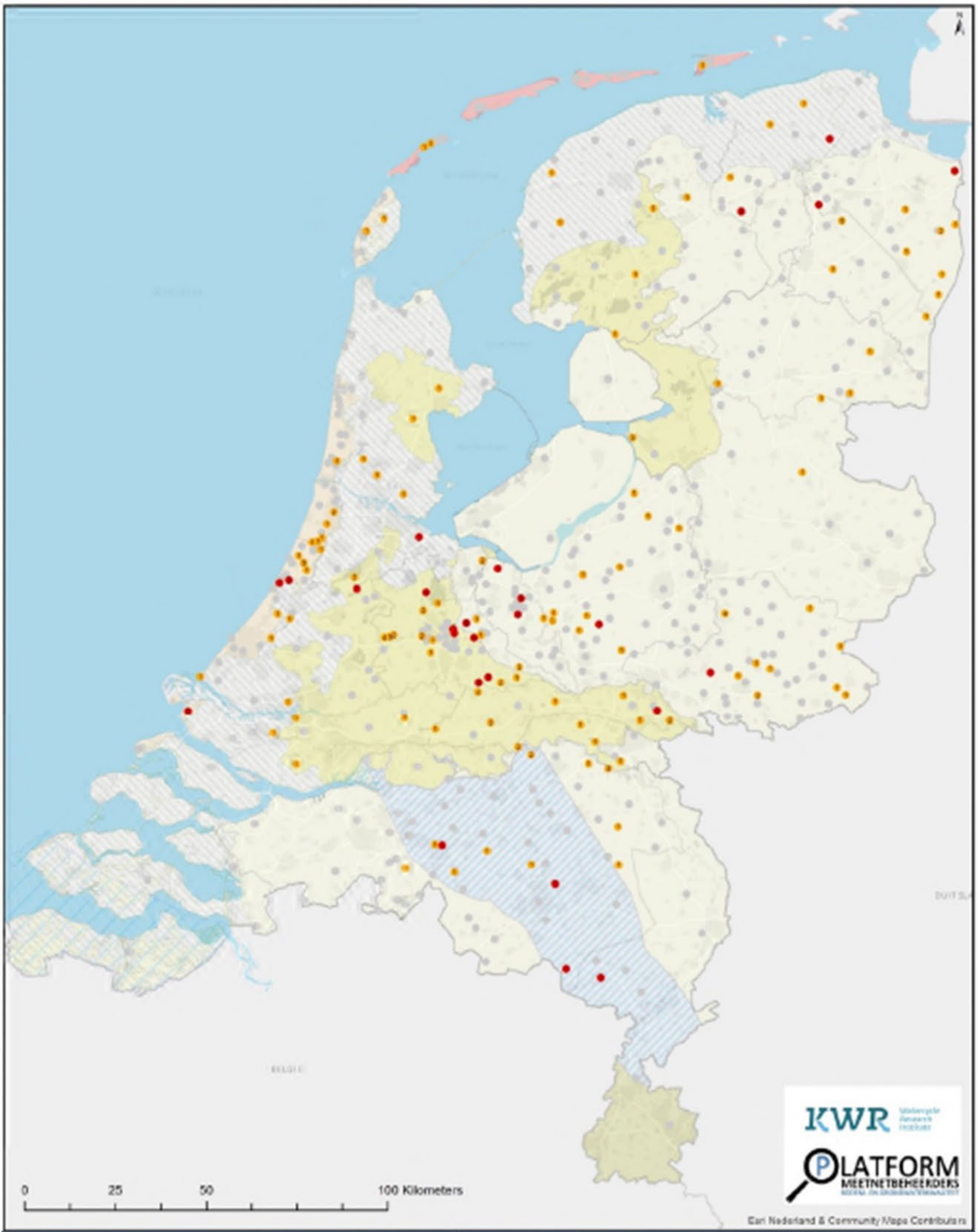
8.3.1 Surface water abstraction

Human pharmaceutical residues and X-ray contrast agents are only partially treated in wastewater treatment plants, which is why they are almost continuously discharged into the recipient surface water. Due to continuous emissions, concentrations remain high in recipient waters of sewage treatment plants. This is also referred to as *pseudo-persistence*. The average measured concentrations in surface water tend to vary from 0.1 µg/l to 10 µg/l (Monteiro and Boxall, 2010; ter Laak et al., 2010; ter Laak et al., 2014). In 2017, a total of 24 pharmaceutical residues exceeded the signalling value of 0.1 µg/l in the Meuse. Tiamulin, a veterinary antibiotic, was first observed in the Meuse in 2017, in quantities above the signalling value (ERM target value). In 2017, pharmaceutical residues exceeded the signalling value of 0.1 µg/l in the Rhine (Stroomberg et al., 2018), the concentrations of veterinary medicines fell below the signalling value.

8.3.2 The condition of groundwater abstraction sites

The concentrations of pharmaceutical residues in groundwater are lower than in surface water, often within the range of nanograms per litre (Lahr et al., 2014; Ter Laak and Kools, 2016a). As detection limits have decreased during the past few years due to improved analysis methods, these lower concentrations of pharmaceutical residues may also be measured in groundwater on an increasing basis. An exploratory study into the prevalence of residues of veterinary medicines in the Netherlands (ter Laak et al., 2017) shows that a number of substances that can be earmarked as 'probably veterinary' are found in groundwater. The explanation of the veterinary origins by the (historical) use as a human medicine or pesticides hampers the explanation of the exact origins.

During a national analysis of Dutch groundwater (Sjerps et al., 2017b), 101 types of pharmaceutical residues were analysed (see Figure 8-1). Pharmaceutical residues were found in a quarter of the groundwater samples taken from the provincial measuring networks (observation filters); in 5% of the groundwater samples, they exceeded the signalling value of 0.1 µg/l that applies to sources of drinking water. The most prevalent pharmaceutical residues in groundwater are phenazone and carbamazepine, which were found in more than 5% of the samples. As these results were derived from the provincial measuring networks, they are not entirely representative of groundwater as a source for the production of drinking water. They *do* indicate that pharmaceutical residues are found in groundwater in many locations. Another significant fact is that half of the pharmaceutical residues found were measured against a reporting limit that is ten times higher than the signalling value, which means the chances of finding these substances are low and checking against the signalling value is difficult.



WFD and non-WFD observation wells

- < detection limit
- > detection limit, figure = number of compounds
- > Signalling value, figure = number of compounds

Total overview of medicines

Number of substances that exceed the signalling value or the detection limit

The map shows a transparent, themed background, with KRW bodies of surface water as reference points

Figure 8-1: the number of medicines that exceed the signalling value or the detection limit in provincial measuring networks on the basis of a one-off measurement. Source: Sjerps et al., 2017b. No overview of surface water was included.

8.4 Outlook

The trend in the emissions of human medicines differs from substance to substance, from country to country and from year to year, also because of the changing policy of prescription and admission. Emissions are rising globally (Oldenkamp et al., 2019), and the emission of medicines is expected to continue to rise in future (Moermond, 2016). The RIVM predicted an increase in Dutch consumption of various medicines until 2050 (Van der Aa et al., 2011). This increase varies from 8 to 68% for anti-rheumatics and analgesics. This is also expected to increase the pressure of pharmaceutical residues on sources of drinking water.

Since 2009, the use of antibiotics for animals in the Netherlands has fallen by approximately 60%. The trend of the use of other veterinary medicines is not known. Also, it is uncertain if veterinary use will continue to fall. The autumn of 2019 will see a study of the latest status in the field of veterinary medicines and an inventory of the knowledge gaps.

The differences between the trends of human and veterinary medicines can be explained by a more than one decade-old policy to reduce the use of medicines in the veterinary sector (antibiotics in particular). This applies less to the use of human medicines, as the role of these medicines for patients is considered more important than their environmental impact. However, Dutch physicians prescribe fewer antibiotics than their foreign counterparts and they keep an eye on consumption for cost reasons.

The Water without Pharmaceutical Residues Chain Strategy, led by the Ministry of Infrastructure and Water Management, aims to reduce pharmaceutical residues of human origins in groundwater and surface water. All the links in the chain of the healthcare and water sectors work together to achieve this objective. Within the Chain Strategy, an Implementation Programme has been set up for the period between 2018 and 2022. In October 2018, the healthcare sector signed the Green Deal for Sustainable Healthcare, with reducing pharmaceutical residues being one of the four pillars.

9 Emerging substances

9.1 Introduction

In this report, emerging substances are defined as substances for which no standard is available yet and whose impact on man and the environment is still insufficiently clear. This category includes, among other things, industrial substances, consumer products (such as detergents, sweeteners, caffeine), hormone-disrupting substances and medicines. However, these substance groups cover more than just emerging substances because they also include substances that have already been regulated. Also, these substances may have different origins and different emission routes into the environment. Caffeine, for instance, is a consumer product, but it can also be an ingredient of medicines. Medicines were discussed in Chapter 8.

This chapter focuses on substances that can be distinguished by their use as industrial *products* and industrial *chemicals* (Schwarzenbach et al., 2006). The first category forms part of the products that are sold by the chemical industry and that may, therefore, end up in the water chain during or after use by both consumers and professional users. The other category is used or is released during the industrial process (as an intermediate product, as a reaction medium or as a waste material) but does not end up in the industrial product as such. Whether the substance forms a part of an industrial product or is (in principle) only used or released at an industrial location makes a big difference for the potential emission routes as well as the possible measures.

Two recent examples are pyrazole, a waste material, large quantities of which ended up in the Meuse due to a poorly functioning industrial wastewater treatment plant (Baken et al., 2016) and GenX, a substance used in coatings, which ended up in the air, groundwater and surface water near one of the largest production sites of this substance in Europe (Beekman et al., 2016; RIVM, 2018). In both cases, the monitoring of waste streams and granting of permits was not appropriate to detect and regulate emissions adequately. In the case of GenX, it concerned a so-called indirect discharge (into the sewer), during which the impact of the discharge on the recipient surface water was inadequately tested.

9.2 Quality requirements

New developments and new applications in the chemical industry lead to an ever-changing range of emitted substances, and measuring methods can now demonstrate an increasing number of substances at low concentrations (see, for instance, ter Laak et al., 2012; Brunner et al., 2019). Furthermore, numerous substances that probably have been in the water for a longer period could not be measured until recently, after the development of measuring methods in the analytical chemical sector. Often, no (statutory) standards have been set for both types of substances and information about their risks is also often lacking, making it difficult to establish a standard.
Examples include fire retardants, solvents, petrochemical products, pigments, chemicals in plastics, resins and coatings and complexing agents.

This is why individual standards are lacking for numerous industrial substances, even though there are signalling values for substance groups. The Drinking Water Regulation, for instance, uses a detection parameter of 1.0 µg/l for drinking water companies, while the WFD drinking water sources monitoring and verification protocol uses a signalling value of 0.1 µg/l for water managers (see Chapter 3).

9.3 The condition of sources of drinking water

9.3.1 The Meuse and the Rhine

The prolonged and continuously developing measuring efforts by drinking water companies (united in the Association of River Waterworks RIWA) and the central government (by the Directorate-General for Public Works and Water Management) regarding the Meuse and the Rhine indicate that contaminants of industrial origin can often be found in rivers and that they lead to non-compliance with the standard. Industrial substances that exceeded the test values in the Meuse and/or the Rhine in 2017 included melamine, 1,2-dichloroethane, 1,4-dioxane, benzotriazole, tetrachloroethylene, trichloroethylene, benzothiazole, diethylenetriaminepentaacetic acid (DTPA), diisopropyl ether (DIPE), methenamine, methyl tert-butyl ether (MTBE), pyrazole and trichloromethane. In a number of cases, substances were found in such high concentrations that exemptions were needed for the intake of water for the production of drinking water. These contaminants included acetone, diisopropyl ether (DIPE), 1,4-dioxane, ethylenediaminetetraacetic acid (EDTA), melamine, pyrazole, trifluoroacetic acid (TFA) and the solvent Urotropine (methenamine) (Stroomberg et al., 2018; Bannink & van der Ploeg, 2018).

9.3.2 Groundwater

During a study into the prevalence of substances in groundwater, based on provincial measuring networks, the presence of a number of industrial substances was also analysed (Sjerps et al., 2017b). These measurements cannot be directly linked to sources of drinking water, because areas without a water abstraction site were also sampled. Still, this study does provide a picture of the wider prevalence of industrial substances in the subsoil. As a standard for these substances is lacking, this study used the signalling value of 0.1 µg/l of the WFD. Out of the analysed substances of a potentially industrial origin, bisphenol A, PFOA and PFOS were found in more than 10% of the samples across the Netherlands, albeit in low concentrations (Sjerps et al., 2017b).

9.3.3 Abstracted groundwater and surface water

Based on the final evaluation of the first-generation drinking water protection files, Wuijts et al. (2014) prepared a national overview of (potential) problems with emerging substances in sources of drinking water. In 6% of abstractions of groundwater and surface water for the production of drinking water, emerging (industrial) substances were earmarked as hazardous substances (Figure 9-1). This means that their concentrations exceed the signalling value of the Drinking Water Regulation (Appendix A, Table IIIc) once or more often. As for the national picture about abstractions, the map also shows abstractions that have closed down by now (Figure 9-1).

In 13% of these abstractions, one or more emerging substances are earmarked as potentially hazardous substances, because they exceed 75% of the signalling value. When production or use increases, the signalling value for these substances may be exceeded. In RVIM's evaluation from 2014, emerging substances resulted in non-compliance with the standard at 13 groundwater abstraction sites, surface water abstraction sites and riverbank groundwater abstraction sites. These substances are earmarked as a 'current hazardous substances' (Table 9-1, copied from the 2014 evaluation), while the report also focused on 'potentially hazardous substances' (Wuijts et al., 2014).

Table 9-1: The number of abstractions in which emerging substances constitute current and/or potentially hazardous substances, copied from (Wuijts et al., 2014). For an explanation of the definitions, consult that report).

	Number of abstractions with 'emerging substances' including industrial substances		
	current hazardous substances	**potentially hazardous substances**	**current *and* potential**
Groundwater abstractions	2	9	0
Surface water abstractions, including riverbank groundwater abstractions	11	18	10
Total	*13*	*27*	*10*

Figure 9-1: abstractions for which a drinking water protection file was available and where emerging substances (including industrial substances) have been earmarked as (potentially) hazardous substances (Wuijts et al., 2014).

9.4 Outlook

9.4.1 Surface water

The emission of industrial substances into the aquatic environment is estimated at approximately 1,600 tonnes per year (Moermond, 2016). Industrial substances have a wide range of properties and applications, which means the scope and route into the environment are highly diverse. These substances end up in the water system via industrial wastewater treatment plants and sewage treatment plants (indirect discharges) but they also end up in the environment as a result of atmospheric deposition or local use. The (mandatory) water quality parameters that must be presented and tested for industrial discharge permits do not cover the wide range of industrial substances in wastewater. Also, the application and processing of substances for non-professional use is hardly checked, which means that neither the competent authorities nor the drinking water companies have a clear picture of the substances, their quantities and where they end up in the water system.

The industrial substances fall under REACH legislation (with a few exceptions) and therefore, information about their behaviour in the water systems and their impact on living organisms should be widely available. However, this information is often too limited to set up monitoring programmes or determine specific risks or control measures for the (drinking) water chain. Data about the substances in REACH cases *do* offer references to detect and evaluate emerging substances (Kolkman and Ter Laak, 2012; Ter Laak et al., 2015).

The drinking water sector was recently confronted with 'unknown compounds' such as LCAqua-033 (which turned out to be pyrazole) and LCAqua-057 (which turned out to be 8-hydroxypenillic acid). These substances emerged via the quality control of the drinking water companies, and their presence in sources of drinking water proved to be higher than estimated when they had not been identified yet. This underlines the importance of monitoring, a source-oriented strategy and risk analyses. During the groundwater monitoring process, numerous (industrial) substances are detected whose origins are not immediately clear (ter Laak et al., 2012).

9.4.2 Groundwater

During the past years, it has become increasingly clear that industrial and other emerging substances end up in the groundwater via infiltrating surface water. Measures to improve the quality of surface water should, therefore, have a positive effect on the quality of groundwater in areas with infiltrating surface water. However, this does not necessarily mean the targets of the WFD are reached, i.e. improving the quality of groundwater intended for the production of drinking water and aiming for a reduction of treatment intensity. This will probably require additional measures in some areas, explicitly aimed at the quality of sources of drinking water.

Also, some industrial substances, including PFAS, can end up in groundwater via atmospheric deposition. The risks of atmospheric deposition of industrial substances do not, however, form a part of the groundwater protection policy of the provinces. Some groundwater abstractions may not be able to meet the targets of the WFD because they are vulnerable to atmospheric deposition.

9.4.3 Structural strategy

The Water Quality Delta Strategy lists the issue of emerging substances as a priority. The so-called 'structural strategy of emerging substances' was set up as part of the Water Quality Delta Strategy with the aim of continuously mitigating the risks of drinking water-relevant emerging substances from point sources. This is done in collaboration with the industrial sector, the drinking water sector and research institutes, by gaining an insight into which emerging substances may end up in the environment, their risks and by reducing emissions (Schultz van Haegen, 2017). An Emerging Substances Implementation Programme is currently under development under the leadership of the Ministry of Infrastructure and Water Management. A first version thereof was sent to the Second Chamber at the end of 2018.

10 Other new threats

10.1 Introduction

This chapter describes a number of relatively new threats to the quality of sources of drinking water. In contrast with the emerging substances discussed in the previous chapters, these threats are not yet included in regular monitoring and statutory frameworks are missing. The threats were selected on the basis of the scale on which they may influence the quality of the sources of drinking water. We have made a distinction between threats that mainly relate to surface water and those that mainly relate to groundwater. With regard to the quality of surface water, we first discuss microplastics, followed by nanomaterials and antimicrobial resistance. With regard to the quality of groundwater, we discuss drugs waste, underground storage and mining.

10.2 Surface water

10.2.1 Microplastics

The potential threat of plastics became public knowledge thanks to the so-called plastic soup, the prevalence of large clusters of plastic floating in the oceans. Much of this plastic originates from land (see Rochman, 2018, among others). It is becoming increasingly clear that plastic is omnipresent. It has been demonstrated to occur in many environmental compartments, soil, sludge, surface water and the air. Microplastics are defined as particles of less than 5 mm in size (SAPEA, 2019). The most prevalent types of plastic are Polypropylene (PP), nylon, Polystyrene (PS), Polyethylene (PE), and in various forms such as film, fibres, foam and pellets (beads) (WHO, 2019b).

Universities and research institutes are studying the measuring method to describe the presence and risks of microplastics in water. After all, drinking water companies and water managers want to know if and how many particles are present in surface water and what measures they can take. There is hardly any data about the prevalence of (visible) particles of microplastics in surface water and there is no insight about the even smaller fractions due to a lack of reliable measuring methods (Kosuth, et al. 2018; Mintenig, et al., 2019; Mason et al., 2018; Schymanski et al., 2018).

The first studies of the visible particles up to 5 mm point to a general prevalence of low levels of microplastics in drinking water from surface water (1-470 particles/l) and to even lower levels in drinking water that is produced from groundwater (0.7 particles/m^3). Concentrations vary from a couple to hundreds of particles per litre, depending on the size of the particles. The general picture at the moment is that the smaller the fraction in the study, the higher the quantities found (WHO, 2019b).

Based on the limited information currently available, there is no proof that points to a health risk (SAPEA, 2019; WHO, 2019b). Preliminary indicative risk analyses show that a continuation of the current use of plastics may create risks for the ecosystem (Everaert et al., 2018; Besseling et al., 2017, Burns & Boxall, 2018). The WHO argues, therefore, that more research is needed in order to get a clearer picture of the exact effects of microplastics. In order to be able to conduct an extensive risk analysis, it would be useful to map out the environmental load, including the load on the sources for drinking water. At the start of 2019, the Netherlands Organisation for Health Research and Development (ZonMW) started a large-scale study into the effects of microplastics and nanoplastics on public health.
The research question if accretion on plastics reinforces the spread of disease and antimicrobial resistance forms a part of that.

In anticipation of the risk analyses of microplastics, the European Commission elaborated a strategy for plastics in a circular economy, listing the possibility of preventive and reactive measures (EC, 2018). For instance, the aim is to ban plastic carrier bags and to reduce single-use plastic.

10.2.2 Nanomaterials
The production of materials of very small dimensions is known as nanotechnology. Nanomaterials have specific properties such as conduction or a purifying effect through the use of metal oxides. Nanomaterials are mostly used in order to make existing technologies more sustainable, such as improving solar panels. This technology is expected to experience strong growth, which may result in higher emissions into the water chain.

Research has shown that nanoparticles can currently only be found in low concentrations in the Dutch environment and that wastewater purification plants remove a lot of them (Bauerlein et al., 2017; Peters et al., 2018). Still, due to the anticipated sharp increase in applications, it is important to keep tracking and measuring these materials and particles as well. The question, however, is how the risks posed by these particles affect the quality of surface water as a source of drinking water (Westerhoff et al., 2018). The nanoparticles that make up the nanomaterials can behave considerably differently than other particles. If the particles contain metals, for instance, they sometimes react stronger than metals in a free, undissolved form. The European Commission recently amended the REACH appendices in an effort to clarify the REACH registration of nanomaterials. Perhaps this provides more clarity about the potential risks of using nanomaterials. This process has an implementation phase of approximately five years.

10.2.3 Antimicrobial resistance
The link between the prevalence of antibiotics and antimicrobial resistance is something the medical sector is familiar with. What we also know is that the water system plays an important role in spreading resistant bacteria (Bengtsson-Palme et al., 2017). The WHO considers antimicrobial resistance a significant risk to public health (WHO, 2019a). In previous chapters, we explained that there is only a limited data set about medicines and transformation products in surface water (Moermond, 2016) and the same applies to antibiotics. It is now clear that various types of antibiotics, including the active ingredients, are found in both groundwater and surface water (see Chapter 8).

In collaboration with other institutes, the RIVM studied how many resistant bacteria end up in surface water in the Netherlands via wastewater (Schmitt et al., 2017). In addition to manure, treated wastewater (the effluent from a sewage treatment plant) is the biggest source of antibiotics-resistant bacteria ending up in the environment. Highly resistant micro-organisms (HRMOs) such as ESBL-producing E.coli and resistant Enterobacteriaceae were found in 60 to 100% of the wastewater that was studied. Furthermore, antibiotics and conversion products, resistant bacteria and antimicrobial resistance genes were also found in the treated wastewater and they end up in surface water through discharge (Sabri et al., 2018).
There is very little systematic research into the sources of drinking water, which means the risks posed to the quality of drinking water are not clear.

10.3 Groundwater

10.3.1 Drugs waste
It is becoming increasingly clear that the illegal production of synthetic drugs, amphetamine (speed) and MDMA (XTC) is rife in the Netherlands. Criminals increasingly turn to other synthetic drugs too, such as methamphetamine and ketamine, which are produced in illegal labs using precursors, solvents, salts and strong acids and bases. The production of one kilo of amphetamine and MDMA generates an estimated twenty and seven kilos of waste respectively (Europol, 2016). This uncontrolled production takes place in unsafe locations, and the illegal processing and dumping of the resulting waste is a growing cause for concern (Schoenmakers et al., 2016). After all, the waste ends up in the environment in an uncontrolled manner. When waste is dumped directly into the natural environment, it can infiltrate in the soil. Dumped waste can also pose a threat to surface water via a direct discharge or, indirectly, via a discharge into the sewer or by mixing the waste with manure or other products. This way, these substances may eventually also end up in sources of drinking water.

On the basis of seized precursors, the production of synthetic drugs in the Netherlands is estimated at 610 tonnes of amphetamine powder and 153 tonnes of MDMA crystals. This would mean the volume of waste is up to twenty times as big. The size of this illegal sector is, therefore, not just a concern to the police and the judiciary, it is something that affects the environment, the water sector in particular. Also, production seems on the increase. An analysis of the risks for sources of drinking water is not yet available.

10.3.2 Underground storage and mining

The Netherlands is on the eve of a transition to sustainable energy. Broadly speaking, this transition is a heat transition because a large volume of energy consumption in the Netherlands is related to heating and cooling buildings and homes. The use of TES systems (at a depth of up to 200 metres) is already increasing. In 2018, for instance, 1976 open systems and 812 closed systems were known to be in use. The development of geothermics (at a depth of more than 1 km) is encouraged via a programme of the Ministry of Economic Affairs and Climate Policy. The development of geothermics is estimated in the Geo-energy master plan (Platform Geothermie 2018): from 17 (2018) to 75 by 2025, 175 by 2030, and 700 by 2050.

The PBL expects cold and heat storage in the subsoil and geothermal energy to play a large role in the energy transition in the Netherlands (Hoogervorst, 2017). We therefore expect growth in scale of existing energy applications in the subsoil in the next few years. This may be designed with so-called heat cascades, where heat networks are supplied from geothermics and heat surpluses are stored in the subsoil and used later on. The use of the potential of energy production from surface water, wastewater and drinking water demands an increase in scale of subsurface energy storage so as to coordinate phase differences between heat/cold demand and supply (Kruit et al., 2018).

The risks for the quality of groundwater and the way in which risks can be made manageable differ strongly, depending on how the energy is applied (open TES, closed TES or geothermics). Broadly speaking and without making any further distinction as to application, the following risks may arise:

- Aquifers and confining layers are fully or partially pierced. This means that some existing contaminants can reach greater depths faster and be attracted by groundwater abstraction.
- Leakages from plants (general) or wastewater reservoirs (geothermics) of liquids that are being used or pumped. Examples include drilling liquids, chemicals for well regeneration and corrosion inhibitors. Leakages may occur due to corrosion of the casing and in aboveground plants. Temperature effects may also occur, such as metals dissolving (at high temperatures), the mobilisation of existing contaminants and a rise in temperature of pumped-up groundwater.

The extent to which these effects occur and eventually affect the quality of abstracted groundwater strongly depends on the type of application, where, how and at what scale.

Apart from extracting geothermal heat, the subsoil is also used to store oil, gas, CO_2 and production water from gas extraction (in Twente). The final storage of radioactive waste in the deep subsoil is one of the options included in a study by the Ministry of Economic Affairs and Climate Policy (Opera Advisory Group 2018). The growing number of activities in the subsoil also lead to a continued depletion of potential, alternative groundwater abstraction sites that could act as a backup when an abstraction site becomes unsuitable.

11 Synthesis

11.1 Introduction

This report provides a factual overview of the current quality of sources of drinking water in the Netherlands. The final evaluation of the first-generation drinking water protection files (Wuijts et al., 2014) was used as a starting point and supplemented with general reports and evaluation reports on a national scale that were published since. This means that recent stocktaking studies for specific regions, such as the evaluation reports of the second-generation river basin management plans, are not included in this report. Also, the final evaluation of the second-generation drinking water protection files will be completed this year and could not be included in this report. These reports may contain newer and more detailed information than the information in this report. This mainly applies for (1) soil contaminants due to potential false positives (potential soil contaminants that have now been studied in more detail), resulting in a potential overestimation of the issues reported by Wuijts et al. (2014), and (2) salinisation on account of new knowledge gained during ongoing drought evaluations for 2018. Furthermore, there is not enough information available about emerging substances in general and pharmaceutical residues for groundwater in particular that would enable us to provide an adequate picture of the chemical condition of sources of drinking water. Nevertheless, some of the themes in this report can serve as a basis for drafting the agenda and can be used for looking after the drinking water interests in the water quality policy for the next few years.

This chapter first outlines the main threats for the quality of various types of sources of drinking water, based on previous, themed chapters. Surface water, groundwater and riverbank groundwater are subsequently discussed. The chapter concludes with a general outline of the perspectives for action.

11.2 The condition of surface water as a source of drinking water

Measuring data shows that the quality of surface water as a source of drinking water production is mainly affected by pesticides, salinisation, pharmaceutical residues and industrial substances. As a result, signalling values and standards for surface water at intake points were exceeded. This means that in the case of the parameters in question, the quality requirements for a good condition of sources of drinking water, ensuing from the WFD, are not always met. In some cases, signalling values were exceeded for such long periods of time that the intake of surface water became subject to exemption or was even temporarily halted. These situations primarily but certainly not exclusively occur during summer periods with low river discharge. Apart from monitoring and intensive treatment, the drinking water companies, therefore, also depend on surface water buffers taken in previously or on a temporary increase in groundwater abstractions.

Besides the aforementioned themes, it becomes increasingly clearer that microplastics, nanomaterials and antibiotics resistance may pose a threat to the quality of surface water as a source of drinking water. Due to a lack of systematic monitoring data, knowledge of these threats is still being gained. Consequently, the present state of knowledge makes it difficult to provide a clear picture of the condition of surface water with regard to these themes.

The Royal Netherlands Meteorological Institute (KNMI) prepared various climate scenarios that give the debate about substances in water an extra dimension. These scenarios indicate that climate extremes will increase, but they differ in intensity of change. The chance of extreme precipitation may result in an increase in leaching and runoff of substances. During periods of little to no precipitation, concentrations of all kinds of contaminants may rise in surface water. Due to a rise in the number of extreme precipitation events, the runoff of substances from diffuse contaminant sources and sewage overflows will increase. Furthermore, due to extreme quantities of precipitation, water treatment will be less efficient (Brunsch et al., 2018) and sewage overflow will become more prevalent.

Due to low river discharge, dry summers, expected in two out of the four climate scenarios, will result in reduced dilution of contaminants and an increase in salinisation. Besides, this may cause increasing emissions, for instance as a result of an increase in medicine use on account of an ageing population (Sjerps et al., 2016), to have a bigger impact of the quality of surface water. Also, after the discovery of previously unknown contaminants such as pyrazole and GenX, new hazardous substances are expected to be identified as well.

From the foregoing it follows that the quality of surface water as a source of drinking water is under increasing pressure from various sectors and that this pressure is likely to rise in the future. This means that we do not only need measures that enable us to comply with existing European legislation but that measures are also required in order to mitigate the effects of climate change and increasing use of emerging substances.

11.3 The condition of groundwater as a source of drinking water

Measuring data shows that the quality of groundwater as a source of drinking water is mainly affected by nitrate, pesticides, old soil contaminants and salinisation. There are also indications that traces of industrial substances, (veterinary) medicines and emerging substances occur in groundwater on an increasingly larger scale. Due to the continuing and increasing load of groundwater, it is contaminated at increasingly greater depths and with increasingly more substances. By now, various contaminants have reached about half of the groundwater abstraction sites. Based on measuring data and knowledge groundwater travel times, we expect to find contaminants at a growing number of groundwater abstraction sites in the near future. This confirms the interpretation by the Water Advisory Committee that the continuous contaminant load of groundwater will result in a steady and long-term, if not irreversible, deterioration of the quality of groundwater.

Until recently, the contamination of groundwater was mainly related to activities on the surface and confining clay layers (if any) created reliable barriers against distribution of contaminations. By now, the subsoil is used more and more often for infrastructure and buildings, for the storage of heat, cold and various substances, abstracting groundwater and various mining activities. Such applications can increase the risk of contamination of the abstracted groundwater. On the one hand, this is caused by existing contaminations reaching depths faster through the penetration of clay layers and on the other hand, because leakages in plants may cause new contaminations. Underground energy applications and the associated risks will increase in scale following the imminent energy transition. This may put more pressure on the quality of groundwater resources intended for the production of drinking water and this will reduce available space for the development of alternative abstraction sites.

The effects of climate change on the quality of groundwater are still unclear, although it does seem that extreme weather will be more prevalent. This may lead to an increase of nitrate leaching from agricultural land due to reduced nutrient uptake and increased mineralisation of organic matter. Also, climate change may cause an increase in plant diseases and plagues, which in its turn may lead to an increase in the use of pesticides in the agricultural sector and by citizens. In contrast with surface water, climate change is not expected to cause an immediate increase in salinisation of abstracted groundwater. It may have an indirect impact, because demand for drinking water and groundwater rises.

Monitoring data from the drinking water companies shows that contamination of groundwater may affect the quality of abstracted groundwater for decades to come. The current 30-year-old groundwater protection policy is based on the principle that relocating groundwater abstraction sites and increasing treatment intensity are realistic options of dealing with insufficient water quality. By now, relocating abstraction sites is hardly possible due to strong competition regarding the water and space available. In addition, increasing treatment intensity violates Article 7.3 of the WFD (the aim to reduce treatment intensity). Because of these changes, the quality of groundwater must be, in the words of the Water Advisory Committee, improved urgently and that also applies to strategic groundwater reserves in order to maintain future availability for the purposes of drinking water production (Water Advisory Committee, 2017).

11.4 The condition of riverbank groundwater as a source of drinking water

The quality of riverbank groundwater as a source of drinking water is predominantly affected by soil contaminants and surface water that contains pesticides, medicines and emerging substances, including industrial substances. Furthermore, various riverbank groundwater abstraction sites along the Lek are sensitive to salinisation. In terms of nature, the quality issues are very similar to those for surface water as a source of drinking water. Thanks to soil passage, many contaminants do not reach the abstraction site or do so in small quantities. Poorly degradable substances will have a delayed effect on the quality of the riverbank groundwater taken in. Given the purifying effect of soil passage, the risks posed by microplastics and nanomaterials are assessed slightly lower and the rise in peak concentrations caused by climate change will have a lesser effect compared to surface water as a source of drinking water. On the other hand, fewer measures are available in the case of the abstraction of riverbank groundwater, because selective intake is not possible and the buffer reserves are often smaller than those for surface water abstraction. Furthermore, old soil contaminants pose a threat to the quality of abstracted riverbank groundwater in many locations, because these abstraction sites are often situated in or near highly urbanised areas.

Like the quality of surface water, the development of the quality of riverbank groundwater is likely to come under increasing pressure in future due to climate change and an increase in emissions of substances caused by, among other things, rising use of medicines on account of an ageing population. Also, urbanisation and an increase in the use of the subsoil for energy transition, for instance, is a major point for attention, as in the case of groundwater abstraction.

11.5 Perspectives for action

The WFD stipulates that sources of drinking water have to be in a good condition and that member states have to aim for reduced treatment intensity for the production of drinking water. Realising these targets requires adequate use of the following instruments, at least:

1. A source-oriented strategy, aimed at reducing emissions into groundwater and surface water.
2. A chain-oriented strategy aimed at mitigating the risks of industrial substances and medicines in various phases of development, application and distribution in the water system.
3. Regulation and enforcement, aimed at responsible use of the space available (a future-oriented groundwater protection policy) and the use and application of substances in the agricultural sector, the industrial sector and by consumers (environmental policy). This also includes the harmonisation of standards from various acts and policy frameworks and making the signalling values in the WFD drinking water sources monitoring and verification protocol operational for groundwater.
4. An incentive and facilitative policy for desired functions (such as nature-friendly and environmentally-friendly agriculture) or activities (such as water conservation), thus creating synergy between socially desirable developments and the importance of drinking water.
5. Awareness-raising and encouraging desirable behaviour, mainly aimed at farmers and citizens.
6. Environmental management for the benefit of early warning, awareness-raising and early-stage management in spatial development processes.
7. International collaboration aimed at reducing emissions into surface water in the upstream areas of the Rhine and Meuse river basins.
8. A continuation and, where necessary, an expansion of monitoring and management of mobile soil contaminations for the protection of the quality of abstracted groundwater.
9. Early warning aimed at the early detection of new threats and risks to the quality of groundwater and surface water. We need this information in order to be able to take adequate source-oriented or effect-specific measures.

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