Evaluation of the EU Drinking Water Directive

Draft final report

Client: European Commission, DG Environment

Rotterdam, November 24, 2015

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Authors: Erik Klaassens, Hans Kros, Paul Romkens, Wim de Vries, Adriana Hulsmann, Joachim Schellekens

Quality Control: Marie José Zondag

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Study team

The study team supporting the European Commission in the review of Directive Study supporting the revision of the EU Drinking Water Directive is drawn from the following institutions:

Ecorys Nederland BV - an international organisation for economic consultancy and research. Its highly qualified staff members work to serve the interests of private and public clients worldwide. The company specialises in advice on complex market, policy and management issues and bases its work on the best available research, knowledge and expertise. Ecorys covers a wide range of water policy areas such as drinking water resources, production and distribution, wastewater collection, treatment and discharge, flood control, storm water surge, and drainage systems, coastal zone development, wetlands, climate adaptation urban and rural areas, and water pricing, privatisation of water companies, and governance. Ecorys has a strong track record in evaluating policies, programmes and institutions and in impact assessments.

Alterra (Netherlands) - part of the Wageningen University and Research Centre concern, Alterra offers a combination of practical and scientific research in a multitude of disciplines related to the green world around us and the sustainable use of our living environment. Alterra engages in strategic and applied research to support design processes, policymaking and management at the local, national and international level. Expertise includes the interactions between land and water management, land use and climate for the purpose of sustainable water management, taking account of various sectoral interests and ecological and habitat requirements.

ACTeon (France) - a private research and consultancy bureau dedicated to innovative approaches to environmental policy. Specialized in the “soft” dimensions of the environment, i.e. (environmental) economics, sociology and governance issues, ACTeon is covering a wide range of policy issues, namely water, agriculture & the environment, forestry, marine resources, renewable energy, biodiversity. ACTeon is very active in the European scene where its economic expertise is widely recognized (in particular in the field of water).

KWR Watercycle Research Institute (Netherlands) - owned by the Dutch water (cycle) companies, provides services to ascertain a well-functioning water cycle through optimal water management. KWR is responsible for the execution of the joint research programme of the Dutch water sector (water supply companies and water cycle companies). KWR has many years’ experience with the technical, scientific and administrative aspects of the Drinking Water Directive 80/778/EEC and 98/83/EC.

REC (Regional Environmental Centre for Central and Eastern Europe) is an international organization with a mission to assist in solving environmental problems. The Centre fulfils this mission by promoting cooperation among governments, non-governmental organizations, businesses and other environmental stakeholders, and by supporting the free exchange of information and public participation in environmental decision making.

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Abbreviations

CAP	Common Agricultural Policy
CPD	Construction Products Directive
DWD	Drinking Water Directive
EAS	European Acceptance Scheme
EC	European Commission
ECI R2W	European Citizen Initiative *Right to Water*
E. coli	Escherichia coli
EPA	Environmental Protection Agency
EU	European Union
JC	judgement criteria
MS	Member State
NSF	USA National Sanitation Foundation
WFD	Water Framework Directive
WHO	World Health Organization
WSZ	Water Supply Zone[1]

Member States

BE	Belgium
BG	Bulgaria
CZ	Czech Republic
DK	Denmark
DE	Germany
EE	Estonia
IE	Ireland
EL	Greece
ES	Spain
FR	France
HR	Croatia
IT	Italy
CY	Cyprus
LV	Latvia
LT	Lithuania
LU	Luxembourg
HU	Hungary
MT	Malta
NL	Netherlands
AT	Austria
PL	Poland
PT	Portugal
RO	Romania
SI	Slovenia
SK	Slovakia
FI	Finland
SE	Sweden
UK	United Kingdom

[1] The DWD defines small WSZ as serving less than 5,000 people or less than 1,000 m3 a day on average

Executive Summary

The evaluation's purpose

This Report presents the outcome of the evaluation of the Drinking Water Directive. The evaluation assessed to what extent the provisions of the Directive have been effective, efficient, coherent and relevant and it analysed to what extent the actions based on the Directive provided value added at EU level and it analysed the coherence with the relevant EU policies. The evaluation covers the period 1998-2014.

Methodology

To visualise the links between policy goals, activities, actors and intended outcomes of the DWD, an intervention logic was set-up. The intervention logic was developed on the basis of an analysis of the provisions of the Directive itself, a review of EU policy documents relevant to drinking water; and on initial interviews with key stakeholders.

The next step was to link the set of evaluation questions included in the Terms for Reference for the evaluation and in the Drinking Water Smart Regulation Roadmap published by the Commission in May 2015, to judgement criteria and indicators. These criteria and indicators guided the data collection and analysis process and formed the basis on which evidence based conclusions could be drawn with regard to the evaluation criteria.

The evaluation used both desk research and stakeholder views to obtain evidence. Desk research included the review of relevant policy documents, position papers, and legislation, an extensive analysis of key parameters related to water quality, and the review of costs and benefits associated with the DWD.

Stakeholder views were collected through various means: some 30 interviews with key stakeholders representing regulators, industry, utilities, NGOs, and academics. In addition, the evaluators and DG ENV jointly hosted a stakeholder conference on the 26th of May that was attended by approximately 70 stakeholders from across the EU.

Another key information source has been a Public Consultation which was conducted prior to the evaluation. This Public Consultation incorporates 5,875 completed responses, 56 positions of stakeholder institutions and 80 positions of EU citizens.

In the course of the information gathering process some limitations were identified. The quality and quantity of data on the effects of the DWD across the EU proved uneven, the available information did not lent itself to a counterfactual analysis and quantification of benefits related to the DWD proved difficult.

Key findings

Overall, the evaluators found that the Drinking Water Directive is still fit for purpose by providing a relevant piece of legislation which protects the health of EU citizens and which provides efficient mechanisms to implement measures at EU and Member State level, which could not have been provided as efficient and effective by MS and/or regional authorities. The answers to the evaluation questions found below provide a summary of the evaluation's findings.

Effectiveness

EQ1 To what extent has the Directive achieved its objectives?

The DWD has contributed to achieving its objectives to provide a better protection of human health from the adverse effects of any contamination and has ensured clean and wholesome drinking water for (most) citizens in the EU. The most significant effect of the DWD was seen in the increase in compliance for parameters related to materials in contact with drinking water. Less convincing evidence exists for several agricultural/ catchment related parameters.

EQ2 Which provisions have been most appropriate for protecting human health?

By setting parameters for microbiological substances, the DWD has reduced microbiological outbreaks. Monitoring of the parametric values was found to be an effective way of collecting information if the DWD standards are met. The frequency of monitoring sometimes is below what is required. Most of the remedial actions performed are related to the microbiological parameters and to a lesser extend to chemical parameters. The provision of derogation has been found to be effective as it allowed MS to apply the parameter values at a feasible pace. Article 10 has been effective as it is applicable to the treatment and to distribution of the drinking water, a phase in which considerable contamination of drinking water can occur. As many Member States experienced problems with the implementation of the article its effectiveness has been reduced. The compliance with the requirement of reporting to the Commission is high but the information submitted by Member States is found insufficient to perform a thorough compliance check and adequately inform e.g. the European Parliament. Regarding information provided to consumers there are important differences between Member States regarding the quality of reporting and according to the Public Consultation consumers satisfaction on the information provided is only 20%. The DWD review process of Annex I is found to be lengthy and time-consuming, this is however justified by the seriousness and implications of any proposed change.

EQ3 What main factors have influenced or stood in the way of achieving the objectives of the DWD?

The measurement of groundwater and surface sources is very difficult due to the complex nature of the extraction zone itself. Therefore it can be concluded that compliance at the tap is the most effective method to guarantee the objective of wholesome and clean drinking water. The reduction of non-compliances can for a large extent be ascribed to improvements in the distribution network.

EQ4 What results, if any, did the DWD achieve beyond its main aim to protect human health, for example towards environmental protection? And EQ5 Did the Directive cause any other unexpected or unintended changes?

The DWD can be linked to a number of effects that go beyond the protection of human health, such as increased awareness on drinking water quality and to some extent additional environmental legislation such as the Nitrate Directive, the improved quality of domestic wastewater, and increased attention for materials in contact with drinking water.

Efficiency

EQ6 To what extent are the costs related to the implementation of the DWD justified, given the benefits which have been achieved?

It has been calculated that the total cost of the EU28 drinking water sector in 2014 amounts to 46.5 billion euro of which 18% (8 billion in 2014) can roughly be attributed to the DWD. Some of the found benefits have been assessed at a qualitative level because not all effects can be monetized (lack of available data on avoided sickness for instance). It was found that the lead standard set by the DWD and has probably led to significant welfare benefits across Europe. Other notable benefits that can be attributed to the DWD are the aesthetic improvements with respect to drinking water,

the existence of a EU baseline regulatory framework and the general improvement of the quality of drinking water both for consumers and other users. Overall an assessment if the costs related to the implementation of the DWD are justified is difficult to make due to a lack of benefit quantification possibilities. Quantitatively it was found, based on expert judgment and conducted interviews, that total attributable benefits outweigh total attributable costs quite significantly.

EQ7 Have there been technical or other developments since the Directive came into force which could contribute to achieving the objectives more efficiently?

It was found that various technical and other developments since the elaboration of the DWD have contributed to achieving the goals of the DWD, such as the new approach to monitoring (leading to faster decision making in case of need for remedial action) applied in some MS, new ISO approved method to improve the analysis of microbial quality of water, technical innovations increasing awareness of water consumption at the consumer level and developments in sensor technology.

EQ8 To what extent does the Directive allow for efficient policy monitoring?

Member States' reporting on the quality of drinking water to the Commission is valuable for policy monitoring, but as there are limitations to the information of these reports, which are related to inconsistency in methods of reporting and its low frequency, the efficiency is doubtful.

Coherence

EQ9 To what extent are the DWD provisions internally coherent?

There are some minor issues regarding the internal coherence of the DWD. One issue concerns Article 10 provisions for substances and materials are in relation to the parametric values of Annex I. It was found that all other provisions of the DWD are internally coherent.

EQ10 To what extent can effects be linked to provisions in other EU legislation - in particular regarding pollution prevention at water abstraction points or during treatment and distribution? And EQ11 Which effects did the DWD have in areas targeted by other EU legislation?

The DWD is coherent with Directives relevant for drinking water such as load-based Directives, and for Directives regulating food quality and other agricultural products. The coherence of the DWD with the Water Framework Directive (WFD) is especially important as the protection of drinking water resources is established as an indispensable part of the plans and measures under the WFD. This has made the WFD the most relevant for the quality of drinking water.

Relevance

EQ12 To what extent is the DWD approach to protect human health from the adverse effects of any contamination of drinking water still appropriate?

It is found that the DWD remains fit-for-purpose when considering the overall EU objectives in terms of providing clean and wholesome drinking water to improve and/or safeguard human health. Having in place a directive with requirements that set an overall minimum quality within the EU has actually provided a situation that in the whole EU a minimum level of drinking water quality is guaranteed. Additionally, the DWD has led to a more consistent regulatory framework when compared to 20 years ago, shown in particular through the increase in overall water quality as derived from an increase in compliance. Consequently, transparency has increased (even though it is not at an optimal required level) due to the requirement to report to the EC and the public. Below, the relevance of provisions, with a link to relevance of the DWD, is discussed:

- **Quality standards** as presented in Article 5 of the DWD concern microbiological, chemical and indicator parameters. Microbiological parameters included in the DWD are considered relevant

indicators of water quality, although incidents with specific pathogenic micro-organisms may occur when neither indicator parameter is detected.

- Since the DWD came into force, **analytical methods** have improved and new methods have been developed. New or improved methods can be applied, provided sufficient equivalence testing is performed. The directive's relevance could be improved if ways can be found to allow for the use of new and innovative monitoring technologies when they become available, taking into account specific methodological requirements, but without the need to revise the directive or its annexes.
- The relevance of indicator **parameters** such as colour, odour, taste, turbidity and hardness is questionable, since many of these parameters do not have numeric values in the directive, and acceptable levels differ geographically. It is therefore argued that water suppliers and Member States are better equipped to determine preferred indicator values.
- **Monitoring** actions (Article 7 of the DWD) are relevant for the verification of the quality standards set in Annex I of the directive. However having different monitoring requirements for different sized water supplies is considered to cause a reduction in the relevance of the directive, since this undermines the provision of a minimum quality level of drinking water for a sizable proportion of the EU-population.
- **Derogations** (Article 9) are an convenient accommodation for MS to implement Annex I of the directive at a feasible pace. The relevance of this article is, however, expected to be reduced when more and more water quality parameters in all MS reach the requested level. Other options to deal with exceptional circumstances should therefore be investigated.
- **Remedial** actions (Article 8) are an important tool for Member States to enforce the DWD and require actions in case of non-compliance. However, this tool is only used when an undesirable situation has already occurred, so the relevance of the directive could be improved if additional measures were included, aimed at the prevention of such situations in the future. Possible measures are water safety planning and risk analysis.
- The **reporting** process under the DWD is seen as increasingly important in view of a more critical attitude of present-day consumers and the need for evidence based policy making at EU level. Article 13 deals with the requirements on reporting, but it is generally agreed that the Commission needs additional tools besides the DWD to adequately address reporting needs of both legislators and consumers.

EQ13 Which other parameters than those currently set in the DWD have become more important for human health?

Next to the parameters currently included in the DWD other parameters than those currently set in the DWD have become more important to safeguarding human health, such as Chromium Cr, VI, Perfluorinated compounds, some types of endocrine disrupting compounds, and nanoparticles.

EQ14 Can any obsolete provisions in the Directive be identified and if yes, why are such provisions obsolete?

The relevance of some provisions has been reduced due to new legislation: natural mineral waters (Directive 2009/54/EC) and radio-activity parameters (Article 31 of the Euratom Treaty).

EQ15 Why has the DWD not been adapted to technical and scientific progress?

No adaptation of the DWD was needed to allow the use of technical developments as the Directive is not prescriptive. Independent of changes in the legislation various technical developments, for instance related to ICT (WISE reporting), have been put in practise and led to benefits regarding efficiency. The adaptation of the Directive with regards to scientific progress, for instance the adaptation of parameters in Annex I has been discussed, but it was found that a full revision was not (yet) needed.

EQ16 What are citizens' expectations for the role of the EU to ensure drinking water quality?

The DWD takes the need of EU citizens into account, although there is a growing demand to better link EU legislation on drinking water with the needs of citizens regarding information provision and participation.

EU citizens consider that water provided is of good quality and generally affordable. This is confirmed by reports on water quality reports in the period 2005-2013 which how that the water quality in all, excluding some regions and relatively newer MS, MS is safe.

The EU-added value

EQ17 What has been the EU added value of the Directive?

There has been a notable improvement in the quality of water which can be linked directly to improvements in the distribution networks. Furthermore, without drinking water legislation in place at EU level, it would have been unlikely that improvement in water quality would have been as widespread as we witness them today. Reasons for a high level of EU added value through existence of the DWD are:

- All Member States are progressing towards the same level of drinking water quality;
- Efforts at EU and Member State level to build up a common comprehensive body of knowledge around water quality parameters and monitoring techniques based on common EU wide rules and agreements;
- Improved information to consumers has led to an increased awareness of the importance of high quality drinking water;
- The DWD is an opportunity to optimize processes and share resources, resulting in various efficiencies and cost savings; and
- Efficiency gains for firms, either through using tap water in their production process and/ or through harmonization of production processes across borders.

Moreover for some MS, and especially those with a federal structure such as Germany and Austria, EU regulation is seen to be helpful by the national government to achieve compliance. Federal bodies often have a high level of independence and are more likely to comply with regulation coming from the EU or regulation based on EU legislation.

EQ18 Is there any possibility to compare EU legislation on drinking water quality with legislation in place in similar regions outside the EU?

In comparing DWD with the approaches in countries such as the USA, Canada, Australia and New Zealand it was found that they have good practices in place for monitoring, a risk-based approach based on local characteristics (similar to current EU developments) and the so-called '95% confidence' approach. In the USA, the public is further actively involved in various stages of the water management process.

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1 Introduction to the study

1.1 Objective and scope of the study

The study aims to support the Commission in the evaluation of the Drinking Water Directive (DWD), in line with the requirements of the regulatory fitness programme (REFIT) of the European Commission.[2] This evaluation is a direct follow-up to the first successful European Citizens' Initiative (ECI) *Right2Water -Water and sanitation are a human right! Water is a public good, not a commodity!*[3]

The evaluation has been conducted in line with the EC evaluation guidelines and evaluation standards, including the identification of those provisions of the Directive which would benefit from a revision and of those which are still fit for purpose is expected.

This report is the key deliverable of the evaluation process, presenting the critical judgements and answers to the evaluation questions.

1.2 Policy context of the 1998 Drinking Water Directive

High-quality, safe, sufficient drinking water is essential for life: we use it for drinking, food preparation and cleaning.[4] For the past 30 years, EU drinking water policy has been designed to ensure that water intended for human consumption can be consumed safely on a life-long basis, and this represents a high level of health protection.

European water policy began in the 1970s with the adoption of programmes as well as legally binding legislation. As regards programmes, the First Environmental Action Programme covered the period 1973–1976. In parallel, a first set of legislation was adopted, starting with the 1975 Surface Water Directive and culminating in the 1980 Directive relating to the quality of water intended for human consumption (80/778/EEC).

The underlying principle for the previous Directive was –similar to the current Directive - that, in view of the importance for human health of water for human consumption, it was necessary to lay down quality standards with which water was to comply. To this end, the 1980 Drinking Water Directive established a high number (62) water quality standards regulating water intended for human consumption.

However, in spite of the many benefits of the 1980 Directive, by the end of the 1980s, it was realised that there were some shortcomings. For example, the Directive did not provide Member States with an adequate legal framework within which to respond to variations in the quality of raw water and to the technical difficulties encountered in the production and distribution of drinking water. Furthermore, both scientific and technological knowledge had changed substantially during the decade that had passed,[5] and it was necessary to adapt the original Directive in accordance with the principle of subsidiarity by reducing the number of parameters for which Member States

[2] Regulatory Fitness and Performance Programme (REFIT): State of Play and Outlook Accompanying the document Better Regulation for Better Results – An EU Agenda {COM(2015) 215 final} {SWD(2015) 111 final}

[3] Commissions' reply to the ECI - (COM(2014) 177 final)

[4] European Environment Agency (2014). Performance of water utilities beyond compliance. ISSN 1725-2237, Copenhagen.

[5] Towards Effective Environmental Regulation: Innovative Approaches in Implementing and Enforcing European Environmental Law and Policy; Demmke (2001).

were obliged to set water quality objectives and by focusing on compliance with essential quality and health parameters. The new Directive also aimed to provide for the safeguarding and promotion of sustainable use of water intended for human consumption, an objective which can be considered as foreshadowing the Water Framework Directive.

The legal process for the new Directive started in 1994 with the submission of the "Proposal for a Council Directive concerning the quality of water intended for human consumption".[6] After a first and second reading by the European Parliament, the Directive was formally adopted by the Council of the European Union on November 3,1998.[7]

The key aim of the Directive is to protect human health from the adverse effects of contamination of water intended for human consumption by ensuring that it is `wholesome and clean' (Art. 2(1) and 3). It applies to all water intended for human consumption, as well as water used in the production and marketing of food, subject to certain exceptions including natural mineral waters which are regulated pursuant to Council Directive 80/777/EEC (Art. 2(1)).

In the revised DWD 98/83/EC standards have been updated and irrelevant parameters have been deleted. Sampling methods and sampling points have been better defined and analysis methods and performance criteria as well as analytical quality control have been specified. There is increased transparency on appropriate derogation provisions and on information and reporting. Important improvements in water quality aimed for in the DWD are a reduction in the value for copper from 3 to 2 mg/l, reduction in arsenic and nickel values. Also a major change in the reduction of the lead values in drinking water in a two-step approach from 50 to 10 ug/l over a 15 year period (estimated cost of compliance for 12 Member States between 27 and 34 billion euro.[8] Other important aims were the reduction of the disinfection by products in drinking water trihalomethanes and bromate. Another new aspect of the DWD was the product specified parameters acrylamide, epichlorohydrin and vinylchloride, all to be achieved through product specification.

1.3 Intervention logic

The first methodological step was the development of a simplified intervention logic. It illustrates the basis of a systematic prioritisation of the objectives, the identification of the anticipated effects of the Directive and how the objectives correspond to the effects. The intervention logic forms the basic framework for assessing to what extent the implementation of this Directive has resulted in the anticipated effects, and whether or not the objectives have been achieved, and whether the actual effects were foreseen. The intervention logic (Figure 1.2) present in a birds-eye-view the objective and the anticipated effects. In most evaluation studies carried out for the Commission, the main source for identifying the anticipated effects of a Directive is the ex-ante Impact Assessment carried out for the Directive. However, the DWD was designed before the Commission Guidelines on Impact Assessment was first adopted in June 2005.

The intervention logic of the DWD was developed by the team on the basis of the following elements:

- Analysis of the provisions of the Directive itself;
- Review of other EU policy documents relevant to drinking water; and

[6] Proposal for a Council Directive concerning the quality of water intended for human Consumption (95 /C 131 /03) COM(94) 612 final — 95/0010(SYN), http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:51994PC0612&from=EN.

[7] Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0083&from=EN.

[8] Source: Ierotheos Papadopoulos EC Prague meeting May 1999

- Initial interviews with key stakeholders[9].

The intervention logic illustrates, in particular, the expected linkages between the identified needs and broader policy goals and the more specific operational objectives of the Directive. This intervention logic, as depicted in **Error! Reference source not found.**, represents the understanding and interpretation agreed with the steering group and the external consultant with regard to the expected causal linkages between activities, output, results and impact (global objective). Below, these elements are described in more detail.

Objectives. The key (global) objective of the DWD is "to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean".[10] Possible variables measuring impacts of the Directive are changes in water-borne diseases. Further or indirect impacts include i) land-use in water abstraction zones; ii) agricultural behaviour related to fertilisation and use of plant protection products; and iii) research and production of water distribution material.

The specific objective of the Directive is to ensure high drinking water quality, the result of which can be measured by the compliance of water quality with standards for microbial parameters, chemical parameters, and indicator parameters.

Output and activities. The Directive's provisions provide the legal context for actions by Members States (MS) and the Commission. These outputs and related actions are discussed in more detail in the following chapters. Below we list the six outputs that are considered to be the core provisions of the Directive, together with the related activities. A schematic overview of the intervention logic is presented overleaf:

- Parametric values set:
  - Parametric values are determined at EU level;
  - MS set values for other parameters.
- Standards set for materials in contact with drinking water
  - MS take measures to avoid contamination from materials in contact with drinking water.
- Limited derogations provided:
  - Limited derogations are prepared / approved by MS or Commission.
- Monitoring system in place:
  - Monitoring performed by MS according to Annex II and III of the DWD;
  - Supply zones and water distribution are established and adapted.
- Remedial actions taken:
  - Remedial actions are taken by MS;
  - Measures are taken to reduce or eliminate the risk of non-compliance;
- Reports on water quality available:
  - Monitoring performed by MS;
  - Up-to-date information is made available to consumers;
  - Reports on water quality are submitted to the Commission.

External factors. There is a number of external factors with important consequences for the Directive's impact, results and outputs. These factors, which will be discussed at appropriate points in the report include, are among others:

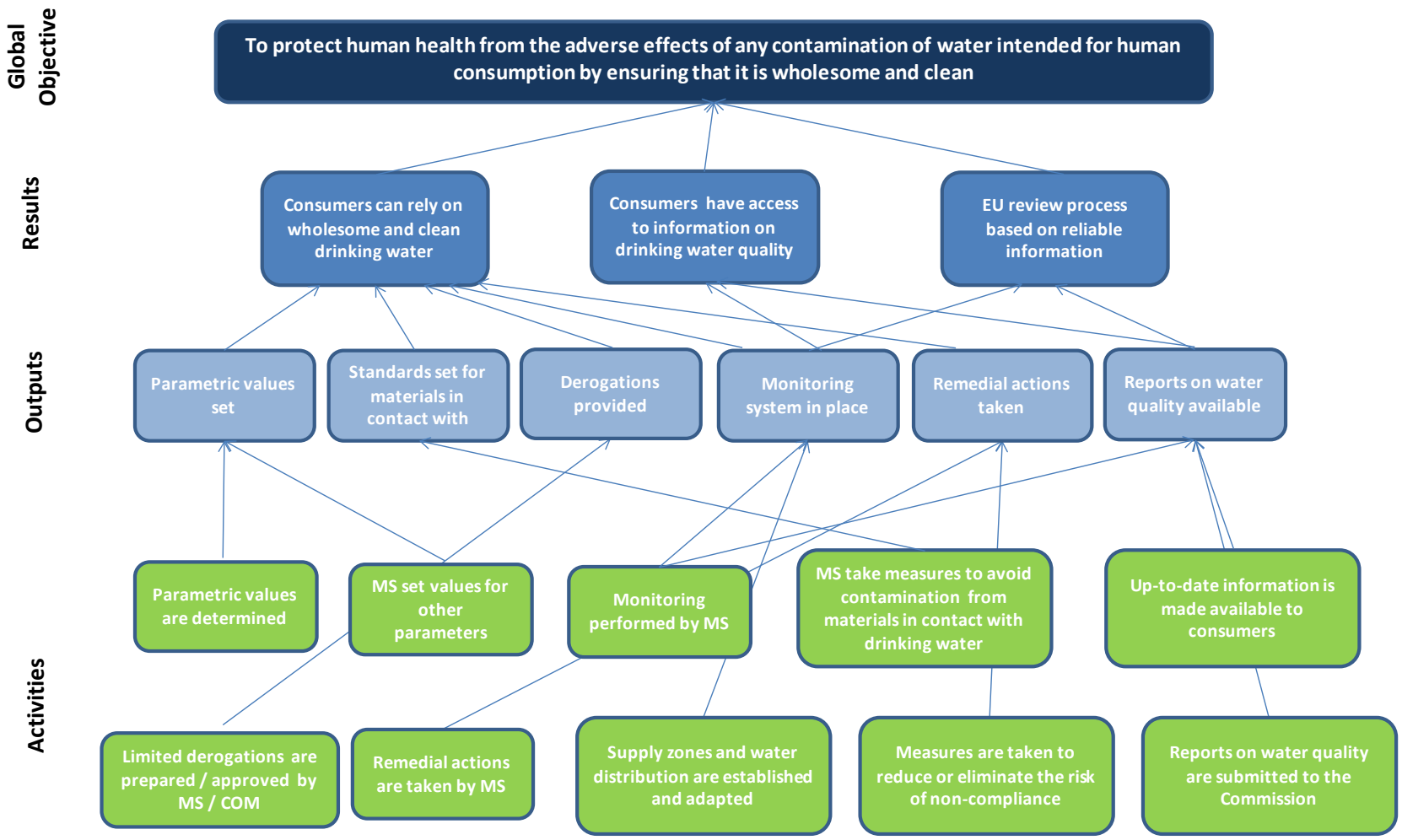
- National/regional characteristics related to drinking water management such as abstraction sources, disinfection;

[9] Stakeholders include Member State (water) authorities, Commission staff, research organisations, the general public, industry groups and international NGOs.

[10] *Ibid*; Article 1.

- Evolution of treatment techniques;
- Scientific development of analytical methods;
- Other EU legislation (water framework, agriculture (CAP), nitrates, pesticides, food, construction products);
- Pressures related to human and economic activities;
- Climate change effects (floods, droughts, scarcity).

Figure 1-1 Intervention logic DWD



Source: Ecorys (2015)

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1.4 Evaluation methodology

1.4.1 Evaluation approach

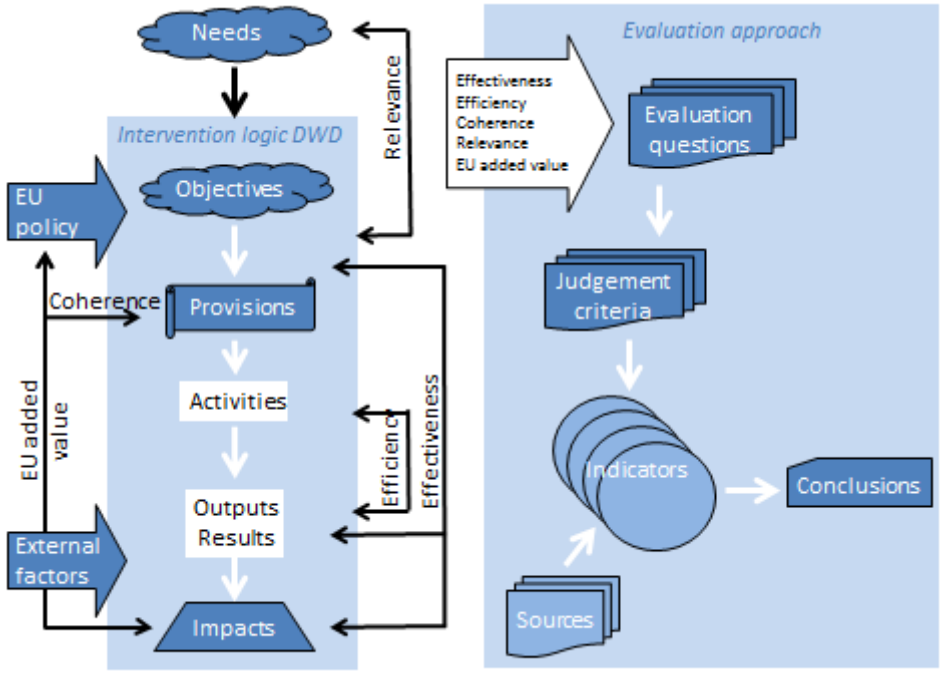
According to the Commission's Better Regulation Guidelines for Evaluations and Fitness Checks, all evaluations are to consult on the mandatory evaluation criteria, which are[11]:

- Relevance of the intervention in relation to the identified needs/problem it aims to address;
- Effectiveness of the intervention;
- Efficiency of the intervention in relation to resources used;
- Coherence of the intervention with other interventions which share common objective; and
- EU added value resulting from the intervention compared to what could be achieved by Member State action only.

These criteria have been used in this evaluation and linked to the DWD intervention as illustrated in Figure 1-2. A set of evaluation questions from the Evaluation Roadmap, has guided the process of assessing the evaluation criteria.[12]

To help answer the evaluation questions, judgement criteria (JC) have been defined for each of the evaluation questions. For each of the judgment criteria, indicators were defined. In the figure below we illustrate the linkage between the various elements of the intervention logic and the evaluation methodology.

Figure 1-2 Linking the intervention logic with the evaluation approach



Source: Ecorys (2015)

Where available, quantitative indicators were used. However, in most cases information on indicators was only available in qualitative terms and judgements were based on plausible reasoning. The lack of quantitative information was particularly problematic for the analysis of costs and benefits. Benefits are mostly related to the avoidance of illness and very little research has been carried out in his domain. On costs, we were able to assemble data on some but not all cost

[11] Commission Staff Working Document "Better Regulation Guidelines", {COM(2015) 215 final}; {SWD(2015) 110 final}.

[12] http://ec.europa.eu/smart-regulation/roadmaps/docs/2015_env_041_drinking_water_en.pdf.

categories related to drinking water, and furthermore the link of these categories to the Directive is not always clear. A more detailed discussion on these limitations is found in chapter 2.3.

1.4.2 Evaluation questions

Below we list the evaluation questions for each of the five evaluation criteria. As the nature and scope of these question vary considerably, the depth and scope of the analysis also vary.

Effectiveness analysis considers how successful EU action has been in achieving or progressing towards its objectives. The evaluation is to form an opinion on the progress made to date and the role of the EU action in delivering the observed changes. We will therefore look at changes in compliance with the drinking water quality standards, and relate these with the actions called for by the Directive's provisions. The evaluation questions related to effectiveness are:

- EQ1 To what extent has the Directive achieved its objectives, e.g. to reduce contamination of water intended for human consumption and to protect human health?
- EQ2 Which provisions have been most appropriate for protecting human health? To what extent have parameter requirements and also general ones for Member States been effective and why?
- EQ3 What main factors, in particular related to water bodies, agriculture and distribution networks, have influenced, or stood in the way of, achieving the objectives of the DWD?
- EQ4 What results, if any, did the DWD achieve beyond its main aim to protect human health, for example towards environmental protection?
- EQ5 Did the Directive cause any other unexpected or unintended changes?

Efficiency considers the relationship between the resources used by an intervention and the changes generated by the intervention (which may be positive or negative). In order to assess if the DWD is efficient, the evaluation looks at the various cost categories related to the provisions of the Directive such as administration, monitoring, remedial actions, and reporting and relates these to the (changes in) volume of water supplied or number of people served. The evaluation also looks at the benefits related to providing clean and wholesome water. These benefits are largely indirect (such as avoiding cost of sickness and absence of work) and difficult to quantify. Questions on efficiency are:

- EQ6 To what extent are the costs involved with implementing the DWD justified given the benefits which have been achieved?
- EQ7 Have there been technical or other developments since the elaboration of the Directive that could contribute to achieving the objective more efficiently?
- EQ8 To what extent does the Directive allow for efficient policy monitoring?

Coherence of the DWD is assessed at two levels: i) by verifying to what degree the internal provisions of the Directive work together or not and ii) if verifying the interlinkages with other legislative acts in the same policy field that came into force afterwards. Questions on coherence are:

- EQ9 To what extent are the DWD provisions internally coherent?
- EQ10 To what extent can effects (on quality of drinking water) be linked to provisions in other EU legislation -in particular regarding pollution prevention water abstraction, preparation and distribution (including materials and products used)?
- EQ11 Which effects has the DWD had on areas targeted by other EU legislation -in particular legislation on food, chemicals, pesticides, fertilisers, agriculture, water abstraction, preparation and distribution, product policy?

Relevance looks at the relationship between the needs and problems in society and the objectives of the intervention. In this context, the evaluation needs to establish whether the overall objectives

of the Directive in terms of improved drinking water remain fit-for-purpose and it needs to look at any changes in the regulatory framework over the last years. More specifically, the evaluation looks at the relevance of drinking water parameters and at the relevance of other important provisions. The evaluation questions related to relevance are:

EQ12 To what extent is the DWD approach to protect human health from the adverse effects of any contamination of drinking water still appropriate?

EQ13 Which other parameters than those set currently in the DWD became more important for human health?

EQ14 Can any obsolete provision in the Directive be identified and if yes, why are such provisions obsolete?

EQ15 Why has the DWD not been adapted to technical and scientific progress?

EQ16 What are citizens' expectations for the role of the EU to ensure drinking water quality?

EU-added value looks for changes that can reasonably be related due to EU intervention, rather than non-EU interventions. In many ways, the evaluation of EU added value brings together the findings of the other criteria, presenting the arguments on causality and drawing conclusions, based on the evidence to hand, about the performance of the EU intervention. Questions on coherence are:

EQ17 What has been the EU added value of the Directive?

EQ18 Is there any possibility to compare EU legislation on drinking water quality with what is in place in similar regions?

Annex A (Evaluation matrix) brings together the evaluation questions, judgement criteria, indicators, and the sources of information. The matrix initially included in the Inception Report was slightly adapted to reflex more fully the elements contained in the Evaluation Roadmap.

1.4.3 *Information sources*

In this section we list the relevant information sources which were used to obtain the necessary information for this evaluation and we discuss the limitations linked to these information sources. Besides these sources, the study team was able to draw on the available expertise of the consortium partners, notably KWR and Alterra.

Public Consultation

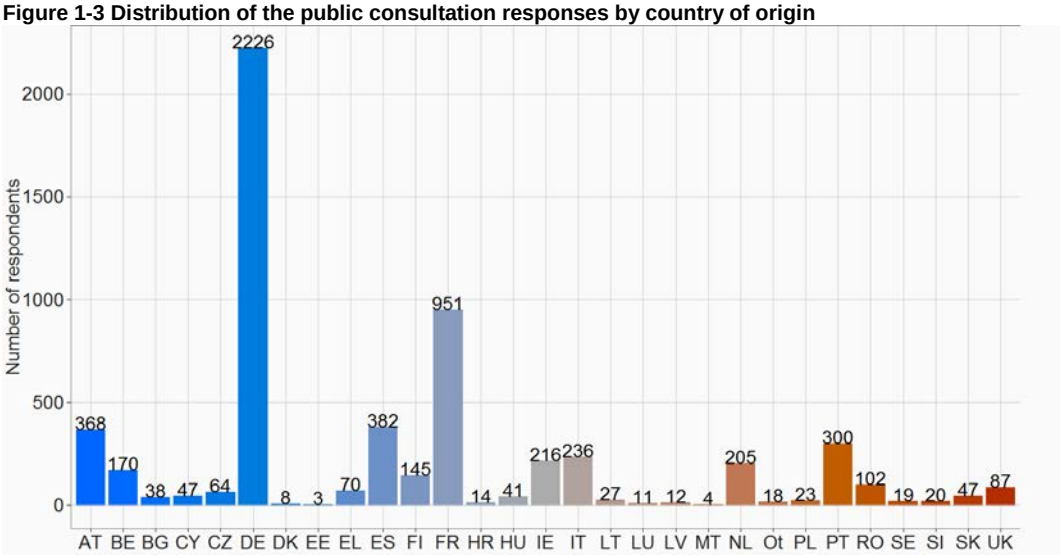
In 2014, the Commission launched an EU-wide public consultation on the DWD, notably in view of improving access to quality drinking water in the EU. The aim of this consultation was to get a better understanding of citizens' views on the need and the possible range of actions which could be undertaken in order to improve the supply with high quality drinking water. The survey was opened from 23.06.2014 until 23.09.2014 at http://ec.europa.eu/eusurvey/ (see the questionnaire in Annex 3) and was available in all EU languages. The report on the Public Consultation is part of the current evaluation study and provides a valuable source of information. The draft report is available online as a separate document: "Analysis of the public consultation on the quality of drinking water".[13]

In total, 5908 answers were received. Some surveys were incomplete and hence removed from the database. The final database therefore consists of 5875 survey's. In addition to the survey, stakeholders (national authorities, international organisations, non-governmental organisations and other interested parties including individual citizens) were invited to submit their position on the issues addressed in the questionnaire. As a result of this invitation 56 positions form institutions

[13] Analysis of the public consultation on the quality of drinking water; Ecorys (2015); http://ec.europa.eu/environment/consultations/pdf/analysis_drinking_water.pdf

were received. Furthermore a total of 80 citizens also expressed their opinion and sent their positions.

Figure 1-3 Distribution of the public consultation responses by country of origin



Source: Ecorys (2015)

After accounting for the biased answers, the survey answers were each given unique identification number. All answers to open questions were translated into English and all closed questions were codified. Identification of data was done according to; the type of respondent; type of institution; type of sector; country of origin; type of area – rural or urbanized; and the size of the WSZ[14]. Country-related weights were calculated and attributed to each response in the survey. These weights are proportionate to the share of the population per member state in total EU population and they are inversely related to the number of responses to the public consultation received. The aim of the attribution of weights is to ensure that the average proportions analyzed are representative at EU level.

The outcome of the survey provides the evaluation study with some very interesting and important outcomes, such as:

- Drinking water in the EU is perceived as accessible (82%), as long one does not go abroad;
- Drinking water and drinking water services are affordable in the EU (65%);
- The quality and sensation of drinking water in the EU is acceptable (71%).

However, there are also threats to the quality of drinking water. Consumers perceive the pollution from agriculture (such as pesticides and fertilizers), abstraction of hydrocarbons (shale gas and oil), industrial sources (heavy metals) and human consumption in combination with inadequate treatment (ammonium and nitrate).

Respondents were additionally asked to provide feedback regarding the functioning and future aims of the DWD. Questions related to the quality standards in the DWD, the monitoring approach and control of drinking water, outcome of activities to inform consumers on the quality of their drinking water and most effective ways to improve providing information to consumers. The most notable results are provided below:

- Consumers disagreed (55%) with the statement that the list of parameters to be monitored could be reduced to a few key parameters, most relevant for human health.

[14] Large water supply zone (serving more than 5,000 persons) or a small water supply zone (serving less than 5,000 persons).

- 57% agreed that the parameter list should be updated to include new and upcoming polluters, however this should only in special cases lead to an increase in costs for the consumer.
- Consumers believe that monitoring should not be reduced and that results need to be more transparent and available (through online fora).
- Consumer information should, if not done already, be easily available to consumers and more importantly be understandable for the general public. In the coming years consumers additionally expect that information is more up-to-date or near real-life.
- In the case of a pollutant in the water supply around 50% of respondents believe that the current regime for taking remedial action is OK. However, the current regime should be supplemented by additional preventive actions (and faster communication if there is a drinking water problem).
- Respondents were not overly positive or negative when it came to derogations. Overall the data shows however that respondents favour a reduction in the number of granted of derogations. Furthermore a new derogation regime should be more strict.

In additional to this, respondents were invited to provide feedback in a broader context. Main interest of respondents, with respect to possible aims that the DWD can in the future deal with, are related to materials in contact with drinking water, incentives to reduce the amount of drinking water consumed, move from controlling at the tap towards a system control approach and inform consumers on the possibilities of water reuse in households.

Stakeholder conference

At an early stage of the evaluation, a stakeholder conference was organised. The goal of the conference was to inform stakeholders on the evaluation methodology approach and to gather information on the functioning of various aspects of the DWD. The stakeholder conference provided an interesting platform where participants shared opinions regarding the functioning of the DWD. The stakeholders represented industry (17), consultants (2), research centres or universities (4), government or public authorities (13), and NGOs or civil organisation (2).

The outcomes of the stakeholder conference fed - together with the first desk research and preliminary expert opinions - into the development of interview questions, which the project team used to approach various MS regulators, water utility operators, members of the academia, members of the industry and consumer stakeholder groups to collect further information for the main evaluation questions.

Desk research

The desk research has involved a review of a wide range of documents; a bibliography of which is provided in Annex E. These include, among others, Member State reports on investments in drinking water, EUR-Lex reports on parametric values (national monitoring data, including derogations per parameter and member state), position papers from various stakeholder groups and the text of other relevant Directives.

Interviews with key stakeholders

After the stakeholder conference consortium experts developed a list of questions which was used to collect additional, where possible evidence-based, information regarding the functioning of the DWD on the five main evaluation criteria. The evaluators interviewed various MS regulators, water utility operators, members of the academia, members of the industry and consumer stakeholder groups. A full list of all interviewed persons is found in Annex F.

1.5 Structure of this report

After this introductory chapter, Chapter 2 presents the findings of the evaluation in which each of the five evaluation criteria (effectiveness, efficiency, coherence, relevance and EU added value) is analysed under a separate heading. For each of the evaluation questions the evidence relating to the judgement criteria is described and analysed, and at appropriate places conclusions are drawn. These conclusions are summarised for each Evaluation Question in Chapter 3.

2 Analysis of evaluation questions

2.1 Effectiveness

For the evaluation of the effectiveness of the Directive Water Directive we focus on the degree in which the Directive has reduced contamination of water intended for human consumption and has improved consumer satisfaction. The performed monitoring and the periodic synthesis reports offers a good basis the perform an assessments of the effectiveness. Based on these data we evaluated the recorded trends in concentrations over time in view of the protection of drinking water, i.e. the parametric values. Furthermore we assess where and under what circumstances non-compliance occurred (locations of and their characteristics in terms of Source -Pathway-Receptor aspects (e.g. industrial area in a region with sandy and receptor is surface water or rural area with small water supply zones).

The supporting information used for the evaluation of the effectiveness isThis section is a compilation of results presented in Annex B (pollution trends in water quality of monitored substances) and Annex C (draft report on the Pilot Study regarding microbiological outbreaks and chemical incidences). The assessment of the (likely) contribution of the DWD partly inevitably overlaps to some extent with the section 4.3.2 on the effectiveness of remedial actions.

The answer to this evaluation question (EQ1) is based on an analysis of two judgement (or success) criteria: parameters show an improvement of drinking water quality (JC1.1); and the DWD can be considered as the main factor in the improvement of the quality of water intended for human consumption (JC1.2).

For the first judgement criterion we have analysed the changes in compliance rates of concentrations, making a distinction between microbial, chemical and indicator parameters. Furthermore, we have analysed trends in: (i) the quality of drinking water and (ii) health impacts due microbiological outbreaks and chemical incidences and iii) the (likely) contribution impact of the DWD on the observed to those trends.

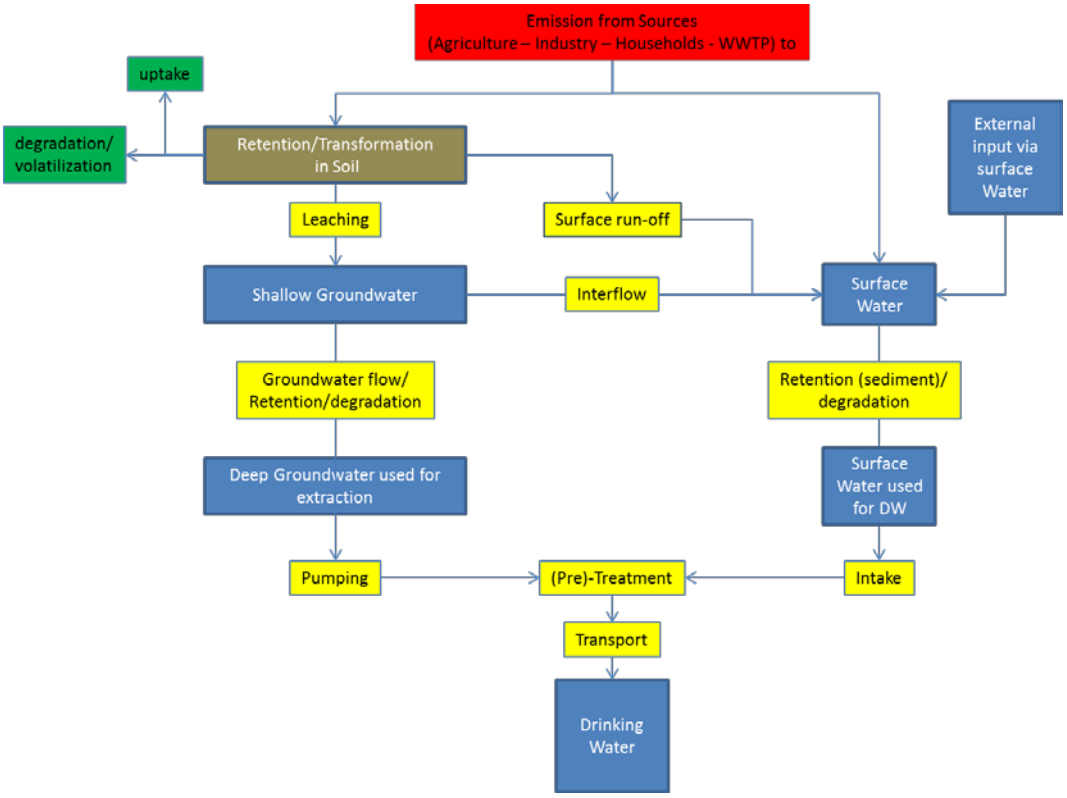
The concentrations of a parameter are largely dependent on the process of drinking water production (abstraction) and distribution. During the process of drinking water production, several cases of non-compliance could occur. The sources of contamination of water resources are multi-fold and very much depend on a combination of activities (land use) in the abstraction area resulting in inputs of chemicals into the aquifer or surface waters, geological conditions in aquifers used for abstraction, and subsequent handling of water during processing and distribution.

To assess whether the DWD actions led to improvement of the drinking water quality, we looked at the dominant causes of the contamination of drinking water sources using source, pathway and receptor analysis, considering process-based factors such as retention and transport velocity. Figure 2.1 illustrates these dominant causes both for groundwater and surface water.

Conducting an analysis of all factors linking sources and the resulting concentrations in aquifers (and hence the impact of the DWD on such concentrations) has not been feasible due to the complexity of processes and variation across MS in both conditions (geology), land use (inputs) and policies. However, our (partial) analyses shows that for specific substances the source-pathway-receptor approach is the best way to quantitatively establish a link between all processes acting

upon aquifers and hence the quality of drinking water. Below we discuss the three components of the source-pathways-receptor analysis.

Figure 2-1 Source, pathways and receptors of (microbial, chemical and indicator) parameters in drinking water



Source: KWR/Alterra, 2015.

Diffuse and point sources are relevant for surface and groundwater quality, such as intended (nutrients) and unintentional (metals, pharmaceuticals, nano-particles) application to (arable) land via fertilization, manure application and or use of secondary nutrient sources (sludge, compost etc.), internal sources of contamination (e.g. lead and copper) that occurs during treatment and/or transport. There are several **pathways** and **processes** that determine the magnitude of the flux of substances from source to receptor, such as. plant uptake, run-off to surface water and leaching to groundwater, retention/release processes in soils, sediments and aquifers e.g. adsorption, precipitation including redox controlled precipitation or dissolution. For our analysis we distinguish between two main types of **receptors** i.e. groundwater and surface water. Additional factors that need to be included in the source-receptor-pathway analysis are those that affect the flux of substances via an impact on processes and/or pathways and hence affect the quality of water (ground- or surface waters). Examples of such factors are:

- Soil properties that affect uptake (nitrogen, metals), retention (metals and organic pollutants) and degradation (nitrogen and organic pollutants) processes;
- Climatic conditions and foreseen changes therein that affect the water balance at the surface and hence surplus, dilution of substances, and travel time. Examples of such factors are precipitation and flooding;
- Size of the WSZ due to its impact on travel time and differences in (cleaning) technology applied in the abstraction and distribution process.

Approach qualitative assessment

In view of the effectiveness also a relation between the Source Pathway Receptors and the parameters has been made. In this analysis we used the following main categories (as used in the MS Synthesis reports) during of causes of non-compliances:

- Catchment related, resulting from either application to soil or water systems (e.g. nutrients, pesticides);
- Treatment plant related;
- Public distribution network related;
- Domestic distribution network related;

Approach quantitative assessment

The following datasets were used for the evaluation of the compliance:

1. Non-compliances (drinking water contamination data) of the selected parameters in time based on synthesis reports at MS level (1993-2005) and more detailed information since 2005 using the plain submitted data by the MS (Eionet data, see http://rod.eionet.europa.eu/obligations/171) including the period 2005-2013.
2. Based on summary reports at MS level and the Eionet data, trends of the water quality at EU level was evaluated in terms compliance of parameters that have been monitored during the whole period 1993 – 2013.

It should be noted that the analysis below does not cover (emerging) parameters not regulated by the DWD. Furthermore we noticed that to some extend the available Eionet data was limited due to: (i) erroneous data and (ii) missing data. As a result it was possible to evaluate the compliance during the whole monitoring period 1993 – 2013 for only 9 parameters in about 2-4 MS.

Observed trends in compliance (JC1.1)

In order to protect human health a list of parameters is provided in the Annexes of the DWD. All the parameters set out in the Directive have shown an increase in compliance over time based on summary reports at Member States' level (1993-2005) and more detailed information since 2005 in Excel sheets. Overall, the number of exceedances decreased between 2005 and 2013 for the sum of all microbial parameters, chemical parameters and indicator parameters. Some parameters show clear positive trends, including cadmium, nitrate, clostridium perfringens, colour, iron, manganese and turbidity. The effect is significant in countries with initial large (IE, PT, UK) or very large (PL) exceedances. In many countries with small exceedances in 2005, there is hardly any trend.

With respect to all parameters, the main cause of non-compliance have been catchment related sources and treatment plant sources combined contribute to approx. 45% of all non-compliances. The sum of the distribution networks, including public and domestic distribution amounts to approx. 29% of the sum of all non-compliances. The remaining part is equally distributed among combined sources (15%) and unknown sources (13%). However, significant differences between countries and parameters exist.

In order to assess the effectiveness of the use of parameters in the DWD to protect human health a study was carried out on a number of parameters presented in the table below. The full study on pollution in drinking water is included in Annex B of the DWD, including a more elaborated discussion on the potential contribution of the DWD in water quality improvement.

Table 2-1 Parameters for which the evaluation was carried out

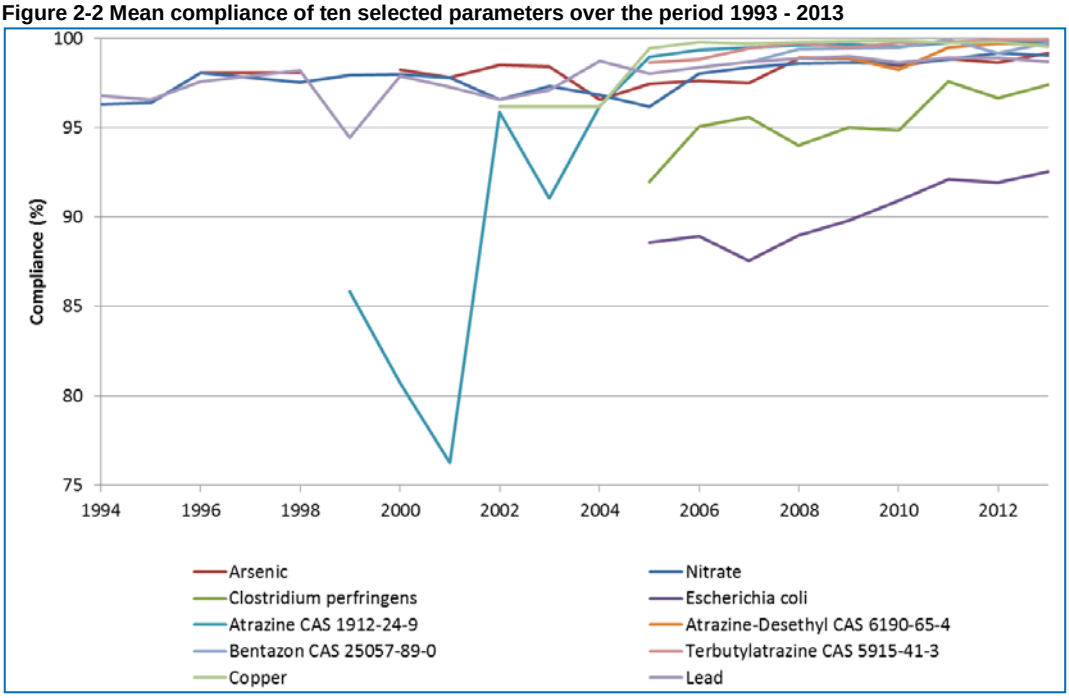
Group parameters	Suggested by EC (minimum)	Included in the initial pilot study
Microbial parameters	*E.coli*	E.coli, Cl. perfringens
Chemical parameters (geogenic)	--	Arsenic
Chemical parameters (anthropogenic) Pharmaceutical and Endocrine Disrupting Chemicals	Diclofenac, E2 or EE2	--
Related to fertilization	--	Nitrate
Related to plant protection	A pesticide	Atrazin, desethylatrazine, terbutylatrazine, Bentazon
Related to materials in contact with drinking water	Lead	Lead, Copper

Main outcomes from study on pollution in drinking water were:

- For the select parameters changes over time were largest for E.coli, Cl. Perfringens and Atrazine. For all other parameters compliance changed from ca. 95% to near 100%;
- In respect of the selected parameters, there is an overall improvement in all Member States, but the variation among them is significant especially in the exceedance of Escherichia coli and Cl. Perfringens show a rather erratic behaviour. Results have shown a decrease in the median concentration of both lead and Escherichia coli;
- The overall number of non-compliances for the 10 selected parameters is less than all parameters (totalling to a number of 40,695). The overall distribution of causes for non-compliances for the 10 selected parameters is, however, more or less equal to that of the all parameters;
- Nitrate, arsenic and pesticides are largely controlled by catchment conditions, lead and copper are largely related to distribution systems and both clostridium and E. coli have no dominant cause of non-compliance.

Figure 2-2 also shows an increase in compliance with time for all parameters over the period 1993 - 2013, changes being largest for *E. coli*, *C. perfringens* and *Atrazine*. For all other parameters it changed from ca. 95% to nearly 100% compliance. Note that the increase in compliance of *Atrazine* was most likely due because this pesticide was banned in by the EU in 2004.

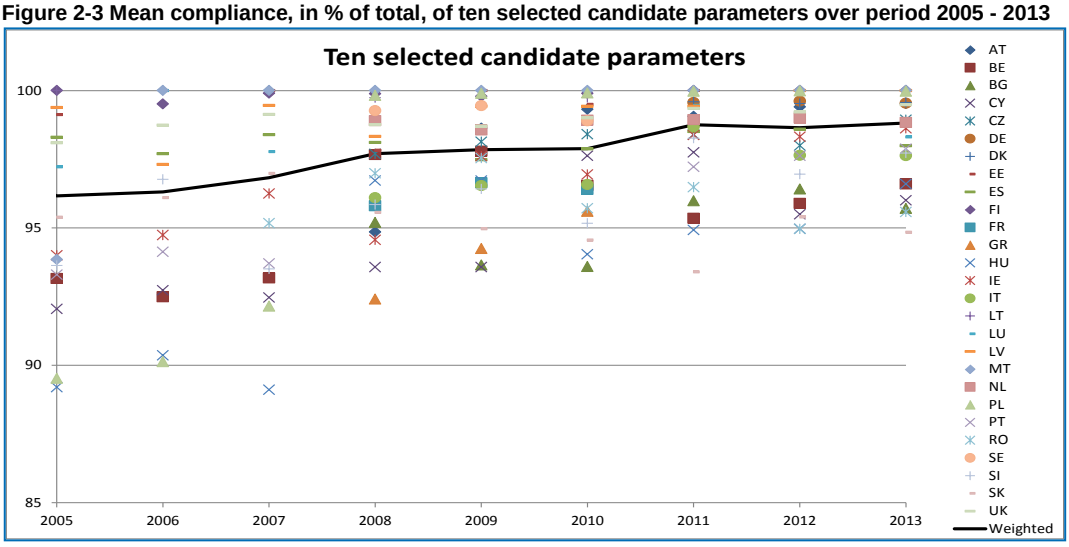
Figure 2-2 Mean compliance of ten selected parameters over the period 1993 - 2013



Source: Alterra/KWR. based on Eionet data and Synthesis report data

In Figure 2-3 below we present the trends in mean compliance of ten selected parameters (each value represents a MS) for the period 2005-2013. The trends for the individual parameters are presented in Annex B Section 2.2.

Figure 2-3 Mean compliance, in % of total, of ten selected candidate parameters over period 2005 - 2013

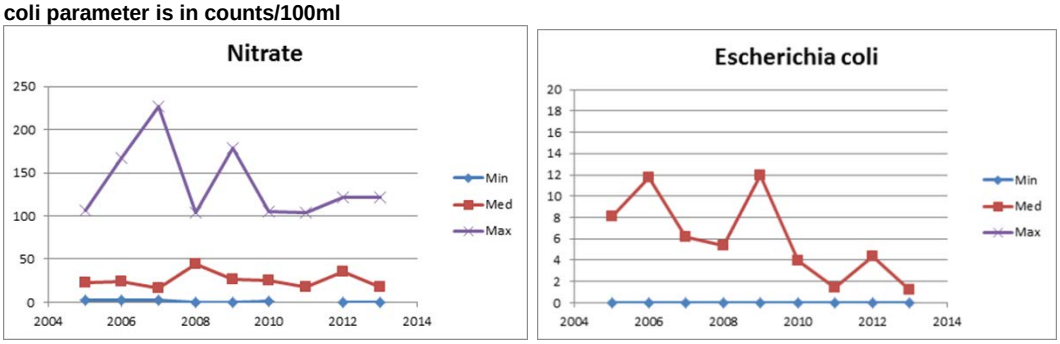


Source: Alterra/KWR. based on Eionet data

The graph shows an increasing mean compliance with time over the period 2005-2013, both in each separate MS and in the whole EU . These results represents the aggregated national summaries for the 10 parameters as submitted by the MS. However, the spread of compliances per MS and per parameter is rather large (see Table A.B. 0.2 in Annex B). E.g. for Arsenic 72% of the reported non-compliances were in HU, which is related to the natural origin of arsenic in groundwater (mainly in eastern HU). Nevertheless, the mean compliances per MS for the 10 selected parameters in either increasing or remain constant for all MS.

As an illustration, below we show trends in annual minimum, median and maximum concentrations over the period 2005-2013 derived for two of the ten candidate parameters at EU level. The results show a decrease in the median concentration of E. coli but no clear trend for Nitrate.[15]

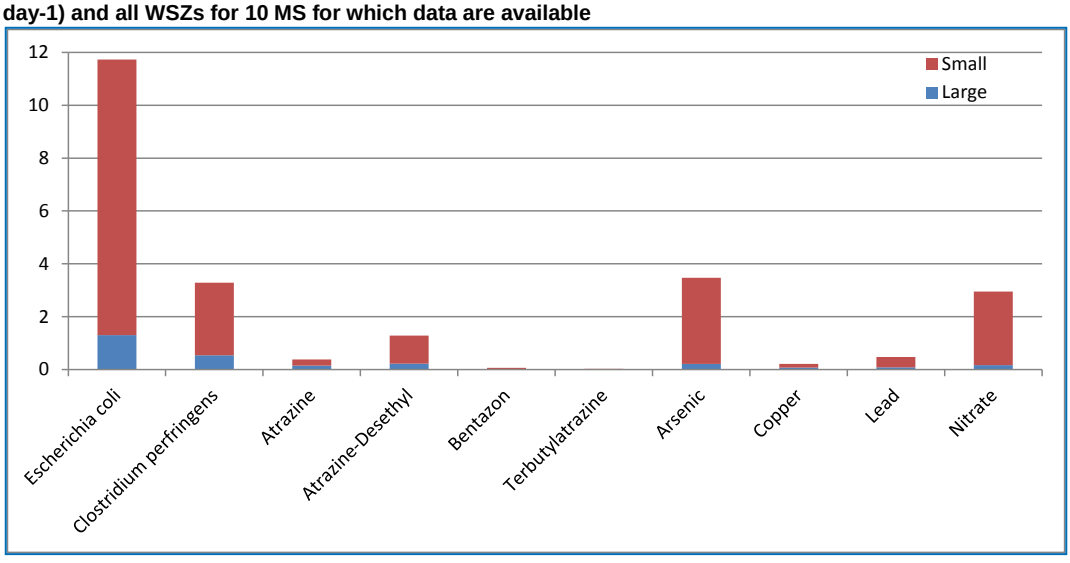
Figure 2-4 Trends in water use weighted minimum, median and maximum concentration at EU level of two selected parameters over the period 2005 – 2013. The nitrate parameter is given in µg/l and the E. coli parameter is in counts/100ml



Source: Alterra/KWR, based on Eionet data.

In general water quality is poorer in small than in large water supply zones (WSZs). This is illustrated in Figure 2-5 for the ten candidate parameters, in terms of percentage non-compliance based on an analyses of all individual large and small SWZ at EU level for the period 2010-2013. Results are based on the ten Member States for which data were available for both small and large WSZs, i.e. BG, CY, ES, HU, LU, MT, PT, RO, SI and SK. While non-compliance is always less than 2% and mostly near negligible for all ten parameters in large WSZs, it is up to 12% for E Coli in small WSZs.

Figure 2-5 Percentage compliance of the ten candidate parameters for large and small WSZs (< 1000 m3 day-1) and all WSZs for 10 MS for which data are available



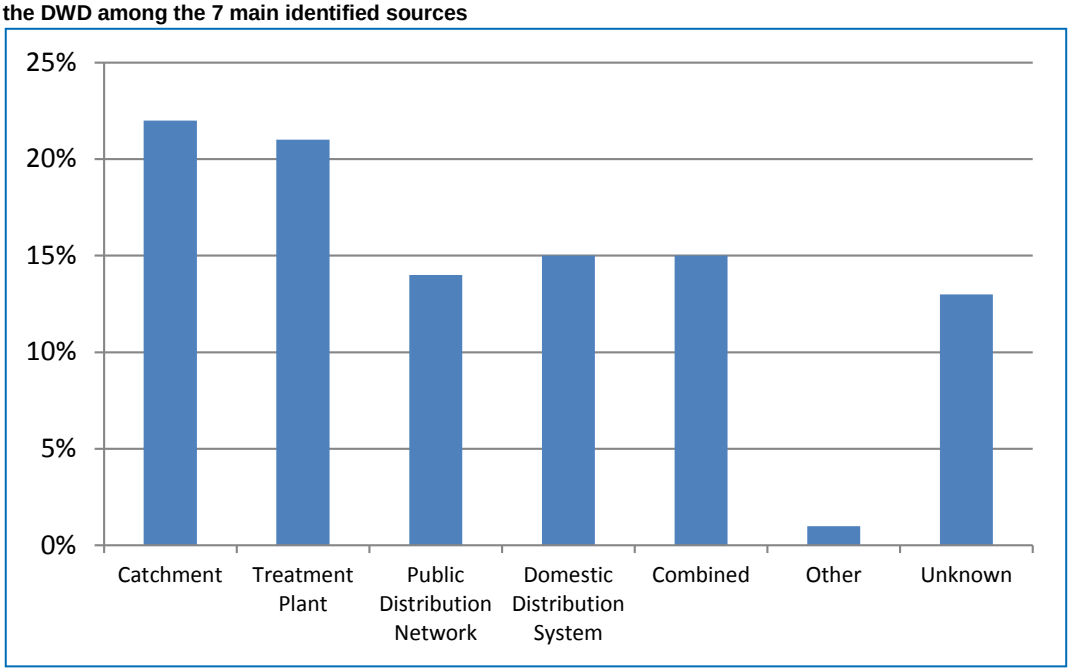
Source: Alterra/KWR, based on Eionet data.

Figure 2-6 shows the overall distribution of all reported non-compliances for all parameters included in the DWD at EU level (40,695 in total) among the 7 groups distinguished. The contribution of catchment-related sources and treatment plant sources combined contribute to approx. 45% of all non-compliances. The sum of the distribution networks, including public and domestic distribution

[15] Beware that median concentrations are not always calculated in national databases. For example, in the Netherlands, the database only contains minimum, average and maximum concentrations at a given sampling location and in the dataset, the average concentration is thus provided instead of the median.

amounts to approx. 29% of the sum of all non-compliances. The remaining part is equally distributed among combined sources (15%) and unknown sources (13%).

Figure 2-6 Overview of distribution of causes for the non-compliances of all parameters monitored in the DWD among the 7 main identified sources



Source: Alterra/KWR, based on Eionet data.

Contribution of DWD to observed improvements in drinking water (JC1.2)

The overall trends as reported in the previous section illustrate the substantial increase in the mean drinking water quality. The question now arises to what extend the DWD can be held responsible for the observed increase in the mean drinking water quality in the EU (JC1.2).

Impact of DWD on substances controlled by land use and geology (nitrate, arsenic and pesticides)

For parameters such as nitrate, arsenic and pesticides where *catchment related causes* dominate, it can be deducted that other directives regulating the inputs (e.g. the nitrates directive and pesticides directive; Directive 2009/128/EC) could be held responsible for the observed trends in water quality, especially if acceptable levels as regulated by those directives are equal to or lower than those imposed by the DWD. However, substances such as arsenic (in groundwater) are of natural origin and related to rather local geochemical conditions and they cannot regulated by emission control. One also has to consider the travel time and decay rate of substances in relation to the timeframe during which the DWD has been in place. Considering the long time-delay in case of abstraction of *deep groundwater* for drinking water it is highly unlikely to observe impacts of measures reducing inputs in deep aquifers within a time scale of 1 to 2 decades. The travel time of water on average equals 1 meter per year which implies that it takes more than 20 years for dissolved nitrate to reach deep groundwater wells. This holds even more for arsenic which interacts with the solid phase resulting in retention (notably via sorption to oxides). This line of reasoning suggests that for *deep* groundwater, observed changes in concentrations must have been due to the DWD (Article 5/4, Annex I), e.g. by mixing of waters or closing wells rather than a relation with reduced inputs as imposed by other Directives.

Since the impact of land use (emission) clearly will become noticeable in shallow groundwater (let alone surface water) it is likely that, such as in the Netherlands, several water abstraction zones using shallow groundwater have been closed due to increased levels of nitrate which was

considered unacceptable because of the implementation of the DWD. In those cases, the Nitrates Directive was not able to prevent non-compliances for nitrate and an additional improvement of water quality was achieved due to the DWD (Article 5/4, Annex I). Despite the observed improvements in water quality, nitrate concentrations in subtracted (shallow) groundwater may still exceed the DWD standard. In order to prevent this, it is more effective to monitor the nitrate concentrations in shallow groundwater rather than in subtracted water.

In shallow groundwater or surface water is used for drinking water purposes, it cannot be ruled out that reductions in concentrations and in non-compliance have resulted from increased efforts to reduce inputs of nitrate and pesticides as well.

An absolute scaling of the impact of the DWD relative to that of other directives which have become active during this timeframe (including Nitrates Directive, Pesticides Directive) is not possible since all of these Directives share to some extend the level of regulation (for nitrate and pesticides both the DWD and related Directives regulate water quality at the same level).

Impact of DWD on lead and copper

For copper and lead, for which *distribution network related causes* dominate the exceedances, the DWD has clearly been one of the main drivers which has resulted in the decrease of the non-compliances, mainly due to Article 10. This holds in general for all parameters for which exceedances are related to causes in the distribution network, since the DWD is the single most important Directive addressing these substances after the water has been processed and requires remedial action in case of non-compliances. A reduction of non-compliances can thus be attributed to the DWD.

On the other hand, the DWD has had limited or no impact on the quality of water *prior to* the interaction of water with the distribution network. Water quality in groundwater and surface water are largely controlled by natural processes (retention of metals by sediments and soils), whereas inputs to the system are regulated by Directives targeting environmental quality. These include: (i) the Water Framework Directive, in which the acceptable copper levels in surface water is much lower than the parametric value of the DWD and (ii) the Nitrates Directive and the Directive regulating additives in feed and fodder (70/524/EEC), which both regulate application rate and quality of manure. Considering the allowed input levels either via fodder, manure or water and the strong retention of copper and lead to the solid matrix it is highly unlikely that concentrations of copper in aquifers (i.e. before interaction with the distribution network) would reach levels at which the DWD becomes effective. Normal observed ranges of copper in shallow or deep groundwater are in the order of magnitude of 1 to several 10's of micrograms per litre whereas the DWD regulates copper at levels in excess of 2000 microgram per litre.

Impact of DWD on mixed causes

For some parameters in the DWD, notably the microbiological parameters, no clear main cause for the observed non-compliance was found. Based on the data supplied other than the chemical substances discussed earlier (nitrate, pesticides, copper, lead), increased levels of microbiological parameters are not so much related to land use or slow processes (infiltration to groundwater), but related to (partly unpredictable) incidents such as shortcuts in distribution systems leading to the accidental contamination of the drinking water distribution system with (treated) sewage effluent. The latter may also be catchment-related in case of contamination of surface water used for drinking water. Having a DWD in place clearly accelerates the chances of early detection even though the frequency of the monitoring periods can be such that outbreaks can occur and lead to widespread infections. It is thus very likely that the DWD has contributed to the decrease in microbiological parameters. An indicative illustration of an qualitative assessment of the likelihood

that DWD has an impact on the drinking water quality is given in the table below. It is, however, not possible to determine the extent to which the DWD indeed has resulted in a decline in exceedances of the non-compliances of microbial parameters.

In Table 2-2 an illustration is given of an indicative qualitative assessment of the likelihood that DWD has had an impact on water quality for particular parameters. For more details we refer to Annex B, section 3.3.

Table 2-2 Illustration of an indicative qualitative assessment of the likelihood that DWD has an impact on water quality in the catchment and distribution system and on the reduction of non-compliances

Parameter	Likelihood that DWD has an impact on water quality in a specific aquifer			Likelihood that the DWD has an impact on water during distribution	Likelihood that the DWD resulted in a reduction of non-compliances
	Surface water	Shallow GW	Deep GW		
Nitrate	+?	+	0	0	+
Pesticides	+	+?	0	0?	0
Arsenic	-?	-	0	0	+
Microbial indicators	+?	0	0	+?	+
Copper	0	0	0	++	++
Lead	0	0	0	++	++

++ very likely that the DWD has an impact
+ likely that the DWD has an impact
0 likely that the DWD has no impact
- very likely that the DWD has no impact
? Not sure

Conclusions on JC1.2

Having a DWD in place clearly accelerates the chances of early detection even though the frequency of the monitoring periods can be such that outbreaks can occur and lead to widespread infections before an increase in concentrations of unwanted parameters or indicators has been detected. Nevertheless it is clear that the DWD has substantially contributed to the decrease in the number of non-compliances of microbiological parameters.

It is, however, not possible to determine the extent to which the DWD indeed has resulted in a decline in exceedances of the non-compliances of microbiological parameters. The decline in pesticides (atrazine) cannot be attributed to the DWD, but was due to atrazine being banned in by the EU in 2004. Our analysis on pollution in drinking water revealed that i) changes over time were largest for microbial parameters, and pesticides and compliance rates vary from ca. 95% to near 100%; ii) there is an overall improvement in all MS, but the variation among them is significant; and iii) the overall number of non-compliances for the 10 selected parameters is less than for all parameters.

Water quality is poorer in small than in large WSZ. While non-compliance is always less than 2% and mostly near negligible for all ten parameters in large WSZs, it is up to 12% for E. coli in small WSZs.

In summary, having a DWD in place is the main factor explaining the trends in water quality and decreases in non-compliances for distribution network related sources such as for lead and copper. Even though an additional effect of the DWD in view of the observed trends in non-compliances cannot be excluded for several land-use/catchment related parameters including pesticides and

nitrate, the main drivers of change are very likely other relevant directives. The absolute magnitude of the contribution of the DWD relative to that of other directives is however impossible to quantify.

2.1.1 *Which provisions have been most appropriate for protecting human health? To what extent have parameter requirements and also general ones for Member States been effective and why? (EQ2)*

Parameter requirements have been the most appropriate provision for protecting human health (JC2.2)

The objective of this paragraph is to identify any trends in microbiological outbreaks and the impact the DWD has had.

The two microbiological parameters mentioned in the DWD - E. coli and Enterococci - are mere indicating organisms which normally do not cause any threats to human health. They just indicate the possible contamination of drinking water. Microbiological incidences causing disease are often reported for micro-organisms. These include for instance pathogenic E.coli - also known as STEC/VTEC - Campylobacter, Shigella, Salmonella, Legionella pneumophila, and viruses Calicivirus, Rotavirus, Norovirus and parasites (such as Cryptosporidium and Giardia). These are the most significant health risks associated with microbial contamination of drinking water. In the case of an outbreak it is not always possible or easy to find out what the contribution of drinking water is or has been. Epidemiological information for the abovementioned organisms often does not specify the actual source of the contamination (whether it is food or water, for instance).

At least on annual bases, all EU Member States and Iceland, Liechtenstein and Norway provide information from their surveillance systems to the European Centre for Disease Prevention and Control on the number of occurrences of the 52 communicable diseases and health issues under mandatory EU-wide surveillance. Reports are issued according to the case definitions established by the EU.

An investigation of the data shows us that in many countries microbial incidents are relatively constant over time. The ECDC points out that epidemiological results have to be used and interpreted carefully as health and surveillance systems vary between countries. The data are a mere qualitative indication of the occurrence of diseases.

In addition to the ECDC epidemiological data mentioned above there are examples (e.g. provided by the EC drinking water regulator) that the DWD has considerably reduced microbial outbreaks. One example is Ireland where the majority of drinking water comes from surface water supplies. As a result, most of their raw waters contain E. coli as it is ubiquitous in surface waters everywhere. Since the Directive came into force in 2004, considerable treatment actions have been enforced and the number of incidents of E. coli contamination of water supplies in Ireland has reduced by around 90% in public water supplies and private group water schemes. The real improvements in public water supplies took place after 2007, when the Environmental Protection Agency (EPA) which was given enforcement powers over the public water supplies took several initiatives to reduce the number of incidents (e.g. setting minimum standards for disinfection systems including mandatory process alarms) and started to take enforcement action (including prosecutions) where action was not being taken.

Conclusions on JC2.2

It can be asserted that the DWD has actually contributed to the reduction of microbial outbreaks mentioned in the example of Ireland but also in other MS (see analysis of microbiol compliance data above). Since the Directive came into force, countries have enforced considerable treatment

actions and the number of incidents of E. coli contamination of water supplies has been reduced. Improvements should be linked to the increased powers conferred to (environmental) protection agencies. Linking this analysis to the first judgement criterion listed for this evaluation question we can conclude that setting parametric values for microbiological parameters has indeed been an appropriate provision for protection human health.

Monitoring actions are considered an effective way of collecting information on the water quality (JC2.3)

As a result of the implementation of the DWD, monitoring systems have been designed and activated; also laboratories to analyse drinking water have been established in all Member States. However, monitoring approaches differ between Member States and even between different WSZ within individual Member States, resulting in different levels and availability of monitoring data. The frequency of monitoring is stipulated in Annex II to the Directive. This Annex defines the minimum frequency of sampling and analyses for drinking water in distribution networks (or from a tanker or used in a food-production undertaking), except for small WSZ where the frequency could be decided by the Member State concerned. With the recently adapted amendment to the Directive[16] the overall approach has become more flexible, allowing Member States to decide, on the basis of a risk assessment, which parameters to monitor. They can now also choose to change the frequency of sampling, as well as to extend the list of parameters to monitor in case of public health concerns. The revised Annex II and III now asks for a minimum frequency of monitoring of one time per year for small WSZ. This change was welcomed by all stakeholders as it reduces the need to monitor parameters which pose no risk in the supply zone and at the same time requires water authorities to monitoring water quality of small WSZ. At the same time, stakeholders suggested to fully integrate a risk based approach into the DWD, not as an alternative for monitoring, but to give them equal weight: one to prepare for threats and one for keeping tabs on what actually happened.

The issue of small supply zones has long been perceived a potential risk to consumers as it is estimated that about 65.5 million people or 13% of the EU population are served from these small water zones[17]. According to the report on the quality of water in small supply zones, 40% of these were not in compliance with the DWD regulations, and 19% were not monitored in accordance with the DWD requirements, affecting over 11.5 million people. Thus, although this situation has now been remedied, it illustrates the importance of monitoring requirements as an essential element to safeguard drinking water quality for all European citizens.

Monitoring can be considered the first step in a chain of control measures that will ascertain that drinking water meets quality standards as set by the DWD. As monitoring systems are operational in all MS, this is considered an effective provision. From the monitoring reports submitted by MS for the period 2008-2010 it was concluded that out of 27 Member States, 9 did not meet the minimum monitoring frequency. This observation was based on self-reporting by Member States who were asked to provide information at WSZ level on the number of analyses carried out compared to the number of analyses required by the Directive. The importance of this information lies in the fact that compliance with the monitoring frequency is a prerequisite of assessing compliance with the parametric values and thus affects the picture which emerges from synthesis documents on the quality of drinking water produced by the Commission. For all MS, it appeared that for five countries (BE, ES, IE, SE, SK) the percentage of WSZ that did not meet minimum requirements was very low. For 13 countries (CZ, DE, ES, FI, FR, IT, LU, LV, MT, NL, PL, PT, UK) it was low and for another 9 (AT, BG, CY, DK, EL, HU, LT, RO, SL) it was reported to be high.

[16] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L1787&from=EN

[17] "Small water supply zones in the EU – Reporting year 2010" report (dated 26 March 2013)

With regards to the transparency of monitoring data it was interesting to observe opposing views being expressed. One paper (Norway) stated that results should be available online and/or made publicly available, whereas another (CZ) stated that this type of information should be restricted to the state authorities. Aqua Publica Europea was of the opinion that transparency, as a way of providing useful and understandable information which ensures greater stakeholders' participation, is crucial to raise public awareness on common challenges, thus reducing conflict situations and increasing ownerships of decisions.

Some of the experts contacted for this study consider the frequencies of monitoring mentioned in Annex II too low in many occasions to safeguard the quality year-round. They are in favour of more year-round-monitoring. Some of them also suggest to include the end-users more in this process. During the stakeholder consultation, the national regulators indicated that the current density and selection of sampling points requires an update. They consider these insufficient and therefore advocate more frequent sampling and more extensive monitoring to guarantee the safety of all consumers, especially for the larger WSZ.[18] The recent revision of Annex II provided an answer to many of these concerns.

The inclusion of the option of using Water Safety Plans in the revised Directive was also welcomed by many stakeholders. In their opinion, this would lower the risk of contamination and enable water companies to learn more about their drinking water sources. The amendment to Annexes II and III allows Member States to derogate from the monitoring programmes they have established, provided they perform credible risk assessments which may be based on the WHO Guidelines for Drinking Water Quality and should take into account the monitoring carried out under Article 8 of Directive 2000/60/EC.

Conclusions on JC2.3

The monitoring systems and the laboratories set up in all MS are considered an effective way of collecting and analysing information on the water quality and this can be considered as the first and essential step towards the protection of human health from the adverse effects of any contamination of drinking water. However, for one-third of the MS countries the frequency of monitoring established by MS is below that what is required which undermines the quality of the synthesis reports of the Commission. The recently revised Annex II and III allow MS more freedom in monitoring frequencies and parameters to monitor with Water Safety Plans in place. This revision also addressed the call for a minimum frequency of small WSZ.

Requirement for remedial action is considered effective (JC2.4)

The DWD requires Member States to regular monitoring of drinking water quality, to take remedial action in case the monitoring reveals problems, and to provide to consumers with adequate and up-to-date information to consumers on their drinking water quality. Remedial actions differ from case to case, but can be roughly distinguished into two categories:

1. Catchment and treatment-related:
   - Action(s) to terminate or mitigate the cause;
   - Action(s) to change from one source to another;
   - Establishing, upgrading or improving treatment.
2. Network related:
   - Replacement, disconnection or repair of defective components;
   - Cleaning, scouring and/or disinfecting contaminated components.

[18] Stakeholder consultation on the revision of the DWD (May 2015) Member State regulators.

Specific remedial actions are required to address the different sources of pollution. Competent authorities decide on what remedial actions should be undertaken when drinking water suppliers fail to meet the parametric values set in the DWD. The remedial action depends on what is most suitable per specific case.

Data from Member States show that in cases of incidents and failures to meet the quality standards, in general remedial action is taken by Member States within an appropriate response time. In relation to the microbiological parameters, measures entailed improving the treatment and cleaning of the contaminated components of the public distribution system. For chemical parameters, failures were addressed through better agricultural practice, conditioning or treatment of the water, change of the source water, and providing information to the public.

An inventory of remedial actions (RA) reported by MS was made for the period 2005-2013 based on the EU MS reports ad the Eionet data.[19] This has been done for 12 MS with a continuous monitoring record for the 10 parameters as listed in Table 2.1 (see Appendix 2 of Annex B). A summary of the total reported RA is given in Table 2-3. Most RA were undertaken at catchment and treatment level, where pollution of the source water is the most common problem. The remedial action undertaken was most often aimed at terminating or mitigating the cause of the problem. Upgrading or improving the treatment was the second most applied remedial action and changing the water source was least often chosen as a measure. According to the Eionet data for the period 2005-2013, most of the remedial actions were treatment-related (in 1,185 out of 5,222 WSZ), either establishing, upgrading or improving treatment systems, followed by catchment related actions (942 WSZ), public distribution system related actions (756 WSZ) and domestic distribution related actions (483 WSZ). By far (about 85%) the most of the catchment related actions were actions to terminate or mitigate the cause.

Table 2-3 Total reported remedial actions per parameter for the period 2005-2013 based on data from 12 countries with a continuous monitoring record for the 10 parameters.

Parameter	Catchment	Treatment	Public Distr.	Domestic Distr.	Emergency Actions	Other	Total
Arsenic	133	49	5	3	0	67	257
Atrazine	12	7	0	1	1	19	40
Atrazine-Desethyl	31	41	1	0	9	44	126
Bentazon	10	6	0	0	1	4	21
Cl. perfringens.	294	249	95	48	25	396	1107
Copper	0	4	4	40	23	31	102
E. coli	274	646	601	228	92	587	2428
Lead	11	63	33	159	134	236	636
Nitrate	176	115	16	4	7	166	484
Terbutylatrazine	1	5	1	0	1	13	21
Total	942 [1)]	1185	756	483	293	1563	5222

[1)] For 821 WZS these are action(s) to terminate or mitigate the cause and for 106 WZS action(s) to replace source

Most of the RA are related to the microbiological parameters E Coli (for 2,428 WSZ) *C. perfringens* (for 1,107 WSZ), followed by lead (for 636 WSZ), nitrate (for 484 WSZ) and arsenic (for 257 WSZ). The remedial action for E. coli are mainly treatment-related. The RA for lead are mainly domestic distribution network related, but remarkably also catchment related. The RA for nitrate are mainly catchment related with an emphasis on replacing source. Except for the catchment related RA for lead, the RA performed by the Member States seems plausible.

[19] Member State reports of the DWD (2010) and Synthesis report on the Quality of Drinking Water, 2008-2010 (EC, 2013).

In case of water network related non-compliance, remedial action is evenly aimed at both replacement and repair of defective components, as well as cleaning, scouring and disinfecting contaminated components. Some Member States also require the consumers to be informed, this is however not common practice throughout the EU according to the Member State Reports.

In the current situation, the remedial actions come into play when the undesirable situation is already in existence; water quality is already below acceptable levels. The Czech Republic and the Baden-Württemberg municipalities therefore support the implementation of an additional preventive measure as a supplement to the remedial actions. These could include measures such as water safety planning and risk analyses.

Conclusions on JC2.4

In the period 2005-2013 there has been an increase in remedial actions reported by Member Sates. Most of the actions were related to microbiological parameters (*E. coli* and *C. perfringens*) and - to a lesser extent - to chemical parameters (lead, nitrate and arsenic), and the actions dealt with treatment and distribution networks (both public and domestic) related, all to a similar extent. It is very likely that the remedial actions performed on the basis of Article 8 have improved the drinking water quality in the period 2005-2013. This is supported by a (modest) increase in the observed compliance of the microbiological parameters (*E. coli* and *C. perfringens*) and the chemical parameters (lead, nitrate and arsenic) in that period (see Figure 2-2). With over 5,000 remedial actions reported, a more pronounced increase in compliance rates could have been expected.

Derogations are considered an effective mechanism (JC2.5)

With a maximum of three derogation periods, Member States have to take action to ensure the quality of their drinking water supplies as soon as possible and definitely within nine years to the quality standards as indicated in the DWD. Currently, most MS have drinking water supply systems which are compliant with the high quality standards of the DWD. Only six Member States have asked for a third derogation, five of them were granted[20].

Country specific derogations and the impact on human health

Italy and Cyprus, both having high natural boron concentrations in their drinking water, find that compliance with EU boron regulation is more difficult and expensive than originally anticipated, while health benefits are questioned[21]. This opinion is backed by the Scientific Committee on Health and Environmental Risks (SCHER), which, notwithstanding the fact that drinking water concentrations exceed the DWD standards, is of the opinion that the risk is tolerable in general for all age categories.[22]

From the EU Survey the prevailing opinion of the Member States in the EU survey is that a new derogation regime should be introduced to a limited extent and under strict conditions. All countries agree that the current derogation regime should not be extended for a further transition period and three countries are in favour of complete abolishment of the derogation regimes. In addition, the Commission has become

Conclusions on JC2.5

The provision of derogation has allowed MS to apply the parameter values as defined in Annex I of the DWD at a feasible pace, depending on local circumstances. This has proved to be efficient, because otherwise specific water sources could not have been used for an extensive period of

[20] http://cdr.eionet.europa.eu/ro/eu/dwd/envvphazg/

[21] Weinthall, ea (2005). The EU Drinking Water Directive: The Boron Standard and Scientific Uncertainty.

[22] Scientific Committee on Health and Environmental Risks (2010). Derogation on the Drinking Water Directive.

time, without having to resort to other means. We found that the need for this Article has reduced over time, mainly because the Commission has become more restrictive in allowing derogations.

Article 10 has been implemented effectively (JC2.6)

The quote below from the Commission proposal for the Directive for Drinking Water Quality (COM(94) 612 final) provides the necessary background on an Article which has been in the centre of discussions between policy makers, industry groups and scientist for the last two decades:

'The acceptable concentration of treatment chemicals or impurities associated with them are no longer defined exclusively by the MACs given in the previous Directive 80/778/EEC. Account must now also be taken of the specifications for treatment chemicals which MS might adopt in the implementation of the Directive. Concentrations of treatment chemicals or of their impurities in water intended for human consumption should be no higher than is necessary for the purpose for which the treatment chemicals were used, This will have the effect of limiting contamination from treatment chemical and their impurities, and will require the use of good practice in the preparation of drinking water. The general problem of water contamination resulting from materials used for piping and fittings and which come into contact with water intended for human consumption are dealt with in the framework of the Directive 89/106/EEC – the Construction Products Directive. This Directive and its Interpretative Documents set out, amongst other thing, requirements concerning the protection of consumers' health. This will oblige MS to ensure that only those materials which are compatible with the relevant water quality will be available in the future use in contact with water intended for human consumption. This means that MS will have to legislate accordingly'.

Article 10 of the DWD deals with the *quality assurance of treatment, equipment and materials regulation of substances or materials used in new installations*. It aims to ensure that Member States take all measures necessary to prevent hazardous concentrations of substances and materials from ending up in the drinking water as a result of treatment, equipment and materials used. Article 10 also refers to the Construction Products Directive (89/106/EEC) - repealed and replaced by Regulation (EU) No 305/2011 in 2011 - laying down harmonised conditions for the marketing of construction products.[23]

Article 10 of the Directive covers both 'substances' such as chemicals used in the production and distribution of drinking water and materials used for new installations. Chemicals used in the treatment of drinking water are generally (but not always) of certified quality. But even when quality has been checked they should not be used in such a way that they cause an impact on water quality. Examples are e.g. disinfection chemicals which are used to protect the microbiological quality of drinking water but might also cause adverse effects such as trihalomethanes and other disinfection-by-products.

The DWD specifies three chemicals that need to be controlled through product specifications. This was agreed at the time of the adoption process of the DWD because the parametric values which were then the lowest achievable were below the limit of detection of convenient analysis methods. These three parameters[24] are *acrylamide* (specified through the maximum concentration of monomer of acrylamide permissible in *polyacrylamide* used as flocculant), *epichlorohydrin* a coagulant aid (based on the advice of the CSTE), and *vinylchloride* (also based on advice of the CSTE).

[23] Directive 98/83/EC

[24] Acrylamide is a monomer present in polyacrylamide flocculant, is used as grouting agent in reservoirs and boreholes and is present in some types of RO membranes
Epichlorohydrin is present in epoxy-resin coatings and as coagulant aid
Vinylchloride is present as monomer in PVC pipes and as degradation product of tri and tetra in groundwater (latter is not covered by art.10)

Article 10 also covers all process steps used in the production of drinking water such as (membrane) filters, electro-dialysis systems and ion-exchange media. None of these should have an adverse effect on the quality of the water.

The focus is also on construction products in contact with drinking water, such as pipes, valves, appliances but also small parts such as rubber rings, washers etc., basically anything that can come into contact with drinking water. The materials used in the production and supply of drinking water are in principle covered by Article 10 from source to tap. The legal point of compliance in the DWD for water supplied through a distribution network is in accordance with Art.6 at the point, within premises or an establishment, at which it emerges from the taps that are normally used for human consumption. MS shall be deemed to have fulfilled their obligations with respect to the quality of the water supplied where it can be established that non-compliance with the parametric values is due to the domestic distribution system or the maintenance thereof except in premises and establishment where water is supplied to the public, such as schools, hospitals and restaurants. However, if changes in water quality are due to materials used beyond the legal point of delivery and there is a risk that water would not comply with the parametric values there is a joint responsibility of both Member States and property owners in accordance with Art.3. This responsibility includes measures to reduce and eliminate the risk of non-compliance and information to the consumers on remedial actions they can take.

The implementation of Art.10 has caused many discussions as the DWD does not give any guidance on the outline and the operation of a system for the assessment and the approval of chemicals and materials in contact with drinking water. Apparently the implementation was left to the Member States and given the number of substances and the complexity of test and field conditions in the various MS this turned out to be a laborious and long term task. Below we present two real-life case studies provided by an EU28 industry interest group in 2015 to illustrate the type of discussions taking place on this issue:

Case 1: A given substance used as desensitizing agent of organic peroxides is listed in the warenwet (Netherlands) and several chapters of BfR (Germany) but not in the French positive list of substances authorized for the manufacture of drinking water materials. This yields to the situation that polymers and articles containing this substance were not approved in France. Industry was forced to run migration test studies in order to demonstrate that the migration into water is below 0.5µg/l. After four years of work and discussion with the French authorities a derogation was obtained recently with the obligation to verify that the migration is below <0.1µg/l. The applicant submitted then a risk assessment to the French Health Ministry (Direction Générale de la Santé), who after its evaluation requested industry to carry out new in-vitro test. The new requested tests were carried out and ANSES published an opinion confirming the safety of that substance in the intended drinking water applications. Currently industry is still awaiting the modification of the French law. The entire process described above lasted 6 years and during that period materials containing the mentioned substance were put on the market in other EU countries without further objections.

Case 2: A given processing solvent used in the production of a rubber based formulation used to make an O-ring. Given that the current German EPA (UBA) guidelines do not list solvent, the product was deemed as non-compliant. German authorities did not accept industry-self assessment of the use of that solvent in that specific application, not the approval based on mutual recognition, i.e. France follows acceptance of solvents with boiling point <150°C and The Netherlands accepts risk assessment. Industry had to show compliance with the 0.1µg/l migration limit following the UBA guidelines. The petitioner had to provide the analytical method. The certifying laboratories were not able to run migration modelling and the petitioner had to demonstrate compliance using migration modelling. This case lasted two years, during which the product could not be put on the market, which led to an estimated sales loss of an order of magnitude of millions of euros.

Conclusion on JC2.6

Article 10 has been effective as it applies to the treatment and to distribution of the drinking water, a phase in which considerable contamination of drinking water can occur. Article 10 asks the MS to take actions to remove substances in order to comply with the quality requirements in the Directive, but many MS experienced significant problems with the implementation of the article as no further guidance was offered. For this reason the effectiveness of Article 10 is currently low. Effectiveness can be improved by better guidelines from the Commission.

The reporting requirements are considered effective (JC2.7)

Article 13 of the DWD requires that all Member States are to ensure compliance with the Directive by providing adequate and up-to-date information on water quality for human consumption to the consumers. In addition to the information to the consumers the Member States have a reporting obligation to the European Commission.

Most national authorities (ministries of health, environmental agencies or water companies) provide some general information on the quality of the drinking water through various means (consumer leaflets, websites, etc.). This information contains details on and explanations of the key parameters of quality. Often, the reports national authorities submit to the Commission are also made available to the public. The latest DWD reports available refer to the period 2011-2013. As the DWD requires Member States to submit reports for three years, it is often difficult to obtain more recent information.

In some cases, centralized online information systems exist which report on the quality of the drinking water per community and water supplier (e.g. CZ, FR, ES, EE, LU). In the majority of the cases, however, detailed information, including parameters' values, can be found either on the websites of the respective municipalities or on those of the water supply companies. In countries with a federal structure, information on water quality is usually provided through the environmental agencies at sub-federal level.

The water companies often see this obligation to provide information to consumers as a way to increase consumer satisfaction and transparency. However, others are more reluctant to share real time information with consumers. Consumers are increasingly interested in in the topic of water quality as evidenced from the news reports, websites and discussion fora covering this topic. An example of a topic which is recently attracting a lot of attention is micro-pollutants.

In the table below, we provide an overview of the availability and accuracy of consumer information with respect to the drinking water quality was obtained from the national authorities' websites.[25]

Table 2-4 How Member States provide information on drinking water

Country	Information sources in Member States
Austria	Austrian Drinking Water report (latest available for 2011-2013) is prepared by the Austrian Agency for Health and Food Safety and provides information, requested both by the DWD and the national legislation on the quality of the drinking water in Austria. It contains general information about the water supply in Austria and annual overview of the drinking water quality.
Belgium	The environmental site of Wallonia contains information about the water supply in Belgium. It features a comparison of water consumption distribution between different European countries, description of the structure of public water supply in Wallonia, and information about the microbiological quality of water consumed in Wallonia. Flemish Environmental Agency also published a regular annual report on the water quality. The latest report is

[25] All relevant information about the drinking water quality per EU member state has been searched in the respective local languages; however the overview does not claim exhaustiveness with respect to the available information on the drinking water quality in the respective countries, but rather aims to present the reader with an idea of what kind of information is easily available online.

Country	Information sources in Member States
	dated 2013. Brussels Environment also monitors the quality of drinking water in the Brussels region and provides some very general information about the drinking water in the region. The latest report on the drinking water dates back to the period between 2008 and 2010.
Bulgaria	Water quality reports are available both on the sites of the majority of the water supply companies in Bulgaria, as well as on the sites of the Regional Health Inspectorates. They both feature some general information about the drinking water in Bulgaria, as well as detailed information for specific parameters, also by years.
Czech Republic	Reports on drinking water quality within the System Health Monitoring are published annually, where the latest one is for 2014. The report studies in detail the health consequences and risks of contaminated drinking water.
Cyprus	The Public Health Services of Cyprus publish reports to EU for the Control of Water for Human Consumption. The latest report dates from 2011 and contains very detailed yet technical information about parameters.
Denmark	The National Geological Investigations of Denmark and Greenland contains general information about the water quality in Denmark in the form of interactive maps. It also provides the consumers with the possibility to check the key parameters that are, defining the quality of the drinking water in their communities. The Danish Nature Agency also provides useful information about the drinking water in the country.
Germany	German Federal Environment Agency features a number of informative publications about the drinking water in Germany, its system and provides advice on whether to use drinking water from the tap, etc.
Estonia	Estonian Health Board provides overall assessment of the water quality by counties, cities and water supply companies. The reports also feature detailed information about the parameter values registered. The Ministry of Environment also published the DWD-related compliance report.
Finland	The environmental operators in Finland provide detailed information about the quality of the drinking water. For example, the Helsinki Region Environmental Services (HSY) supplies a list of water quality parameters, along with an explanation of the terms.
France	The French Ministry of Social Affairs, Health and Women's Rights provides very detailed information about the water quality by departments, communities and networks. The information contains some general conclusions about the water quality, as well as registered values of specific parameters.
Greece	Information about the drinking quarter quality is available on the sites of the Greek municipalities and water supply companies. They feature also detailed information about the parameter values[26].
Hungary	Hungarian National Public Health and Medical Officer Service provides detailed and up-to date information about the quality of the drinking water in Hungary. It contains detailed annual reports (latest from 2014), as well as answers to some frequently asked questions about the drinking water. The issue of the arsenic contamination of the drinking water in Hungary is treated as well. The site also hosts some scientific publications on the drinking water quality.
Ireland	Ireland's Environmental Protection Agency website is very well structured and contains detailed information about the quality of the drinking water in Ireland. It features both annual drinking water reports, drinking water remedial action lists, general information about the water supply system in Ireland and drinking water audit reports by counties.
Italy	In Italy there is also detailed information about the quality of the drinking water is available. It is usually provided by the water supply companies.[27] There is also some general information available at the Italian water portal site.
Latvia	Latvian Health Inspectorate features some general information on regulation and monitoring of drinking water, as well as detailed overviews of drinking water quality and monitoring overviews by year (the latest is for the 2014). The site also contains information on the lower limits of certain parameters to be achieved in certain districts along with the deadlines.
Luxem-bourg	The Water Management Administration of Luxembourg publishes general information about drinking water in Luxembourg. Water quality however is controlled at community level. Websites provide users with very detailed information, depending on their address. [28]
Lithuania	Lithuanian water supply companies publish reports on the drinking water quality.
Malta	Maltese Water Services Corporation publishes annual reports, where water quality parameters are given. The latest published report however dates back to 2011.
Nether-lands	Dutch National Institute for Health and Environment information about the drinking water quality in the Netherlands, including reports on the drinking water quality (the latest is from 2011). The Dutch government site also contains information about the quality of the drinking water in the Netherlands, including drinking water reports (latest – for 2012).
Poland	The Chief Sanitary Inspectorate of Poland publishes regular annual reports on the sanitary conditions in the country.[29] These reports are up-to-date (the latest is for 2014) and contain information on various issues, among which also on the quality of the water intended for consumption.
Portugal	The Portuguese Water and Waste Services Regulation Authority publishes regular in-depth reports on the quality of the water intended for human consumption.
Romania	In Romania a National Monitoring Centre of the Community Environmental Risks is established under the National Institute of Public Health. Its website provides link to the Romanian DWD Reports, where the latest is for 2011-2013.
Slovak Republic	The Slovak Environment Agency contains links to the Slovak Drinking Water Reports where the latest covers the period from 2011 to 2013.[30]

[26] Example: http://www.deyakav.gr/images/files/h2o_2015.pdf.

[27] Example:. http://aceaato2.it/ViewCategory.aspx?catid=eba39ca3fa0441f197512da921abbc25 or http://www.smatorino.it/monitoraggio?comune=.

[28] http://www.vdl.lu/Citoyens+et+r%C3%A9sidents/Energies_+Eaux+et+Canalisation/Eaux/Qualit%C3%A9+de+l%E2%80%99eau/Recherche+en+ligne.html.

[29] http://www.gis.gov.pl/?lang=pl&go=content&id=30).

Country	Information sources in Member States
Slovenia	National Institute of Public Health publishes annual reports on the quality of the drinking water in the country (latest is for 2014), as well as various other analyses (e.g. on the situation in Slovenia with respect to the boiling water in 2010 as compared to 2005, recommendations in case of water pollution, etc.).
Spain	In Spain a National Information System on Drinking Water has been developed. It collects data on the characteristics of supply and quality of drinking water that is supplied to the resident population.[31] It can be accessed by two types of users – professionals or citizens – and provides very detailed information.
Sweden	The Swedish Food Agency and the trade association for water services companies Swedish Water provide some very useful information about the drinking water quality in the country.[32] Detailed information about monitored parameters is available at the websites of the respective municipalities.
United Kingdom	Drinking water quality monitoring is divided between three agencies with mandates respectively in England and Wales, Scotland and Northern Ireland. The Drinking Water Inspectorate (England and Wales) publish annual reports on the drinking water quality (latest from 2014) as well as consumer information leaflets. The Drinking Water Quality Regulator for Scotland also published very detailed information, both at national and local level.
Ireland	The Drinking Water Inspectorate with the Department of the Environment for Ireland publishes regular reports on the drinking water quality, where the latest is for 2013.

Source: Ecorys (2015)

In spite of the efforts of authorities to provide information on drinking water, the stakeholder survey conducted for this evaluation indicated that consumers are generally dissatisfied with the information they receive on drinking water. Overall, only 16% of the respondents judged the information satisfactory and 58% was of the opinion that the information was unsatisfactory (the remaining 26% did not have an opinion on the subject). Taking those countries into account for which 20 or more responses were received, we observe that of the 27 countries included in the survey, in three countries the share of unsatisfied consumers is more than 75%, in nine this percentage is between 50% and 75%, in four this percentage is between 25% and 50%, and one time the percentage is lower than 25%. By grouping the responses into “old” or “new” Member States, we observe that consumers in “old” Member States are somewhat more satisfied (17%) than those in “new” Member States (10%). The results from the Flash Eurobarometer on consumer satisfaction with information on water-related issues correspond to the findings of the Survey: just 37% of the respondents feel well or very well informed.[33]

The statements below are examples of the critical opinions ventured by respondents on the information provision:

- “The current reporting arrangements do not meet their goal.”
- “The enforcement/legislation in the DWD to provide consumers information on water quality is weak.”
- “The DWD lacks provisions requiring utility providers to provide consumers with up-to-date information on their water quality.”
- “DWD reporting is done every 3 years, but this time lag is considered too big for consumer feedback and the information is generally outdated. Therefore annual reporting mechanism is proposed. Water supply companies, however, publish drinking water reports every quarter.”

More positive responses were also received:

- “In Spain a National Information System of Drinking Water was already established in 1991.[34] It applies to all Spanish municipalities with more than 50 people. The use of this application is mandatory by law for all water suppliers, health authorities and municipalities.”
- “Some water supply companies (e.g. in Spain) made declarations (paper of intent) aimed at giving more and more transparent information concerning the quality of water supplied by public aqueduct.”

30 http://cdr.eionet.europa.eu/sk/eu/dwd.
31 http://sinac.msc.es/SinacV2/.
32 http://www.svensktvatten.se/.
33 http://ec.europa.eu/public_opinion/flash/fl_261_en.pdf.
34 http://sinac.msc.es/SinacV2/.

- "In HR a Central Information System for Consumer Protection is established, where answers and advice to consumers are provided."
- "DWD introduction has had an important positive effect on the conduction of consumer surveys and receiving feedback from the citizens about how they perceive the quality of their drinking water (DE). This has raised awareness."

Except for information related to the drinking water quality, consumers participating in the survey expressed the opinion that they would also like to receive information related to other issues such as water losses in the network, the cost of the supply and profit margins, the investments made, and information related to monitoring measures undertaken.

Below are some of the recommendations regarding the type of information we registered through the consultation. They point mostly to a desire to have more detailed information:

- Information should be summarized and presented in an understandable way for non-specialists. Different information might be provided, depending on the types of users. It should be clearly specified if the water supplied is potable.
- Any additives used in the water should be indicated as well as the residual levels remaining in the potable water alongside with information for the applied treatment procedures.
- The origin of drinking water and the catchment area should be specified.
- More information on the water pricing model should be provided – provide a breakdown of water costs and how paid water taxes/ fees are used. Consumers also require information on planned or completed maintenance and repair works, expenses for preventive measure, data on profit margins.
- With respect to the monitoring and control of the water quality, respondents would like to be provided with information about the number of control measurements for each parameter, the percentage meeting the standards, minimum and maximum reference measurements and an indication of who made the measurement and when.
- Some respondents also request information from more thorough analyses, such as for example, whether in the same period a change took place in other environmental indicators, changes in diseases (including cancer, diabetes, etc.)

The public consultation further highlighted the need to ensure higher transparency which is seen as important for maintaining and improving public confidence (BG). This view is supported by others who claim that consumers have become more demanding on the information and the level of transparency about insecurities (risk communication). Stakeholders from different backgrounds indicated that insufficient information to consumers may turn them to other water resources than DWD protected drinking water. In particular, the responses about the control of drinking water quality include the following specific suggestions:

- Civilian control should be enhanced and non-profit organizations should be involved in water quality monitoring (or monitoring by an independent research body as additional control);
- Surveillance on demand: if there are consumer concerns, the water quality should be tested free-of-charge;
- Development of simple tests that are intended for citizen control on some important parameters should be made.

The Finnish regulator perceived more regular monitoring and thus more information on water quality and better public awareness of the water quality as a positive effect from the DWD. The German regulator saw the DWD as a catalyst for conducting consumer surveys and receiving feedback from the citizens about how they perceive the quality of their drinking water. These surveys are regularly carried out in other Member States. Regulators see consumer surveys as one of the instruments to raise awareness.

Article 13 of the DWD also stipulates the reporting obligation for Member States to the European Commission. The reporting to the EC covers three year periods, on the basis of which the EC publishes a synthesis report on the quality of drinking water in the Community. This reporting to the Commission is designed to check the implementation status of the Directive, and to request data for example on non-compliance, causes, and remedial actions. This information is quite specific, and can be used for legal prosecution by the EC, but also for legal action at national/ regional level to ensure human health protection.

The compliance to submit reports but often incomplete, and the Critical Analysis Report written in 2013 under the ENV.D.2/FRA/2012/0013 Framework Service Contract for Support to the Implementation of the Water Industry Directives states that the information submitted by MS is insufficient for the Commission to perform a thorough compliance check and adequately inform e.g. the European Parliament. Additionally, the report notes that the DWD fails to provide a clear objective for the reporting, and lack of feedback to MS about their (incomplete) returns has caused bad reporting by some of them to continue for many years.

the Synthesis Report on the Quality of Drinking Water in the EU examining the Member States' reports for the period 2008-2010 under Directive 98/83/EC corroborates the findings of the above report and states that the “current set-up for reporting does not provide the Commission with adequate and timely information to perform a thorough synthesis of drinking water quality developments in the European Union. This makes it difficult to provide the Council, European Parliament and the public with updated EU-wide information on drinking water policy and quality on a regular basis. In addition, the way data are collected, processed and reported differs across the EU, which makes it difficult to compare situations in different Member States with regard to their performance and compliance with the Directive”.

With a high compliance of reporting to the Commission and the increasing demand by consumers for more detailed information, the question is whether these two requirements (reporting to the Commission and informing the public) should not be combined.

The critical analysis report as mentioned above further states that the information relevant for consumers differs so much from the information needed by the Commission to perform compliance checks that it would be advisable to have these as two different activities, specifically aimed at the reporting objectives for the respective target groups.

Conclusions on JC2.7

We observed that most national authorities provide general information on the quality of the drinking water and, in most of the cases, they make their national DWD reports also available to the public. However, the variation in the quality of reporting is large and consumers satisfaction on the information provided by the authorities is barely more than 20%.

Consumer preferences as to the type and level of detail of information consumers would like to have are mixed. Whereas two-thirds of the respondents would like to see easily understandable information, the same percentage asks for more detailed information. Providing (detailed) information is needed to ensure higher transparency and is therefore important for maintaining and improving public confidence.

The compliance with the requirement of reporting to the Commission is high but the information submitted by MS is insufficient for the Commission to perform a thorough compliance check and adequately inform e.g. the European Parliament. Given the different information needs of the

Commission and consumers it is advisable to have these as two as different activities aimed at the reporting objectives for the respective target groups.

The review process according to Art 11 can be considered effective (JC2.8)

The review of the Annexes is a different process for Annex I and Annex II and III. Annex I is reviewed every five years by the Commission and if necessary the Commission will make proposals for amendments, where necessary. In the case the Commission decides that amendments are needed this is done by a full procedure involving both the European Parliament and the Council. Since the coming into force of the 98/83/EC Directive no changes have been made to Annex I as it was not deemed necessary.

The adaptation of Annex II and III of the Directive is subject to a five years cycle. The Commission decides together with the Committee composed of representatives of the Member States whether an adaptation of Annexes II or III is needed. In the case adaptations are needed this is done through the Committee procedure. A process of revising Annexes II and III took place in 2014 and 2015. Amendments regarding the Annexes II and III take into account the provided comments from Member States experts and stakeholders during and after the Drinking Water Expert Group meeting of 27 June 2014. The text also takes into account the outcome of the EU-wide public consultation for the relevant parts on monitoring and analysis, carried out from 23 June to 23 September 2014. The amendments now offer the option for Member States to apply risk based monitoring. This means that deviation from the default monitoring programmes in relation to the parameter list and monitoring frequencies can only be done after a risk assessment, providing strong guarantees that the protection of human health is not compromised.

In 2008 preparations were made by the ad hoc Subgroup of the Standing Committee on Drinking Water to revise Article 10 of the DWD on Quality assurance of treatment, equipment and materials. However, this revision however never took place.

Another issue that could be addressed in a revision of the DWD are the provisions on radioactive substances and radioactivity parameters as these issues are addressed in the developments in EURATOM legislation (Directive 2013/51/EURATOM). These provisions are detailed in Annex I and therefore need a full procedure involving the EP and the Council.

Conclusions on JC2.8

On the effectiveness of Article 11 and the distinction in review procedures it is observed hat that the DWD and its articles, as well as Annex I on parameters and parametric values. can only be amended through a full procedure. This process is lengthy and time-consuming which is justified by the seriousness and implications of any proposed changes. The decision to allow a rapid adaptation of the technical requirements of the Annexes II and III through a Committee procedure introduced some flexibility in the Directive to respond to scientific and technical progress. Looking back it is noticed that for a long time since the coming into force of the Directive the provision in Article 11(2) has not been used up until 2014.

2.1.2 *What main factors, in particular related to water bodies, agriculture and distribution networks, have influenced, or stood in the way of, achieving the objectives of the DWD? (EQ3)*

Sources of drinking water or distribution networks do not pose risks to the quality of drinking water (JC3.1)

Based on our review of the factors influencing the objectives of the DWD, in particular related to water bodies, agriculture and distribution networks we can conclude that the characteristics of water

bodies (notably the quality of the water as such in terms of concentrations of relevant parameters) are influenced by land use including agriculture. This relates both to the impact of sources (emissions) as well as (changes in) the nature of the abstraction zone itself (geology). However, the dynamics of these characteristics strongly differ when comparing deep groundwater abstraction zones characterized by a slow response time versus surface water bodies with a quick response time when considering the impact of emission of unwanted substances. As such this difference is not regulated by the DWD in that it does not discriminate in monitoring strategies to overcome this. Having stated this, it is clear that the complex nature of the interaction of substances with the aquifer or sediment matrix hampers a clear solution of this issue. At present insufficient quantitative data is available to derive such aquifer optimized monitoring scheme.

A more process oriented basis to determine relevant monitoring frequencies is a prerequisite that could make the DWD more effective in a sense that is able to detect unwanted changes in water quality in time.

2.1.3 *What results, if any, did the DWD achieve beyond its main aim to protect human health (EQ4) and did the DWD cause any other unexpected or unintended changes? (EQ5)*

The DWD has lead to other than human health related results and also lead to other unexpected or unintended changes (JC4.1 and JC5.1)

We have applied a broad scope to put drinking water in a wider perspective and to identify unexpected or unintended changes, both positive and negative, as a result of the DWD. Below we discuss the following effects:

- The additional awareness of drinking water quality;
- Other EU Directives;
- Pesticides;
- Consumer behaviour.

Awareness of drinking water quality

A positive unintended effect of the DWD beyond the main aim of the Directive is the creation of awareness at the level of all stakeholders involved, where regulators are most affected. Stakeholders interviewed, who have a position as a regulator or are active within the ministry on this issue, informed the study team for that the DWD has put drinking water quality higher on the list of important national policies. The MS that already had relatively good drinking water quality indicated that the importance of consumer information was put higher on the agenda as a result of the increased awareness of water quality. In case of Portugal, a change of national institutional organisation was even indicated as necessary to comply with the new DWD quality standards. The interviewee named the DWD and its indirect effects as an important positive driver to stimulate water companies to comply with the quality standards. The DWD also unintendedly led to more cooperation between MS. Networks of national regulators were formed across the EU to discuss issues that are present in different countries, leading to learning, advice, knowledge sharing and informal discussions. This is a positive unintended result of the DWD, according to a Dutch regulator.

Other EU Directives

The second unintended effect that can be linked to the DWD is that it created the basis for a number of Directives which have been designed and implemented since 1998 (such as the WFD and the Nitrates Directive). There has been a clear link with the levels of regulation of substances between the DWD and those of other Directives, a thorough assessment of other legislation is made in the section on coherence.

Pesticides

The use of fewer and other pesticides is also referred to as an effect of the DWD and other water Directives. In the proposal for a council directive concerning the quality of water intended for human consumption the Commission proposed that the previous precautionary parametric value of 0.1 µg/l for individual pesticides and 0.5 µg/l for the total mixture of pesticides should be retained.

Concerning pesticides, the Commission asked the Scientific Committee (CSTEE) for its opinion on whether scientific knowledge available at that time provided the necessary security and reliability to determine, on the basis of a precautionary approach, individual limit values which guarantee safe drinking water on a life-long basis for the population, including sensitive population groups where relevant and what the correct values for individual substances could be.

In the opinion of the CSTEE the limit values of 0.1 µg/l for each compound or 0.5 µg/l in total adequately protects human health, generally providing a sufficient margin of safety. Bearing in mind the inadequacies in data basis on the toxicity of individual pesticides and uncertainties in the assessment of variables the CSTEE a revised setting of limit values was not in order. In addition referring to the parameters and data used in the WHO-guideline values for the control of drinking water the Committee was of the opinion that they might not provide a sufficient margin of safety for the EU and that information on the toxicity of mixtures was almost entirely missing. The Commission felt obliged to take a careful and precautionary approach by not proposing any amendment to parametric value for individual pesticides at that stage. For a number of pesticides (aldrin, dieldrin, heptachlor and heptachlor epoxide) the parametric value was set at 0.030 µg/l. This value is based on the examination of the then available technical and scientific information and was fully justified from a human health perspective.

Currently, the strict precautionary thresholds are sometimes referred to as anomalous, given that pesticides form a very broad group of substances with a wide range of properties.[35] Although (drinking) water legislation such as the DWD and the WFD are unlikely to directly affect the authorisation of new pesticides on the market, they are related to the extent to which they are used. Indirectly, drinking water legislation might even change types of pesticides and their development. These developments are being recognised by the Dutch Bureau of Statistics, Wageningen UR and the Netherlands Environmental Assessment Agency, which state that a reduction of pesticides in ground and surface water is being noticed and can be linked to the use of fewer and other pesticides in agriculture.[36] Additionally, water companies have installed extra treatment steps to avoid water intake stops due to high pesticide levels in surface water. Although both processes are associated with the need for clean and wholesome drinking water, it is hard to attribute this solely to the DWD. Other water related directives, such as the Nitrate Directive and the Water Framework Directive can also be held responsible.

Consumer behaviour

The Stakeholder Consultation revealed two lines of thinking on consumer behaviour related to improved legislation on drinking water. The first line of thinking was that more extensive drinking water legislation, such as the DWD, increases the quality of drinking water and therefore raises the preference of consumers for tap water. The second line supported the hypothesis that drinking water legislation leads to higher awareness on water quality and therefore results in consumers buying more bottled water, which is deemed safer and qualitatively better by consumers. However,

[35] Shearer, M. and J. Tait (2009) Impact of the EC Water Framework Directive on the Pesticide and Pharmaceutical Industries. Innogen Working Paper No 75.

[36] CBS, PBL Wageningen UR (2007) Emissie van bestrijdingsmiddelen in Nederland, 1984-2000. Retrieved from: http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl020003-Emissie-van-bestrijdingsmiddelen-in-Nederland.html?i=

none of these lines of thought captures the reality of consumer behaviour on drinking water and much research has been done in the EU on the preferences for either tap water and bottled water.

A number of variables are known to influence the consumer behaviour on drinking water, the most important are: perceived taste (bottled water tastes better), pure quality (bottled water is perceived as pure and of better quality), security (food scandals and waterborne diseases in developing countries negatively influence tap water) and health concerns (bottled water is seen as a healthy alternative to other bottled beverages).[37] However, these concerns do not necessarily reflect reality. For example: a study conducted in Italy, a country known for its large consumption of bottled water, found that there is no reason to believe that bottled water is of better quality than the Italian tap water. The results even indicate that some bottled waters contain concentrations of substances that are significantly higher than normally acceptable in tap water[38].

The reason that bottled water is often preferred to the tap water is largely assigned to the extensive marketing campaigns of the industry. Large budgets are allocated to marketing, since the bottled water industry is known to be very competitive and dynamic. The tap water companies however, do not allocate similar resources or means to promote their product. The public consultation on the quality of drinking water by Ecorys indicated that there are large differences across the EU in terms of drinking tap water. The percentage of people that drink water directly from the tap ranges from more than 95% in Sweden and the Netherlands to less than 30% in Poland, Latvia and Ireland[39]. It is therefore hard to state what influence the DWD has had on the consumer behaviour relating to bottled and tap water, and whether this is positive or negative.

Conclusions EQ4 and EQ5

By putting drinking water in a wider context the DWD can be linked to a number of unintended and unexpected effects beyond the protection of human health. Examples of positive effects broadly concern the increased awareness of drinking water quality at the level of national legislators, environmental improvement due to decreased pesticide use and the basis it has created for additional environmental legislation such as the WFD and the Nitrates Directive.

2.2 Efficiency

Efficiency considers the relationship between the resources used by an intervention and the changes generated by the intervention (which may be positive or negative). In order to assess if the DWD is efficient, the evaluation looks at the various cost categories related to the provisions of the Directive such as administration, monitoring, providing information to consumers, and reporting and relates these to the (changes in) volume of water supplied or number of people served. The evaluation also looks at the benefits related to providing clean and wholesome water. These benefits are largely indirect (such as avoiding cost of sickness and absence of work) and difficult to quantify. In this section we will look at the costs and benefits associated with the implementation of the DWD, and to the technical or other developments since the elaboration of the Directive that could contribute to achieving the objective more efficiently. Furthermore we assess whether the Directive allows for efficient policy monitoring.

[37] Ferrier, C. (2010) Bottled Water: Understanding a Social Phenomenon. *Journal of the Human Environment.* 30(2). Royal Swedish Academy of Sciences.

[38] Cidu, R., F. Frau & P. Tore (2010) Drinking water quality: Comparing inorganic components in bottled water and Italian tap water. *Journal of Food Composition and Analyis.*24, 184-193.

[39] Ecorys (2015) Public consultation on the quality of drinking water

2.2.1 *To what extend are the costs involved with implementing the DWD justified given the benefits which have been achieved? (EQ6)*

The Drinking Water Directive has as objective to improve health in Europe through the supply of safe and uniform drinking water across all EU Member States. Various articles in the DWD have led to specific actions to reach this objective. These actions have resulted in various benefits, most of them relating to a reduction in diseases due to an improvement of the quality of drinking water, and others, for instance, to a reduction in ecosystem pollution by parameters taken up in an Annex of the DWD. These actions led to costs for regulators, utility providers, the European Commission and in the end for consumers.

In this section we will first identify, and shortly describe the main identified cost –and benefits associated with the implementation of the DWD, secondly explain our method of attributability of cost(/benefits) to the DWD and thereafter focus on describing and estimating the cost/benefits by providing a quantitative calculation where possible and if not by explaining the impact qualitative.[40]

Regarding the health benefits we calculated quantitatively, where possible, the extend of identified benefits. However many benefits of the DWD can not be determined based on the available data/information[41] and as a result these benefits are described qualitatively. We found a range of benefits that are associated to some extend with provisions of the DWD, such as a reduction of contamination on users of public water services. Effects related to removal of lead pipes can to an extend be quantified, where other such as aesthetic effects (improved taste, odor and/or smell) are discussed more qualitatively.

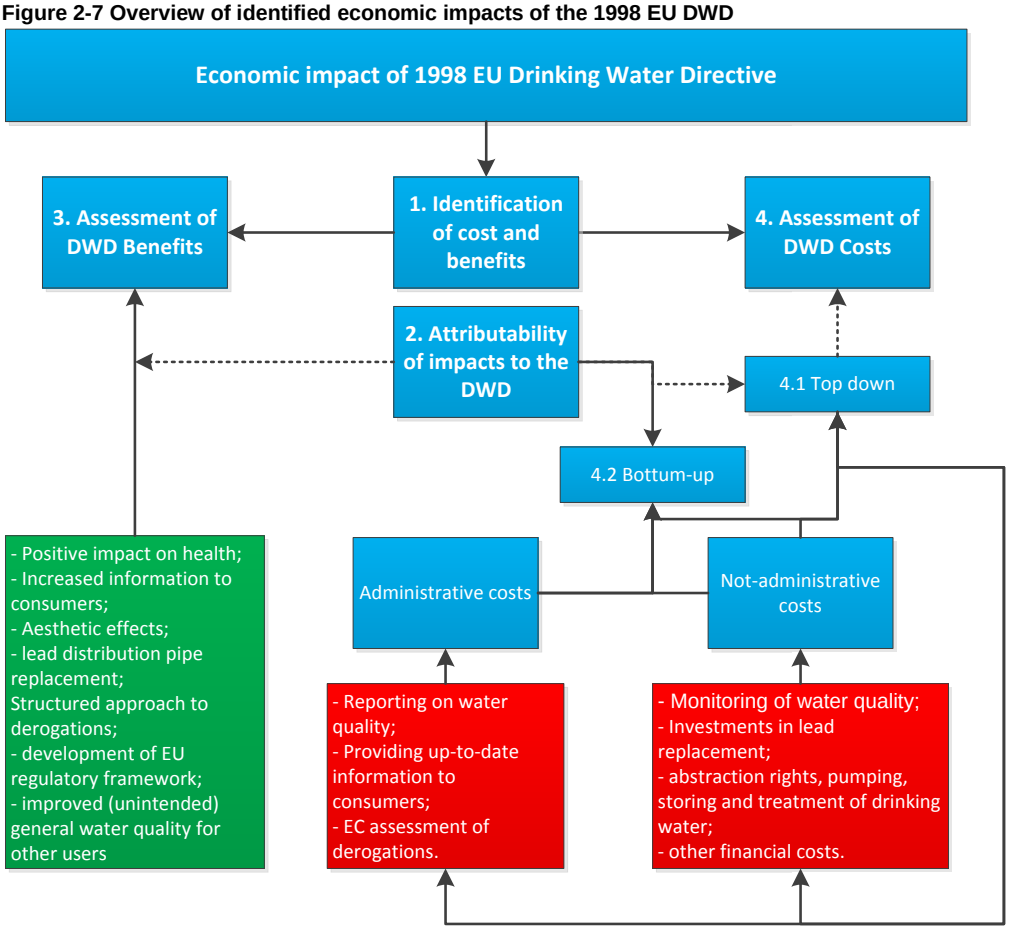
Regarding the cost related to actions of the DWD there are two approaches. A top-down approach, where one looks at total costs for consumers and work out the share that can be attributed to the DWD and a bottom-up approach, where one looks at specific costs components, such as (lead) pipe replacement. This second approach is more accurate and is more practical/feasible for stakeholders to provide feedback on, but can not be conducted for all identified cost components (for instance: to what extend is the replacement of a water purifier for a improved version attributable to the DWD and/or what share of imputed costs is DWD related?).
To provide an as full picture as possible we used both approaches. The top down approach provides a more general picture, has some generalizations and as such the outcome should be seen as a rough indication of total costs and DWD attributable costs. To provide also more accurate and in-depth information on some specific and important DWD provisions we calculated bottom-up the cost for reporting, monitoring, (lead) distribution pipe replacement, EC assessment of derogations and costs for providing information to consumers. These approaches can not be linked together, mainly due to possibilities in double counting, but provide a thorough overview of how the DWD has impacted drinking water supply in Europe from 1998 until 2014.

The figure below provides an overview of (some of the) identified costs and benefits and the overall approach to EQ6. Note that there is a loop from 4.1 Top down to the Not(Administrative) costs and back to the top down and bottom up assessment. This is done since all costs are assessed in the top down approach and some costs are discussed in more detail (depending on available information and importance according to stakeholders) bottom up.

[40] When drafting EQ6 we took note of recommendations made by the EPA, 2002, study: Assessing the Benefits of Drinking Water Regulations : A Primer for Stakeholders.

[41] An estimation of, for instance, the reduction in number of diseases over 17 years is difficult. When taking into account that without a DWD, MS would have taken also 'some/equal/more' action it becomes near-impossible to calculate per MS these benefits and be therefore highly speculative.

Figure 2-7 Overview of identified economic impacts of the 1998 EU DWD



1. Identified (main) cost –and benefits associated with the DWD

During the course of the evaluation we have identified the main provisions of the DWD that lead to costs –and benefits for stakeholders. We have taken the main impacts to MS regulators, water utilities, industry and the EC into account. Based on these information sources we find that the main benefit are related to:

- Positive impact on health through a reduction in microbiological outbreaks and/or chemical incidents;
- Increased consumer information and aesthetic effects;
- Replacement of lead pipes in the distribution network
- Structured approach to derogations;
- Development of a regulatory framework at EU level, leading to a baseline for MS legislation;
- Improved water quality for 'other' water users (ecological benefits for fish and/or recreational users, protection of biodiversity or enhanced nonuse value (the pleasure of knowing that clean water exists).

In addition, we identified the following main cost drivers:

- Administrative costs, such as:
  - the reporting for water utilities to the EC;
  - costs of assessment of derogations by the EC;
  - providing information to consumers;
- Monitoring of parameters by water utilities;
- Replacement of lead pipes in the distribution network and (optional) replacement of lead piping inside housing;

- Costs related to abstraction right, pumping, storing and treatment; and
- Financial issues, in addition to lead replacement, such as other investments, capital consumption and amortisation.

2. Attributability of costs –and benefits to the DWD

The costs –and benefits of the DWD, identified above, have a link to the DWD, but in most cases can not completely be attributed purely to the existence of the DWD. This means that from the total cost and/or benefit only a specific share can be contributed to the Directive. In short this is because the identified actions/improvements of the drinking water system would also have occurred/ occurred to a lesser extend through national legislation and/or other EU Directives without existence of the DWD.

The determination of attributability is extremely difficult, since it depends on many inter-linkages (for some countries there is even a chicken-and egg story, because they had already certain parametric values in their legislation prior to the '98 DWD). Attributability is difficult to determine, but nevertheless crucial when determining the impact of the DWD (or any legislation for that matter). To obtain reliable estimates the evaluators developed, based on available literature and interviews, estimated shares of attributability for reporting-, monitoring –and (lead) pipe replacement costs. Due to the importance of these values, and the possible differences between MS, stakeholders were contacted to respond on these estimations. The stakeholders provided feedback on MS for which they indicated themselves knowledgeable (often their home country) based on the below definition of attributability and in some cases also through additional discussions with the evaluators.

Attributability over 17 years DWD

An activity is 100% attributable if this activity would not have taken place without the implementation of the DWD. An activity is 0% attributable if this activity is already implemented by the MS (please take the 'awaremess raised by the DWD' into account). An intermediate impact of the DWD (so a share between 0% and 100%) on an activity could be because (i) the MS implemented already some sort of similar (perhaps less strict) activity and/or (ii) the MS would, in your opinion, implement at a point in time (later then 1998) autonomously a similar activity. The table below assumes that neither 100% or 0% are likely outcomes (chicken – egg problem) and that MS who joined the EU (and adopted the DWD in legislation) at a later stage than 1998 are, in general, more impacted by the DWD compared to the 15 early EU members.

In the case that stakeholders informed us that we over-/underestimated certain shares (and solid information was given as of why we over-/underestimated) we have adjusted the estimations of the attributability of the DWD regarding reporting, monitoring and (lead) pipe replacement. For 20 out of the 28 MS we received one or more responses. In Annex G we provide the outcome of this activity, where the various colors indicate through what method the share has come to be.

3. Description and/or estimation of total –and DWD attributable benefits

This section outlines our approach with respect to the analysis of the benefits that can be identified due to implementation of the DWD. At its core, the approach of the combines quantitative methods when data is available and applies qualitative methods in the case that data is missing or impacts are very indirect and as such hard to quantify. In addition to the above quantitative and qualitative approach to assess the DWD benefits we included in-depth analysis on specific important topics in the form of case studies. Case studies are an excellent tool for 'filling the gaps' that are left behind by comprehensive quantitative assessments and general literature reviews. They additionally allow for a focusing on a specific selected issue that deserves closer attention.

Positive impact on health through a reduction in microbiological outbreaks and/or chemical incidents

Apart from the question: has the DWD improved drinking water quality (information in Annex B), there is also the question: has the DWD led to a reduction in health incidents, that are (partly) related to drinking water and if we can identify such cases what would the value be of a reduction in incidents. We will assess the impact (benefit) of the DWD on health by identifying trends in microbiological outbreaks and chemical incidences and try to monetize the outcome of such an analysis.

The input consists of incidents and outbreaks reported in literature and obtained through contacts with drinking water regulators. The information on outbreaks and incidents collected will be judged as being related to drinking water or not as for many microbiological outbreaks there is not always a single cause or the cause is unknown (and could be either drinking water and/or food). As a third step the impact of the DWD on the occurrence and frequency of events and outbreaks will be assessed, where (in general) a distinction is made between microbiological outbreaks[42] and chemical incidents[43].

In the search for chemical incidents (through Member States regulators, researchers and WHO), we were told by various experts that unless there is a 'major' event that is reported in the public press most incidents go unnoticed. Water companies are rather hesitant to report on such incidents and also if it is for a short period of time and they can restore the normal situation quickly, such events do not have to be reported to the authorities. No national or European records are kept on chemical incidents. One EU regulator when asked for frequency and details of chemical incidents said that he could not remember any in the last ten years. When asked if that was the result of having the DWD in place he mentioned that that conclusion could not be made, but this was because of better environmental legislation and better practice.

There are some examples of incidents that can be mentioned and the remedial action that was taken to prevent (further) pollution of drinking water. When surface water used for the production of drinking water is polluted as is the case in the River Meuse example below, remedial action is taken by temporarily closing the water intake.

Case study: Remedial Action, closing the water intake of Meuse River

In August 2015 the River Meuse water used for the production of drinking water in the Netherlands did not meet the quality criteria and the intake by the water companies WML, Evides and Dunea was stopped. This remedial action was taken because the source of the pollution the wastewater treatment plant at a chemical factory did not operate properly and pyrazoles were discharged on the surface water and ended up in the Meuse. Temporary closure of the intake of river water is a common remedial action taken by surface water companies to protect the quality of drinking water. Since 2010 there have been five intake stops of River Rhine water due to the too high presence of pesticides.[44] When a borehole is polluted they are often abandoned and alternative sources are exploited. In some cases groundwater does not comply with values for the chemical parameters in the DWD and alternative solutions are not readily available. Such examples are generally addressed through derogations and mostly concern, arsenic in some areas of the EU, fluoride or chromium VI. These are not

[42] Microbiological outbreaks through drinking water include events in which two or more people must be linked epidemiologically by time, location of exposure to water and illness characteristics and the epidemiological evidence must implicate drinking water as the probable source of illness.

[43] Chemical incidents include events in which there is unintended (or sometimes deliberate) release to the (aquatic) environment of chemicals with potential to cause harm to human health through drinking water. In the case of a microbiological outbreak the effects on human health are most acute and obvious. Chemical incidents will only become clear when there are acute physical effects or when consumers reject the tap water because of organoleptic aspects (taste, appearance, odour). Chronic effects of chemical incidents are much more difficult to notice.

[44] Communication with Harry Römgens (Director RIWA Maas, TAPES conference September 2015).

incidents but structural problems. Here the DWD has an impact as Member States have to take remedial actions to comply with the requirements of the DWD.

However with respect to the chemicals incidents, it is, in general, not likely that the DWD has an impact on their occurrence. These incidences are mostly not related to the implementation of the DWD. Something goes wrong and this does not depend on having standards in place. Combined with the fact that no records are kept on occurrence of chemical incidents we have restricted the assessment to microbiological outbreaks.

The microbiological parameter trends have been assessed for the following parameters:

- E.coli and Enterococci;
- Cryptosporidium;
- Campylobacteriosis;
- Giardiasis;
- Shigellosis; and
- Legionella.

In Annex C a detailed overview of instances per MS and background information for each parameter is included.

Through the use of epidemiological data on the potential microbiological parameters that are discussed we were able to assess, to some extent, the reason of outbreaks and in what way the DWD led to a reduction in (these) outbreaks.

- In most cases outbreaks can be caused by various of sources besides drinking water and it is often not clear what source led to a specific pollution;
- The epidemiological data trends indicates an increased number of outbreaks for pathogenic E. coli STEC/VTEC between 2008 and 2012;
- We did not find significant changes in the outbreaks related to Shigella and Giardia;
- Cases related to Campylobacter increased in the period 2007-2011 but showed a slight decrease in 2012;
- Cryptosporidium related cases showed an increase in 2012;
- The only micro-organism that most certainly related to (drinking) water and showed significant increase from the start of monitoring in 1987 till 2012 is Legionella. The significant increase in number of cases can be attributed to increased travel in Europe, through improved analysis possibilities and also somewhat to better reporting by MS; and
- Results for MS may differ, since some MS have seen a huge decrease in E.coli from 2007 onwards (Ireland), where other MS show an increase obscuring the national improvement in the reduction of outbreaks.

In general we find that the epidemiological data are presumably only the tip of the iceberg as water related disease surveillance systems are not necessarily capable to detect waterborne outbreaks due to methodological problems. Comparisons over time are as such currently not very meaningful in terms of assessing an impact of the DWD unless there is convincing evidence that the disease was water borne and reduced due to remedial actions taken because of the DWD. Due to this uncertainty in the data and level of attributability to the DWD no meaningful benefit assessment can be conducted.

Increased consumer information and aesthetic effects

All MS provide information to consumer, see table 2.4, and we found that in general national authorities usually provide some general information on the quality of the drinking water and, in most of the cases, they make their national Drinking Water Directive reports also available to the public.

In spite of the efforts of authorities to provide information on drinking water, the stakeholder survey conducted for this evaluation indicated that consumers are generally dissatisfied with the information they receive on drinking water. Overall, only 16% of the respondents judged the information satisfactory and 58% was of the opinion that the information was unsatisfactory (the remaining 26% did not have an opinion on the subject). Providing (detailed) information is needed to ensure higher transparency and it is important for maintaining and improving public confidence in the quality of drinking water.

Despite the (sometimes) criticized information available regarding water quality provided to consumers, consumers see the provided information as beneficial.[45] In the last 17 years much has been done to increase awareness and knowledge on water quality and water treatment methods under the general public, this effort has seen an incredible boost since the growth of ICT (e.g. smartphones/4G internet). Creating awareness on water quality is an intangible benefit of the DWD and can as such not be monetized. Regarding attributability we attribute the impact of information to consumers similar shares per MS as has been taken up for cost of reporting, see Annex G.

Furthermore we have analysed if there is an increase in aesthetic value (smell, taste and/or smell of drinking water) through the DWD. We interviewed stakeholders on this and set their response of against the general outcome of the Public Consultation. We found that, as the DWD is concerned with the aesthetic quality of drinking water, the aesthetic value often is not taken up in national regulation and as such not an important issue for drinking water providers. We therefore conclude that the DWD does not lead to (unintended) aesthetic benefits.

Replacement of lead pipes in the distribution network

Lead is historically used in water pipes until it became apparent, around 1970, that there are significant health risk associated with a built up of lead in the human body.[46] In particular at risk are children and infants, as lead can have a negative impact on their mental development.[47] Currently it is worldwide acknowledged that human exposure to lead should be minimised and therefore the levels in water, soil, air and food should be controlled. The '98 DWD has set strict maximum lead occurrence levels to control for lead in the drinking water system. As a consequence MS have (in the case that they had lead distribution pipes and/or did not start replacing distribution pipes to comply with new WHO standards already) replaced many to all public distribution pipes over the years.

When determining the direct benefits that the DWD lead standard had on improving health across Europe it is important to understand from what situation we came and how this situation changed.[48] In the middle of the 20th century (1969-1971) there were 70 reported cases of lead poisoning in the UK, 433 in West Germany, 61 in Sweden and 58 in Finland.[49] Much action to reduce lead poisoning has been taken since and currently the number of (clinical) lead poisoning cases in the developed world are rather uncommon and if they occur they are rather mild compared to the 1970's era.[50] From this we find that the '98 DWD, perhaps contributed, but can not have been the main cause of the reduction in lead poisoning. As such the benefits, and reason for high lead

[45] According to most stakeholders.

[46] A too high intake of lead into the human body can lead to lead poisoning (also known as plumbism, colica pictorum or saturnism) and have serious negative impacts on the heart, bones, intestines kidneys and reproductive systems. The treatment methods are the removal of possible lead intake points and chelation therapy. Acceptable levels in the drinking water are set at 10 µg/dl. Acceptable does not mean not harmful, since there has not a safe threshold of lead intake – meaning that any intake is harmful for the human body.

[47] DWI, 2010. Lead in drinking water.

[48] Lead poisoning could occur through various sources (historically most cases were occupational hazards from factories for instance) and we do not have sufficient information to split between paint or water distribution induced lead poisoning.

[49] Hernberg S., 2000. Lead poisoning in a historical perspective. American journal of industrial medicine.

[50] Note: during this period the "safe" lead standard was 80/100 µg/dl, which is a huge difference compared to current 10 µg/dl standards, which are not "safe" but acceptable.

replacement investments, are possibly more indirect. In the case study below we investigate the benefits of a reduction of levels of exposure to lead of minors and set the benefits (although they can not contributed completely to lead pipe replacement) off against the estimated costs in the EU28.

Case study: EU health benefits associated with reduced lead exposure to minors (<6)

A reduction in levels of lead exposure to minors are two-fold. We expect a direct effect due to a reduction in cases of lead poisoning and therefore a reduction in the treatment costs thereof and an indirect effect related to avoided social cost, which is related to having in general a 'smarter' population.[51] In this case study we build forward on work by Pichery et al., 2011, who investigated the welfare effect of lead exposure to minors. His work provides some main inputs on benefits associated with lead reduction from which we will derive the EU benefits of lead exposure reduction. The total benefits are split up in reduced treatment cost and societal benefits due to a general higher IQ of the population. For indirect societal costs the lost life-time earnings, cost of special education, crime and special case intangible cost are taken into account. The table below details the main findings and inputs for our simple EU28 expansion.

Table 2-5 Impact of lead exposure to minors (<6 years)[52]

Level of exposure	Percentage of children impacted	Unit cost of treatment	Total treatment benefits (in mln euro)	Total societal benefits (in billion euro)	Total lifetime benefits (in billion euros)
0 to 14 B-Pb	50%	€ 0	€ 0	€ 0	€ 0
15 to 23 B-Pb	35.1%	€ 120	€ 198	€11.8	€ 22.72
24 to 99 B-Pb	14.8%	€ 120	€ 83	€10.2	€ 10.72
100+ B-Pb	0.1%	€ 2.932	€ 16	€0.44	€0.44

Source: Based on Pichery et al. (2011)

We use the information in the above table to provide an estimation of benefits (reduction in costs) if the level of exposure for minors in the EU28 would fall in the range of 0 to 14 B-Pb. In this estimation we made the following assumptions to generalize across the 28 EU countries:

- The share of minors (<6 years old) is equal across all EU countries;
- The share of children in each exposure group is equal across all EU countries;
- Treatment costs are equal across all EU countries and treatment groups;
- Societal benefits are equal across all EU countries for each treatment group; and
- We corrected the benefits if a country indicated to not have lead pipes.[53]

The above approach results in a total lifetime benefits of approximately 413 billion euro. Avoided treatment costs, in the case that all EU minors have low exposure, is estimated to be 2.3 billion euro, whereas the societal benefits are estimated to be in the range of 411 billion euro.

To achieve these benefits investments have to be made. The abatement costs are mainly related to lead-based paint removal, reduction in industrial pollution and lead water distribution pipe replacements (estimated to total 4 public -and 10 billion euro in private investments (IETRE). Making a direct link between the impact that each abatement action has on found benefits is unfortunately not possible and as such a complete CBA, where one focusses on the drinking water

[51] Not all lead intake will lead to a case of lead poisoning, but lower intake of lead still has a negative impact on IQ.

[52] Pichery et al., 2011. Childhood lead exposure in France: benefit estimation and partial cost-benefit analysis of lead hazard control. Journal of environmental health.

[53] Reduction of two thirds as lead makes up 1 of the three abatement benefits (probably the largest). Impact of this correction on benefits at EU level is of low significance.

and DWD aspects, can not be conducted. However, when comparing the estimated above benefits with the estimated costs of lead distribution pipe replacement (€81 billion euro in total (EU28 between 1998-2014) of this between 1 -and 5 billion euro can be contributed roughly to the DWD[54]). One can easily derive from this that replacing lead pipes has had a significant positive welfare and health impact and most probably outweighs the investment costs.[55]

Structured approach to derogations

There are various, hard to quantify, benefits associated with the possibility for having a derogation for MS. These benefits are due to possibility that a MS can wait with making replacement investments, which reduces or nullifies the share of previous investments that need to be written-off. In addition, MS would have to go a great length to remove the last percentage of a parameter, for instance Boron, to comply to the DWD standards. A derogation allows them to wait for future techniques, which might achieve the DWD parameter (e.g. Boron) goal at lower costs.

Development of a regulatory framework at EU level, leading to a baseline for MS legislation

The DWD has lead to a baseline for national regulators when drafting national drinking water (and other) legislation for at least water providers and (polluting) industries. Some MS have adopted the provisions of the DWD articles and the Annexes with parametric values directly, where others have for instance stricter than required parametric values. When looking at the benefits of the development of such a regulatory framework one ideally sets the current situation of against a situation in which the DWD did not occur. In this hypothetical situation there would not have been a '98 DWD and national regulators would need to develop, or not, their drinking water regulation autonomously using the '80 DWD as starting point. Developing such a framework is costly, needs to be developed roughly anew 28 times over and is to some extent inconsistent with neighbouring countries, leading to different water standards and possibly 'distrust' of water quality abroad by consumers.

Information on cost related to developing a regulatory framework with the detail and work done as needed for 'a representative drinking water directive at MS level, or costs related to developing the '98 DWD for comparison, is not available and depends on too many external actors to determine. Based on interviews with national regulators it is however easy to find that having a regulatory framework in place at EU level is much-more cost efficient and as such leads to benefits. Furthermore the DWD, being discussed at EU level, became a platform where knowledge between similar/different stakeholders and countries is shared and the baseline for providing drinking water is equal (enforcement might however not be) across all MS, leading to increased trust in drinking water quality by consumers.

Improved water quality for 'other' water users (agriculture, biodiversity, ecosystem services, or nonuse value)

A general observation, when determining benefits, is that the DWD contributed to many areas indirectly. For instance through the indirect assistance of the improved water quality for 'other' water users, such as agriculture, biodiversity, ecosystem services and/or recreational users. These benefits are hard to quantify since these systems are impacted by various sources (e.g. water, air, soil) and all of these sources are regulated in Europe through (often) more than one EU and/or national regulation.

[54] See section on cost of lead replacement.

[55] Note: In most EU countries effort is done to replace public pipes. The public pipes are between 5 and 25 percent of total lead pipes, meaning that between 75 and 95 percent is roughly in private use and estimates on actual replacement (DWD does not set this obligatory) are lacking for most MS. Total benefits and costs are for this reason strongly dependent on EU/MS actions to also replace private drinking water distribution pipes (for instance by providing subsidies).

4. Description and/or estimation of total –and DWD attributable costs

Below we describe which DWD provisions have lead to what costs. First by calculating (roughly) the total costs/income that drinking water companies have and the share that can be attributed to the DWD. Second we use the bottom-up approach and determine for selected (based on data availability and importance according to stakeholders and literature) provisions the total –and attributable costs for 2014 and costs over the course of the 98'DWD lifespan.

4.1 Top-down cost estimation

The DWD has led to a more harmonized quality in drinking water supply systems, they are nonetheless different across Europe. There are differences in the country size, and therefore in the length of the piping systems, strictness in legislation, availability of grants and taxes and also in the level of quality and services provided by water supplier. To estimate the total impact of the DWD on this, one first needs to assess the total cost of this sector. Instead of determining costs we used the proxy of total income to define total costs, noting that possible profits are not corrected for (most MS have public water suppliers). To remove discussion on income/costs we use in this section 'effect(s)' to describe outcomes. In the below section we show our methodology to derive the EU28 income for providing drinking water in 2014 and the share that can be attributed to the DWD. In addition we show what the total effect was from 1998 until 2014.

To determine the total effect for providing drinking water we looked at the expenditure ((cost recovery pricing))[56] of water supplied for 6 MS[57] and used the information on total population and differences in income per MS to extrapolate this to the EU. As such the total effect for water providers in 2014 is estimated to be roughly 46.5 billion euro. In total the effect for EU MS water providers between 1998-2014 sums up to 630 billion euro. Note that these numbers also include the 'normal' pipeline network (such as maintenance costs). Total yearly expenditure for Germany in the pipeline network, on average, is for instance around 1.5 billion euro[58].

The total income of drinking water suppliers can be broken down into cost components, as means to provide more insight in the operation of the sector and to where/what the DWD contributed. The following cost components are used to break the total sector up in smaller pieces:

- Taxes, levies, fees, concession fees, Water abstraction charges (7%)
- Metrology / quality control (3%)
- Building management (5%)
- IT technical support processes (15%)
- Resource Management / Water procurement / Extraction / Processing (18%)
- Treatment of drinking water (18%)
- Imputed Costs, such as the pipeline system and overall amortization (33%)
- Other costs, such as travelling to international events (1%)

For the above breakdown of total costs in the EU we used the shares for main components found in practice by Aquabench for Germany (SWB Regional GmbH, 2015[59]).

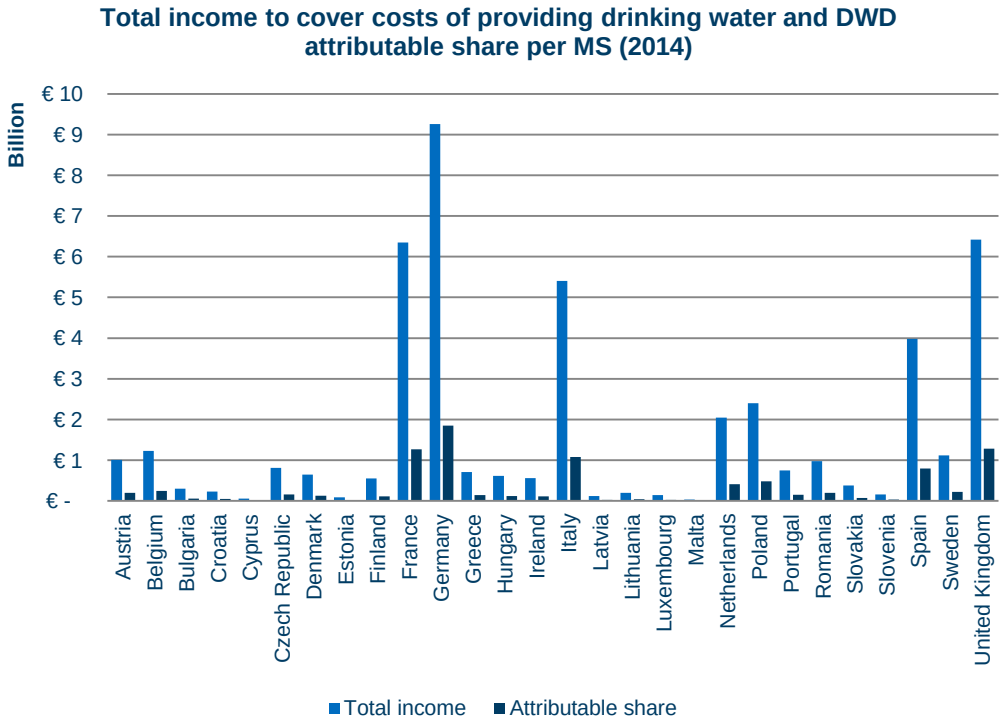
When looking at what share of this effect can be contributed to the DWD we note that calculations enter a grey area. Attributability is based on opinions of stakeholders to some extent and stakeholders have provided feedback on three 'practical' components for which one can provide relatively correct estimates of attributability.[60] For the components resource management, treatment of drinking water and other costs the provided estimates on attributability are averaged to

[56] VEWA, 2015. Comparison of European Water and Wastewater Prices. Water price expenditure information for 2007-2012.
[57] DE, UK (E/W), FR, NL, AT, PL.
[58] WVGW, 2015. Profile of the German Water Sector 2015.
[59] http://wasser.rlp.de/servlet/is/8646/ZV_Eifel_Ahr_WV.pdf?command=downloadContent&filename=ZV_Eifel_Ahr_WV.pdf
[60] Note: providing close to correct estimates of attributability of total amortization was deemed not practical.

obtain a country average attributability share.[61] For metrology the attributability estimations for monitoring per MS are used. We assumed a flat 5 percent attributability[62] for the components building management and IT technical support. The largest component, imputed costs (interest, amortisation, investments in the system and other), relates partially to the impact the DWD had on lead pipe replacement. We used information on German capital expenditure and the share of investments in the pipeline network to estimate the share of imputed costs related to lead replacement (49,3% in 2012[63]).[64] The information from MS experts on lead pipe attributability was further used to calculate the attributable share (Annex G). The component taxes and abstraction charges is assumed not to be impacted by the DWD and attributability is set to 0 percent.

Combining all attributable income/costs we find that for 2014 the total attributable effect is 8.3 billion euro and over the DWD lifespan this amounts up to 109 billion euro. When weighted over all EU MS the DWD roughly attributed to just under 16.5 percent of total costs. The picture below shows per MS the total and attributable effect for 2014, where attributable share is slightly higher (17.8 percent). Furthermore, Table 2-6 provides a breakdown of income/costs for the EU28, the EU28 average attributability percentage and the total income/costs that can be contributed to the implementation of the DWD in 2014 and over the course of its existence.

Figure 2-8 Total income drinking water providers and DWD attributable share per MS, 2014



Source: Ecorys (2015)

61 The shares are between 0 and 75 percent. Not weighing averages the average for EU28 is 42 percent.

62 This is mainly related to providing more and better information to consumer and other general not specified actions that lead to minor costs.

63 Combination of the difference between found 2012 imputed costs for Germany and 2012 reported CAPEX and the share of 2012 reported pipeline system CAPEX. The found percentage for Germany is used to correct and estimate all other MSs lead pipe replacement imputed cost. In the next step the attributability is taken into account, effectively setting countries without lead pipe replacement investments to zero for this specific component.

64 WVGW, 2015. Profile of the German Water Sector 2015.

Table 2-6 Breakdown of income/costs drinking water providers EU28, 2014. Values in billion euro.

Component	Total 2014	Attributable 2014	%	Total DWD	Attributable DWD	%
Taxes, water abstraction, etc (7%)	€ 3.3	€ 0	0%	€ 46.4	€ 0	0%
Metrology / quality control (3%)	€ 1.4	€ 0.5	34%	€ 19.9	€ 6.3	32%
Building management (5%)	€ 2.3	€ 0.1	5%	€ 33.2	€ 1.6	5%
IT technical support processes (15%)	€ 6.9	€ 0.3	5%	€ 99.5	€ 4.7	5%
Resource Management(18%)	€ 8.4	€ 2.5	30%	€ 119.4	€ 33.2	28%
Treatment of drinking water (18%)	€ 8.4	€ 2.5	30%	€ 119.4	€ 33.2	28%
Imputed Costs (33%)	€ 15.4	€ 2.1	14%	€ 218.9	€ 28.5	13%
Other costs (1%)	€ 0.5	€ 0.1	30%	€ 6.7	€ 1.8	28%
Total effect	**€ 46.5**	**€ 8.3**	**18%**	**€ 663.5**	**€ 109.3**	**16%**

Source: Ecorys (2015)

4.2 Bottom-up cost estimation

Administrative costs

i. Reporting on quality of water supply zones

The DWD prescribes that individual water suppliers who supply more than 1,000 m^3 per day on average or serves 5.000 or more persons should report on their quality to the EC[65]. This can increase in the future if small water suppliers, which are not obliged to report, will report on a voluntary basis. The costs related to reporting of water quality to the EC relate mainly to the number of person working days.

To calculate the costs that can be related to the reporting on quality of large water supply zones we combined information through desk research on the weighted average number of person working days per year and MS, the average of the costs per working day of both high –and normal skilled workers and used the EU HCIP inflation data to estimate costs for other than the base year. The table below gives an overview of used inputs in the base year (2010).

Table 2-7 Reporting on quality of WSZ cost estimation inputs

Theme	Value
Number of person working days large WSZ	230 person days
Costs of normal skilled workers	€230.- [66]
Costs of high skilled workers	€350.-

Source: COWI, 2011.

Based on these inputs the total costs for reporting for large WSZ in 2014 amounts to €2.5 million euro. Total costs for the entire duration of the '98 DWD sum up to slightly over €29 million euro[67]. Furthermore, 43%[68] of reporting costs on large WSZ is attributed to the implementation of the

[65] Article 13 of the DWD.

[66] Average hourly labour costs in EU28 are €24.6 in 2014. We assume on average a 7.5 hour billable working day and 25% overhead costs (http://ec.europa.eu/eurostat/statistics-explained/index.php/Hourly_labour_costs).

[67] In these calculations we have controlled for the increase/decrease in number of Member States, since back in '98 the EU consisted of 15 MS and currently it encompasses 28 MS.

[68] See Annex G.

DWD. The share attributable per Member States is not 100% since some MS have set stricter parametric values for drinking water and second we expect, based on interviews, that most Member States would have set up a similar reporting mechanism. Total costs attributable to the DWD for 2014 are then 1.1 million euro and approximately 12.4 million euro over the course of the entire 98'DWD.

ii. Impact of derogations

Article 9 of the Directive allows derogations from the drinking water quality standards under very strict conditions and for a limited time (3 years maximally per derogation). Furthermore a derogation should not pose a potential danger for human health and can only be established if the supply of drinking water in the area cannot be maintained otherwise by reasonable means. In the case that a Member State believes that a longer derogation period is required, it can grant a second derogation for an additional three years and it should communicate the reasoning behind this decision to the Commission. A Member State can request a third derogation from the Commission. The Commission will in this case carefully assess the request and will either grant or refuse the derogation for a final additional period of 3 years[69].

The Commission granted three-year derogations to the Czech Republic, France, Italy, Hungary and Germany, referring mainly to the parameters of nitrate and nitrite, fluoride, boron, arsenic and nickel. The request for a derogation by Estonia has been refused[70]. The costs associated with this is estimated to be 167 (5 third time derogations and 33 days per revision[71]) days for an average fee of €750.-. Therefore total costs to the EC for third time derogations in the period 1998-2014 sum up to roughly 100.000 euro.[72]

iii. Providing information to consumers

One of the goals of the drinking water directive is to improve the information on water quality to the general public. In Europe MS and/or individual water supplier have applied three main techniques to better inform consumers on their water quality, namely:

- by conducting a survey in their service area and improve their service if needed[73];
- by providing (more and more) live information on the website of the water supplier (the use of this techniques has increased over the years due to the fact that an increased share of consumers is actively "online"); and
- some countries inform their consumers by notifying them of the water quality by mail at the same time when they send the water bill.

The costs associated of this action vary strongly per water supplier and per MS. Based on an expert opinion developed through interviews with various stakeholders in various MS we assume that on average one person has a 1/3 fte job within a water supplier, which service an area that consumes 500.000 m^3 per day and through some outsourcing activities (such as contributing to a regional/national satisfaction survey) another 1/3 fte job. This is further combined with an assumed average European labour costs of €290[74].- (assuming 214 working days in a year[75]) times total DWD regulated drinking water supplied in Europe. Estimated total costs for providing information to consumers is then 2.1 million euro in 2014. Tracking the costs of providing information to consumers back to 1998 is difficult, since actions undertaken are not equally over the various years. We estimate that total expenditure on this action over the course of the entire '98DWD is

[69] http://ec.europa.eu/environment/water/water-drink/pdf/report2014/1_EN_ACT_part1_v3.pdf.
[70] https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp.
[71] COWI, 2011. 33 days per derogation is based on section 4.2, p40, input from DG ENV.
[72] This value excludes costs made by national regulators and water providers.
[73] For instance: the Baro 2015 Anglais Consosatisfaction, related to drinking water satisfaction in France.
[74] See table 2.8 (we assume an even split between high and normal skilled labour for this task).
[75] In 2012 the EU average agreed yearly working hours was 1712 hours, or 214 days (assuming an 8 hour work day).

within the range of 10 -to 15 million euro. Furthermore we attribute on average 60% of total costs of providing information to consumers to the DWD leading to 1.3 million euro costs in 2014 and between 6 -and 9 million euro for the entire DWD duration.

Cost of monitoring parameters

Monitoring of drinking water parameters is, according to the handbook on the Implementation of EC Environment Legislation, the main cost component associated with the implementation of the DWD. Article 13.2 of the DWD states the obligation of reporting on (large) WSZ.[76] This implicitly states that monitoring actions should be undertaken by water suppliers. Water suppliers need to monitor for parameters in accordance with Annex I A, B and C and subject to the notes in part C. Monitoring approaches differ between MS, even between water suppliers in the same MS, which results in different levels and availability of data and costs related to this obligation.[77]

We start the cost estimation with the information from a study by Mancini (2005), which provides information on the yearly cost of monitoring for various amounts of daily water supply. The costs for monitoring a WSZ smaller than 1,000 m^3 is 2.500 euro per year and for monitoring a WSZ between 10,000 to 1 million m^3 the costs are roughly 300.000 euro per year, or respectively €2.5 and €0.85 per m^3.[78] In addition to these values, we have estimated the total m^3 water consumption per MS per year, which is done by combining 2004 MS population data[79] and average l/day water consumption.[80] In the next step we split total drinking water consumption between large and small WSZ. Based on various reports the EU average share of small WSZ is 13%.[81] We combined the total cost per m^3 (corrected for possible price differences) with the total m^3 used on a daily basis for each MS for both large and small WSZ[82] to obtain a rough estimate of the total monitoring costs for both large and small WSZ in 2004.

The 2004 outcomes have been extrapolated using historic inflation data[83]. The results per MS have been cross-checked with available national documentation on monitoring costs and adjusted if countries reported annual costs on reporting. For instance Ireland, who published in 2007 that their presumed annual monitoring costs amounted to €2.5 million in 2007. The estimation method as described above finds for Ireland monitoring costs of €2.7 million in 2007. The applied method, averaging over the EU, leads as such to a good approximation (within 10% range).

The total reporting costs for large WSZ in 2014 is roughly €41.5 million and costs for small WSZ are in 2014 €13.8 million. The costs over the duration of 17 years mount up to €674 million. It is however not realistic to attribute all these costs to the implementation of the DWD. For one, because MS already had a monitoring program in place (irrespective of the previous DWD) and/or second, because MS are expected (according to stakeholders) to also have set up monitoring

[76] Annex II, Table B1, has been adapted to include obligation of monitoring small WSZ as of 2011, for this reason we expand the cost estimation from only determining costs for monitoring of large WSZ.

[77] Many water providers monitor more often then needed for the DWD to ensure a proper level of information to conduct good business. This information is not always provided to the EC, as it is not obligatory to provide all information.

[78] Costs for assessment of the monitoring samples is neglectable compared to the 'fieldwork' part (based on a secondary cost source, stakeholder comment and expert opinion within team). The associated costs are however included in the top-down assessment and thus not excluded from the total cost assessment.

[79] The population is corrected for the fact that not all people in a MS are connected to a drinking water supplier (shares are based on Eurostat 2002-2011).

[80] http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Per_capita_water_use_from_public_water_systems_-_latest_year_available_(m%C2%B3_per_inhabitant).png#file (extended by various other sources for missing countries).

[81] Synthesis Report on the Quality of Drinking Water in the EU examining the Member States' reports for the period 2008-2010 under Directive 98/83/EC, for instance.

[82] If the share of population connected to a drinking water supplier is higher than 87% than, on average, there is a part of the population that is supplied by a drinking water supplier. Based on DG ENV, 2009, we know that 84% of small WSZ operated by a water supplier is monitored.

[83] We use the same historic inflation data to extrapolate to both the future and the past around the determined year to determine total (and 2014) costs for all estimations in this chapter.

regulation in a situation without the DWD. The total attributable costs in 2014 are therefore €15.5 million for large WSZ and €4.6 million for small WSZ. In the lifespan of the DWD the monitoring costs for all MS sum up to roughly €233 million euro.[84]

Replacement of (lead) pipes in households and the distribution network

In the past decades large investments have been made to improve the drinking water quality due to the replacement of lead and cement pipes. The replacement of lead pipes has been pushed forward or initiated by the DWD, since the standard for lead in the 1998 EU Drinking Water Directive, changed from 50µg/litre in the previous Directive to 25µg/litre in 1998, and was reduced further to 10µg/litre in December 2013.

To estimate the costs associated with the implementation of the 98'DWD on the lead replacement programs we took as starting point the 95 cost estimation by the EC[85], which predicted costs of reaching the 10µg/litre value for lead in drinking water would costs 70 billion euro over the course of 20 years of implementation. In addition, we looked at the 1998 study by Hayward[86], who estimated that the costs of the lead pipe replacement in the EU would be $100 billion dollar, or 89.7 billion euro[87], over the next 15 years. It is important to take into account that back in 1995/98 the EU consisted of 15 MS and that total costs for (lead) pipe replacement will therefore be higher (in addition to inflation) than either of the estimates in the above studies.

To estimate the total costs of the lead replacement programs we made the following main, to both streamline expected investments per year[88] and to be able to compare outcomes with MS ex-ante studies:

- We assumed that the lead replacement program took 17 years to complete after 1998 ór in the year when a new MS joined the EU (hence only 1 year for Croatia);
- Not all costs off lead replacement can be seen as additional costs. The normal rate of replacement and reduction in costs after replacement due to leakage reduces the additional costs of replacement of lead pipes by 15% (10-20% according to the 95'EC memorandum proposal);
- The 70 to 90 billion euro of lead replacement costs are build up out of two components, namely the distribution pipes and household installations. The obligatory replacement of lead focusses on distribution pipes, whereas the household installations are optional and can not be related directly as an impact of the implementation of the DWD.[89] The share of costs related to the replacement of distribution pipes ranges between 5% and 25%, we will therefore provide the range as outcome of the calculation;[90]

84 See Annex G for the share of costs attributable to the DWD.

85 Memorandum Proposal, DWD, 1995. COM(94)-612final.

86 https://books.google.nl/books?id=FdHZMwgon3wC&pg=PA2&lpg=PA2&dq=estimated+cost+of+replacement+lead+drinking+water+pipes+EU&source=bl&ots=MfFV8mC24c&sig=co9bVBdXGRbN6utUGlsubHvr6FE&hl=nl&sa=X&ved=0CEAQ6AEwBGoVChMIvM3QiJqSyAIVhuwUCh17HgHG#v=onepage&q=estimated%20cost%20of%20replacement%20lead%20drinking%20water%20pipes%20EU&f=false.

87 http://fxtop.com/en/currency-converter-past.php?A=1&C1=USD&C2=EUR&DD=&MM=&YYYY=1998&B=1&P=&I=1&btnOK=Go%21.

88 According to stakeholder interviews with utilities they invest a more or less equal value in infrastructure every year (which has been higher for the entire duration of the lead replacement period).

89 The share of such an indirect impact would be very imprecise, especially since it is unsure what share of EU housing actually replaced lead pipes in the course of the last 17 years.

90 For France the it was determined that total public lead distribution pipe replacement costs amounted to 4 billion euro and private to an additional €10 billion (IETRE). Our approach, which generalizes more due to a EU28 coverage, provides for France a range for public investments between €0,5 and €2,8 billion euro. In total we estimate €11,1 billion for France, which is around 25% lower than reported by IETRE, which implies that for France more than 25 percent of the distribution network is public compared to the EU28 average.

- The costs of lead replacement are divided over the EU15 based on their share of total water consumption. Costs of new MS are added by taking their total water consumption and 75% of the average lead replacement price per m3 for the EU15 MS;[91]
- In the calculated costs per MS we have not taken specific geographic characteristics or country reports into account. The outcome per MS can therefore deviate from country studies;
- The costs related to (lead) replacements of distribution pipes are not completely attributable to the implementation of the DWD. Based on expert judgment, available country reports and feedback from MS stakeholders we estimated the attributability per MS, see Annex G.

Based on the above assumptions and approach the total cost for (lead) pipe replacement in the EU28 in 2014 is estimated to be 5.1 billion euro, of which between €0.25 and €1.3 billion are directly related to the replacement of distribution pipes.[92] The costs in the duration of the DWD amount to just over 81.5 billion euro, of this between 4.1 and 20.5 billion euro is publicly owned. The attributable costs are however lower. The costs attributable to the DWD of the replacement of lead distribution pipes ranges between 75% and 3%[93]. When adding up the various MS this amounts in total to 1 billion euro at the low -and 5 billion euro in the high public share replacement scenario.[94]

Other costs associated with the implementation of the DWD

Other costs, hard to quantify in aggregate terms, can be found as a result of the non-harmonised situation of Articles across the different MS. The industry sector reports, for instance, a lot of costs concerning double and different certification schemes and requirements. (See cases A and B in efficiency). According to various stakeholders harmonization of certification schemes and requirements could lead to mayor cost savings.[95]

Conclusion EQ6:

The approach to Evaluation Question 6 consists out of two sections. The first section identifies, describes and calculated when possible the positive health and other impacts that can be attributed fully/partially to the implementation of the DWD. We found that the new lead standard and as such the additional push to MS to replace lead pipes has/will le(a)d to significant welfare benefits across Europe, mainly related to having less loss of IQ for minors. Other notable benefits that can to some extent be attributed to the DWD are the aesthetic improvements with respect to drinking water, the existence of a European baseline regulatory framework and the general improvement of the quality of (drinking)water both for consumers and other users.

The second section consists of a split up in a top down and (partly) bottom up cost assessment, where the first section focusses on providing a rough first figure on the impact that the DWD had in Europe since its implementation whereas the second section sheds light on specific important (according to stakeholders) components on which the DWD had a strong direct impact. Based on the top down approach we found that the total value of the EU28 drinking water sector in 2014

91 The 75% is a rough estimation to correct for the fact that the 15 EU MS in 1998 are on average wealthier compared to on average the MS who joined the EU after 1998.

92 Note: this value is lower than found when looking at the top-down approach. The reason for this is that there is an error margin in both approaches, top-down related to the share of imputed costs related to lead replacement and bottom-up related to two relatively old studies who provide a base estimation for the total EU28 impact and the share of the high-/low public versus private ownership scenario. For this reason the found discrepancy can be expected and shows that there is, as expected, a relatively large error margin when estimating impact taking 28 countries into account.

93 We exclude MS who reported 0 percent, as they did not have or replace any lead pipes and as such did not have any costs from this.

94 We are aware that some MS have taken more action than the 25% but stick to the range provided in literature as they provide figure for the EU as a whole and when addressing additional actions of 1 country, one should adjust in a similar method all EU15 countries, and possibly extend to 28.

95 This statement could hold if you look purely at cost savings, since costs related to lead replacement and monitoring have very significant direct health benefits!

amounts to 46.5 billion euro of which 18 percent can roughly be attributed to the implementation of the DWD, this however depends strongly on the method of attributing impacts to the DWD (based for a large extent on stakeholders intrinsic knowledge of the operation of a drinking water supply system). Over the course of the DWD the total estimated impact is 109 billion euro.

2.2.2 *Have there been technical or other developments since the elaboration of the Directive that could contribute to achieving the objective more efficiently (EQ7)?*

Cost of monitoring parameters compared to alternative approaches

The requirements in the Drinking Water Directive for monitoring (Annex II) and analysis (Annex III) require updating in order to reflect technical and scientific development. This section will provide a brief overview of some of the identified technical or other developments and describe in what way they contributed to achieving the objectives of the DWD more efficiently.

During the course of the evaluation we have identified some of the main technical and/or other developments, which have had an impact on reaching the objectives of the DWD namely:

- Water safety plans;
- Progress in analysis;
- Progress in ICT;
  - Consumer (up-to-date) information;
  - Smart monitoring of water supply zones;
  - (Smart) Water metering.

Below we will shortly describe what these developments mean for the DWD. Next to that we will describe both the costs –and benefits associated with the development.

Water safety plans

The objectives of a water safety plan (WSP) are to ensure safe drinking-water through good water supply practice, that is:

- to prevent contamination of source waters;
- to treat the water to reduce or remove contamination that could be present to the extent necessary to meet the water quality targets; and
- to prevent re-contamination during storage, distribution and handling of drinking-water[96].

A water safety plan describes the entire water supply system through:

- a System Assessment: including the identification of hazards, determination of existing control measures, assessment and prioritisation of risk and identification of additional or improved control measures;
- by Controlling Hazards: through implementation and maintenance of control measures, establishment of operational monitoring and defining of corrective actions; and
- through Verification and Auditing.

Based on stakeholder interviews with water utility providers a WSP can be applied in addition to regular monitoring. A WSP is a relatively high start investment leading to lower costs on the long run. The stakeholders, generally, agree that a WSP definitely reduces the action time needed if a distortion in the water quality is found (due to a reduction in localizing the source of the disturbance and faster decision making). They however do not think that total costs of monitoring (when placing WSP under the cost category of monitoring) go down. This is for one because they still need to monitor on their entire WSZ and second because of the upfront investment to create a WSP.

[96] WHO, 2005. Definition of a Water Safety Plan.

Progress in analytics

The DWD requires that the quality of the drinking water is high and safe for consumption. Water providers analyse their water using analytic methods to produce reliable and comparable results. For instance chemical parameters need to be analysed with methods that answer to the given performance characteristics in the DWD for trueness, precision, and LoD (DWD, Annex III). For microbiological parameters the method to be used is given in the DWD Annex III, but alternative methods can be used subject to equivalence testing. The applied methods to assess the quality of drinking water have been naturally improving over the years since 1998, creating opportunities for more precise performance criteria, such as trueness and LoD.[97] In terms of microbiological analytical methods, the progress has inter alia resulted in methods beyond culturing. The growth of colonies is routinely used in all microbiology laboratories and is the simplest way to detect and qualify viable microbes. However, the main limitations of these enumeration methods are the lack of discrimination between the targeted microbes and the endogenous microbiota, the time-to-result, false positive counts and the impossibility to recover viable but non-cultivable cells, which are seen as dead.

Recent developments in molecular methods enable faster and more sensitive analyses than classical microbiology procedures.[98] These molecular tools allow a detailed characterisation of cell physiological states and material fitness and thus, offer new perspectives to improve water quality processes. The WHO reaches a similar conclusion in the report on microbial safety of drinking water. Several methods are indicated to give results faster, more sensitive and more specific than current methods based on culturing. The foremost hurdles to future implementation of these improved methods are the lack of standardisation and automation.[99] This means that standardisation of methods and of laboratory procedures is of great importance, if criteria for the microbial quality of water are to be uniform in different laboratories and across borders. Keeping in mind that international standard methods should also be evaluated under local circumstances before being adopted.

Since 1998, five additional methods have been approved by the International Organization for Standardization (ISO), allowing for more opportunities in water quality monitoring.[100]

Progress in ICT

Consumer information

The opportunities and possibilities to provide consumers with information on their drinking water have significantly improved with the progress in ICT in the years after the drafting of the DWD. Reports on the state of the European drinking water quality are already being publicised on the internet, easily accessible for consumers. This could potentially also be possible on a smaller scale, where drinking water companies could signal consumers via apps on mobile devices when drinking water shows deviations from normal levels, both in case of positive and negative deviations. This kind of information is currently scarcely available via websites of drinking water companies. Next to this, there are also opportunities in apps that are developed by individuals, for instance an app that aims to decrease bottled water use by showing consumers where all the public tap water points are.[101]

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97 For example the method for LoD estimation in 1998 was lower than set parameters of AA, VC and ECH.

98 Sohier, D. et al. (2014) Evolution of microbiological analytical methods for dairy industry needs. *Frontiers in Microbiology.*

99 WHO (2003) Chapter 8: Analytical Methods for Microbiological Water Quality Testing. *In: Microbial safety of drinking water: improving approaches and methods.*

100 WHO (2011) Guidelines for Drinking-water Quality. Fourth Edition.

101 The Guardian (2011) Water, Water Everywhere – consumer app of the week. Retrieved from: http://www.theguardian.com/money/appsblog/2011/jun/17/water-water-everywhere-consumer-app-of-week

Smart monitoring of water supply zones

A third technical innovation is the use of sensor devices to conduct remote monitoring of water supply zones. In recent years various MS have started with the implementation of smart meters, examples are the UK, Portugal and Greece (Athens). These countries are rolling out smart-water systems to provide near real-time water quality information accessible to the provider and to the consumers. These smart monitoring sensors require an upfront investment, but lead on the long run to a reduction in the need for monitoring conducted by a person, leading to a cost reduction and an increase in real-time water quality information.

(Smart) Water metering

Metering of water supplied by utilities to residential, commercial and industrial users is common in most developed countries and perhaps not a technological development. There is however a strong development in the UK, where only about 38% of users are metered[102], since they are planning to increase the share of households metered to 90% in 2030. The UK is also in strong contract compared to other developed countries. According to the OECD, OECD countries meter currently more than 90% of single-family houses. Some EU MS are even expanding their metering into apartments (e.g., France and Germany)[103].

In general the costs and benefits associated with water metering are the following:
Water metering is beneficial since it provides an incentive for water conservation, it helps to detect water leaks in the distribution network, hereby reducing the amount of non-revenue water, it can help in the development of more sophisticated tariffs and, more generally, it provides more information to customers and suppliers on water usage and it is a precondition for quantity-targeting of water subsidies to the poor. The estimated benefits for the UK sum up to 16% water savings of average household demand. The cost of water metering mainly relate to installing the of meter (financing of the installation costs), costs of replacing the meter when it wears out, costs related to meter reading, and the costs of additional customer billing and services related to water metering. According to the 2009 Walker Report the costs are £30 per household per year[104].

The above benefits can be increased in the future, since metering systems are becoming increasingly more 'smart'[105]. Therefore a further increase in water savings can be expected across Europe, which is partly driven by the DWD through its impact on increased awareness of the importance of quality drinking water and increased consumer information.

Conclusion EQ7:

There have been various technical and other developments in the last 17 years that contributed in achieving goals of the DWD. In the above section we have highlighted some of the most influential developments that contributed to achieving the goals of the DWD in very different ways, namely a different approach to monitoring leading to faster decision making if there is need for remedial actions, new ISO approved methods to improve the analysis of microbial quality of water, consumer communication: among others a technical innovation making users more aware of their water consumption and leading to a culture change of 16% water savings on average for the UK, and also a new method of monitoring related to new sensors.

[102] Ofwat, Exploring the costs and benefits of faster, more systematic water metering in England and Wales, October 2011.
[103] OECD, 1999. The Price of Water: Trends in OECD countries.
[104] Walker Report, 2009.
[105] Smart: using digital technologies or information and communication technologies (ICT) to enhance quality and performance of services, to reduce costs and resource consumption, and to engage more actively with end users.

2.2.3 *To what extent does the Directive allow for efficient policy monitoring?(EQ8)*

Reporting monitoring is embedded in the provisions of the DWD. Reporting to the European Commission has been set for the parameters, the monitoring frequency and the method of analysis. In the first period also the analytical methods used had to be reported as well as national values set on transposition of the DWD.

Mandatory reporting on large WSZs

Mandatory reporting on three annual basis on monitoring effort and results applies only to large WSZ.

The data and the trends in the data can be used by the EC for assessment of the level of compliance and any improvement or deterioration if the case. The changes in levels of compliance or major changes (both in the positive and negative sense do not vary very rapidly over de years. The three annual reporting therefor provides the EC with information on the status of the quality of drinking water in Europe and in the MS. If needed the EC can use the information submitted by the MS to ask for more detailed information on current situation and progress. This has been done in the past in case the EC was not satisfied with the quality reported. (note AH I am not sure if the mention of the MS involved is correct. TB has to be asked).

Small water supply zones

For small WSZs there are no reporting provisions in the DWD, but the EC has the right to ask for written statistical information on small WSZ (within the scope of the DWD) on the basis of the Treaty. This has been done a few times in the past and provided the EC with useful information on both the (lack of) monitoring of the small supply zones and the quality. This resulted in political attention for the situation in small WSZs, a number of studies into the small WSZs. In the revision of the DWD policy might well change for the small WSZs.

Reporting on derogations

MS have the right to grant derogations for a limited period under condition that there is no threat to human health and there is no alternative way to supply water. For any derogation granted (both art 9.1 and 9.2) except cases under 9.4 information has to send to the EC with the aim to inform the EC. This also is a form of information supply/reporting to the EC, that can be used for policy making.

Conclusion EQ8

The three annual reporting provides the EC with information on the status of the quality of drinking water in Europe and in the MS. These reports are very valuable when monitoring the efficiency of a Directive, because it shows (although not continuously) if, to what extend and in what timeframe water quality improves in each MS. There are however some limitations to the information of these reports, related to inconsistency in methods of reporting (internally in MS) and the fact that information is only provided once every three years. Even though some data might be doubtful (lacking data and the push to show 'good' water quality data) it is clear that the obligation of reporting to the Commission is of great value when monitoring and possibly improving existing policy.

2.3 Coherence

2.3.1 *To what extent are the DWD provision Internally coherent? (EQ9)*

Internal coherence checks to what extent working towards the objective of one provision of the DWD stands in the way of successfully achieving the objective of other provisions. There are several dilemma's regarding the internal coherence of the DWD, among other provisions regarding

radioactivity and Article 10. Furthermore this section evaluates the values set for copper, nickel and lead.

Provisions for radioactivity

The provisions for radioactivity are part of the EURATOM Treaty and have no (longer a) place in the DWD (art 31 expert group EURATOM). Also Annex I note 10 mentions a future adoption of monitoring methods and the most relevant locations for monitoring. These monitoring provision were to be detailed at the latest within 18 months following the date of entry into force. These provisions are no longer relevant and have never been elaborated within the scope of the Directive. The internal coherence with these provisions is lacking as the parameters for radio-activity are mentioned in the DWD together with the parametric values that have to be met, but the legal background for the implementation of the RA provisions is with the EURATOM art 31 expert group.

Parametric values for copper, nickel and lead

The DWD has set values for a number of parameters for copper, nickel and lead and a note in Annex I Part B that the values in the DWD apply to a sample of water intended for human consumption obtained by an adequate sampling method at the tap and taken so as to be representative of a weekly average value ingested by consumers. The sampling method was to be added following the outcome of a study currently being carried out. This study was completed and discussed three possible sampling regimes, 30 minutes stagnation samples (30MS), random daytime samples (RTD) and fully flushed samples (FF). No agreement was reached between the Member States on a harmonised approach to the sampling method. Reasons for this were: differences in consumption patterns in various MS, water scarcity issues which did not promote flushing of drinking water and the legal barriers ion some MS to enter domestic premises and let the water stagnate in the pipes for 30 minutes. In the end no solution was found at the Community level for a representative sample and it was left to the MS. This makes it difficult to compare results for copper, lead and nickel values measured in the various MS. Entry into public and even more into private buildings to take samples at the tap is seen as a major hurdle by some MS as there are no legal tools to legal instruments in most MS. The result is that the selection of sampling points is not purely random and that domestic premises are more often than not excluded. This aspect is not internally coherent for two reasons; first of all the DWD is supposed to regulate drinking water quality at the tap while not all MS actually checks at the consumer's tap in domestic premises and secondly the DWD sets a value for a representative sample and it is not known how samples are taken.

Implementation of Article 10

It is a well-known and established fact that materials for installations used in the preparation or distribution of water intended for human consumption could lead to deterioration of the water quality and consequently cause a risk to human health. The same holds for chemicals used in water treatment. A number of parameters in Annex I of the DWD are predominantly related to the treatment and distribution of drinking water. These parameters are addressed below:

- Disinfection-by-Products (DBP) should - in accordance with article 7.1 - be kept as low as possible in the drinking water produced without compromising disinfection. The DBP parameter mentioned in the DWD is total *trihalomethanes* being the sum of chloroform, bromoform, *dibromochloromethane* and *bromodichloromethane*. For this sum parameter interim values have been set for five years and ten years after the entry into force of the directive (respective values 150 µg/l and 100 µg/l). Another parameter related to disinfection is bromate also with interim values for compliance of 25 µg/l (after 5 years) and 10 µg/l (after 10 years) of entry into force.
- Three parameters in Annex I are regulated through product specification and the parametric value refers to the residual monomer concentration in the water as calculated according to specifications of the maximum release from the corresponding polymer in contact with water.

The parameters are used as substances in the treatment of drinking water (treatment chemicals) and/or in materials used for the distribution of drinking water: acrylamide, vinylchloride and epichlorohydrin. The parametric values are subject to product specification as at the time of the adoption of the DWD the values were below the limit of detection. Due to the advances in analytical methods this has changed. There is a link with the provisions of Art 10 of the DWD.

- Fluoride is another Annex I parameter that can either be from natural sources (present in some groundwaters) but is also added in water treatment. Some MS add fluoride to the drinking water to prevent caries.
- Copper, lead and nickel are parameters in Annex I that mostly relate to materials used in the distribution of drinking water even though nickel can originate from groundwater and copper and lead can also be present in contaminated water sources. The solubility of the these parameter very much depends on the quality of the products used in distribution and general characteristics of the water. For new materials and installations there is an overlap with the provisions of art. 10. With respect to the general matrix of the water the final concentrations in drinking water at the tap depend on many factors and these factors are different for the types of material used. For instance the use of copper pipes is not recommended in rather soft waters. Plumbo solvency and copper solvency are complex areas, where many risk factors are to be considered such as pH, low concentration of bicarbonate, microbiological growth in systems and stagnation time.

When implementing the Directive, the MS had to decide on the way they transposed this obligation put on them by this provision into national legislation. In 1999 some observations were made by the MS on the implementation of Article 10:

- The scope of Article 10 of the DWD (all materials and substances) is wider than the construction products as defined in the CPD.
- Article 10 of the DWD requires from MS to operate a formalised system for assessment and approval of materials and chemicals in contact with water intended for human consumption (article 3 and 4 of the CPD (Council Directive 89/106/EEC).
- The DWD gives no guidance on the outline and the operation of the approval of materials and substances and this is left to the MS.
- Technical specifications based on the CPD should be in line with the implementation of obligations/requirements of the DWD at national level.
- Given the number of substances and the complexity of test and field conditions, it is a laborious and long term task to harmonise all relevant technical specifications at EU level.
- A main issues with the implementation of Art 10 is the fact that MS operate different approval schemes for materials and chemicals in contact with drinking water. Within the framework if the CPD, working groups of CEN have been attempting to develop harmonised test methods since 1990. Progress is hampered by the fact that harmonising the test methods in this field is not possible without harmonising the acceptance criteria, which is however not in the competence of CEN.

As stated before, the major problem with Article 10 is that the article is difficult to understand and therefor difficult to implement for MS. Unfortunately, this study has not been able to establish the number of incompliances that were the result of MS not being able to deal with this article because of the lack of guidance by the Commission. Neither has it been possible to establish the number of remedial actions which could have been avoided if the Directive had been clear about this issue. The internal coherence is lacking as there is no evidence that MS have actually complied with the provisions mentioned in Art. 10. It is not clear if individual MS do actually have a system in place to approve materials and chemicals before they are used in drinking water supply. Also it is not clear if and how MS meet the requirements of the product specified parameters AA, ECH and VC.

Relevant metabolites, degradation and reaction products of pesticides

Relevant metabolites, degradation and reaction products of pesticides are mentioned in the DWD but no definition of 'relevant' has been available for a long time, not in drinking water and not in plant protection products legislation. It was therefore unclear what 'relevant' meant in the context of the DWD. New regulation on PPPs has now provided a definition of 'relevant'.

Conclusion (EQ9)

There are few issues regarding the internal coherence of the DWD. There is a small issue of incoherence in the DWD regarding degradation – and reaction products of pesticides. Furthermore it is unclear whether Article 10 provisions for substances and materials are in accordance with parametric values of Annex I.

It is concluded that all other provisions of the DWD are internally coherent and as such are not evaluated in detail here.

2.3.2 *To what extent are the DWD provision externally coherent and which effects had the DWD on areas targeted by other EU legislation? (EQ10 and EQ11)*

For the DWD, water quality as expressed by the concentration of the selected microbiological, chemical (and indicator) parameters is the key controlling factor. To some extent water quality, including both ground- and surface water is also regulated directly or indirectly by various other EU Directives and by national policies. National policies will not be considered here.

In general, quality of water bodies is regulated on the basis of (i) protection principles (to maintain or achieve a desired quality related mostly to ecological targets, often not related to specific emissions), (ii) emission control principles (to avoid unwanted excessive levels in water, mostly related to emissions from industry, agriculture and households) and (iii) accident related policies. The main types of legislation that directly or indirectly regulate water quality via EU-Directives outside the DWD are:

1. Legislation *targeting water quality* as such, e.g. by setting standards in the water bodies itself, which includes both surface water systems as well as groundwater bodies or even bottled water;
2. General legislation concerning the *use of dangerous substances*, in construction or otherwise, that are being used in technical provisions related to the abstraction, preparation and distribution of drinking water.
3. Legislation *targeting emissions to the water system*, e.g. existing legislation that limits emission of compounds from industry directly to the water bodies (mostly surface water);
4. Legislation *targeting emission to adjacent terrestrial systems* that are linked to water bodies via leaching and runoff. This includes among others all legislation related to emission to soil or air in agriculture (use of fertilizers, pesticides);
5. Legislation that *indirectly regulates the emission to soil or water* via e.g. control of food quality;

When assessing the impact of the five main categories listed here, the direct control or influence on the actual quality of drinking water decreases from 1 to 5 where legislation in group 1 and 2 have a comparable impact on the regulation of the water quality as the DWD itself, through the setting of standards in the water body itself. Legislation in group 3 and 4 also has a direct (emission to water) or indirect (emission to soil) effect on the ultimate quality of water, but the final concentrations as affected by this type of legislation is as such not addressed.

In order to compare the DWD with other Directives targeting, directly or indirectly, several options are available depending on how adjacent policies regulate the ultimate water quality:

- A direct comparison of standards set by the DWD and EU Directives from group 1. This obviously is the most consistent since it allows for the assessment to what extent the DWD poses more stringent or more lenient targets to the water quality;
- An indirect comparison to compare water quality standards set by the DWD and emission related standards. To assess the relation between quality standards set by the DWD and emission control oriented Directives from group 2 and 3 additional assessments need to be made to relate the allowed emission concentrations to final concentrations in the water bodies to be used for drinking water purposes. This involves mixing models in case of emission to (surface) water systems but can include combined emission and transport models in case of emission to soils;
- An indirect comparison of allowed levels of substances in food and other consumable products via exposure modelling (group 4). The level of specific substances in the DWD is related partially also to a maximum daily intake (e.g. Cd).

In this context coherence can be defined in two ways which can be complementary:

- Based on what substances are regulated. This requires an analysis of substances regulated by adjacent policies compared to that of the DWD. This then illustrates to what extent the DWD regulates substances not covered by other Directives (if any), and subsequently;
- Based on a comparison of the absolute value of the standards set for various water bodies. Coherence (of adjacent policies relative to the DWD) would then imply that standards set by adjacent policies are at least equal to or more strict that those set by the DWD.

In this case basically two situations can occur:

- Quality standards in water set in policies are similar or use a more strict standard setting (group 1) or emission regulations to air, water and soil (group 2, 3 and 5) and product standards (group 4) are such that resulting concentrations in water are expected to be equal or below the criteria as set by the DWD. In this case, the EU directives are coherent. Standards set by the DWD are theoretically not limiting or do not require additional actions in so far it concerns the water quality prior to treatment and transport;
- The criteria set by the DWD are more strict than those set by adjacent policies, either directly (group1) or indirectly (group 2 and 3). In this case, the DWD is the ultimate directive in control of drinking water quality and for these substances additional measures may be required to achieve the desired quality before water can be supplied to consumers.

What needs to be kept in mind is that the adjacent policies addressed here primarily address the quality of the water prior to treatment, i.e. the water quality as it would be observed in the different water bodies (surface, groundwater) and do not target the impact of the treatment. For substances particularly related to the presence in drinking water during or after treatment (e.g. during transport from the treatment facility to the tap, such as lead), the DWD will be the main driving instrument.

Below we list the most relevant EU Directives that either directly or indirectly control the quality of water bodies used for drinking water purposes (Table 2-8). In order to evaluate the coherence we used the following criteria to judge whether a directive or regulation is coherent:

- Coherent: This is the case when the related directives include standards in either surface water or groundwater or bottled water, which are equal or lower than the DWD;
- Not coherent: This is the case when the adherent directive includes standards in either surface water or groundwater or bottled water, which are higher than the DWD;

- Unknown: There is an upper limit to the emission of elements to water or to elements in food, but it is not clear whether the resulting concentrations in ground and surface water equals the concentration below DWD standards.

These criteria where defined during in the stakeholder meeting for the DWD revision, held in Brussels on May 26, 2015.

Table 2-8 Overview of relevant EU Directives or Regulation and modes of action (group 1 – 5)

Directive / Regulation	Directive / Regulation #	What is regulated relevant to DWD	Likelihood of exceeding DWD regulations in case of load	Coherence
Nitrates Directive	1991/676/EEC	Standard for nitrate similar to that of DWD		Coherent
Water Framework Directive	2000/60/EC 2008/105/EC	Standards in surface water largely lower than those regulated by DWD		Coherent
Groundwater Directive	2006/118/EC	Standards in surface water largely lower than those regulated by DWD		Coherent
Pesticides directive; Directive[106]	(EC) No 1107/2009 2009/128/EC	Standards in surface water and groundwater similar to that of DWD		Coherent
Urban Waste Water Directive	91/271/EEC	Standards in place for limited number of parameters (N, P)	Note: 15 mg/L for NO3 exceeds 50 mg/L for NO_3 but due to mixing with surface water final concentration will meet DWD standard	Coherent
Radioactive substances in water[107]	2013/51/Euratom	Standards for radioactive substances in water intended for human consumption. Are equal to those regulated (i.e., tritium and total indicative dose) by the DWD.		Coherent
Food contact material legislation[108]	EC) No 178/2002 Preambule recital 6	All water (including water put into bottles or containers) after the point of compliance as defined in Article 6 of Directive 98/83/EC and without prejudice to the requirements of Directives 80/778/EEC and 98/83/EC.		Coherent[109]
Sludge Directive	86/278/EEC	Regulation of *load* to soil, depending on conditions this leads to lower or higher	Not likely	Unknown

[106] See also EQ4/EQ5 for a more thorough description of pesticides directive
[107] See also EQ9 on Euratom
[108] See also Extension to EQ14
[109] Explanation of assessment: Water is ingested directly or indirectly like other foods, thereby contributing to the overall exposure of a consumer to ingested substances, including chemical and microbiological contaminants. However, as the quality of water intended for human consumption is already controlled by Council Directives 80/778/EEC (5) and 98/ 83/EC (6), it suffices to consider water after the point of compliance referred to in Article 6 of Directive 98/83/ EC.

Directive / Regulation	Directive / Regulation #	What is regulated relevant to DWD	Likelihood of exceeding DWD regulations in case of load	Coherence
		concentrations as regulated by DWD		
Fertilizer regulation	REGULATION (EC) No 2003/2003	Regulation of quality of fertilizers (revision)	Proposed revisions most likely do not affect water quality beyond standards set by DWD. For cadmium assessment is not clear	Unknown
Undesirable products in animal nutrition	2001/102/EC	Regulation of quality of fodder and other animal feed products	Not likely due to low acceptable levels in fodder and feed	Unknown
Landfill of Waste Directive	1999/31/EC	Regulation of emission from waste collection site	Not likely due to emission control regulation	Unknown
Industrial Emissions Directive	2010/75/EU	Regulation of all emission from industry	Not clear	Unknown

Main conclusions in view of our definition of coherence regarding the degree of coherence between the DWD and related Directives are:

- A direct comparison of quality standards for parameters (i.e. in water) as set by the DWD and the corresponding parameters in adjacent Directives (notably Nitrates Directives, WFD, Pesticides Directive, Radioactive substances in water) shows that levels as set by the DWD are equal to those set by adjacent Directives (in casu nitrate, pesticides, tritium and total indicative dose);
- Most environmental quality criteria for concentrations in surface water or groundwater are equal to (e.g. Cd, Pb, As) or (much) lower (notably Cu) than those set by the DWD;
- The two previous conclusions imply that the DWD is coherent with a number of relevant Directives but has little or no added value in regulation of these compounds since adjacent Directives already regulate the level as required by the DWD;
- For most Directives targeting water quality, however, the emission is regulated through a restriction of the load and are not so much based on maximum concentrations in water itself. This makes a direct comparison of concentration based standards difficult or impossible since this would require a conversion of load to concentration;
- In addition, there is a considerable time lapse for load-based emissions before entering the aquifer used for water abstraction. This requires complicated transport modelling which is, currently not available for the complete list of substances;
- Whether or not such load-based emissions eventually lead to exceedance of concentration based standards furthermore depends on the nature of the pathway which may lead to complete removal of the substance from the water phase as such due to retention or biological decay;
- For a number of load-based Directives (e.g. the Sludge Directive) maximum loads however are defined such that the likelihood that concentration based limits as set by the DWD will be exceeded is small. This is a result of additional requirements in e.g. the Sludge Directive that states that soil quality (expressed as the concentration in soil) is not allowed to increase beyond levels that would lead to excessive leaching losses;
- For most Directives regulating food quality (both in view of consumption and unwanted substances) and other agricultural products, acceptable standards (in food or fodder, thus indirectly regulating animal food) are also such that the likelihood of corresponding loads to the soil (via fertilizer or otherwise) leading to excess concentrations in groundwater or surface water

is low. In general other environmental Directives are more limiting in this regard than the DWD (e.g. in case of copper emissions to ground- and surface water).

The coherence of the DWD with the Water Framework Directive (WFD) is especially important as the protection of drinking water resources is established as indispensable part of the plans and measures under the WFD, as is information and consultation of the public including citizens, municipalities and water suppliers. A Commission report on the assessment of the 1st River Basin Management Plans was published in 2012, and was update recently. Article 7 of the WFD makes special reference to surface water intended for the production of drinking water. The quality of the surface water should be such that relatively simple treatment is needed to produce drinking water that meets the requirements of the DWD.

Article 7 WFD: Waters used for the abstraction of drinking water

1. Member States shall identify, within each river basin district all bodies of water used for the abstraction of water intended for human consumption providing more than 10 m3 a day as an average or serving more than 50 persons, and those bodies of water intended for such future use. Member States shall monitor, in accordance with Annex V, those bodies of water which according to Annex V, provide more than 100 m3 a day as an average.
2. For each body of water identified under paragraph 1, in addition to meeting the objectives of Article 4 in accordance with the requirements of this Directive, for surface water bodies including the quality standards established at Community level under Article 16, Member States shall ensure that under the water treatment regime applied, and in accordance with Community legislation, the resulting water will meet the requirements of Directive 80/778/EEC as amended by Directive 98/83/EC.
3. Member States shall ensure the necessary protection for the bodies of water identified with the aim of avoiding deterioration in their quality in order to reduce the level of purification treatment required in the production of drinking water. Member States may establish safeguard zones for those bodies of water.

Regarding plant protection product regulations the issue of 'relevant' metabolites, degradation and reaction products of pesticides, has been the subject of long discussions in the Council during the negotiation process. Unfortunately no solution or consensus was reached on what 'relevant' was. Reference was made to the legislation on plant protection products. However, no further definition of 'relevant' was found. The 2009 regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market has 33 definitions and under nr.32 a reference is made to 'relevant' metabolites: *metabolite' means: any metabolite or a degradation product of an active substance, safener or synergist, formed either in organisms or in the environment. A metabolite is deemed relevant if there is a reason to assume that it has intrinsic properties comparable to the parent substance in terms of its biological target activity, or that it poses a higher or comparable risk to organisms than the parent substance or that it has certain toxicological properties that are considered unacceptable. Such a metabolite is relevant for the overall approval decision or for the definition of risk mitigation measures*.

A consistent definition of non-relevant metabolites of plant protection products is asked for by the manufacturing industry , as well as their uniform regulation in drinking and groundwater in the EU, is important to achieve legal clarity for all stakeholders and to establish planning security for development of plant protection products for the European market.

Conclusions on EQ10 and EQ11

Main conclusions regarding the degree of coherence between the DWD and Directives taken up in table 2.5 are:

- The DWD is coherent with a number of relevant Directives and can be considered the ultimate 'defence' for the quality of drinking water;

- For the Directives targeting water quality, the emission is in general regulated through a restriction of the load and they are not based on maximum concentrations in water itself which makes a direct comparison of concentration based standards difficult;
- For a number of load-based Directives (e.g. the Sludge Directive) maximum loads are defined such that the likelihood that concentration based limits as set by the DWD will be exceeded is small;
- For most Directives regulating food quality and other agricultural products, acceptable standards are such that the likelihood of corresponding loads to the soil leading to excess concentrations in groundwater or surface water is low.

The coherence of the DWD with the Water Framework Directive (WFD) is especially important as the protection of drinking water resources is established as an indispensable part of the plans and measures under the WFD. Surface water is preferably of such a quality that relatively simple treatment is needed to produce drinking water that meets the requirements of the DWD.

2.4 Relevance

Generically speaking, the main need of EU citizens regarding drinking water is obvious: it is universally accepted that access to safe drinking water is essential to health. Safe drinking water is considered a basic human right and a component of effective policy for health protection and improving access to safe drinking water can result in tangible benefits to health.[110] More specifically, failure to ensure drinking water safety may expose the community to the risk of outbreaks of intestinal and other infectious diseases. Outbreaks of waterborne disease are particularly to be avoided because of their capacity to result in the simultaneous infection of a large number of persons and potentially a high proportion of the community.

The importance of safe drinking water is underlined by both global and European authorities. In April 2011 the Human Rights Council of the United Nations adopted, through Resolution 16/2, access to safe drinking water and sanitation as a human right: a right to life and to human dignity[111], international treaties, such as the Charter of the United Nations (1945) and the ILO Convention No.161 on Occupational Health Services (1985) also refer to the right to safe water. In the European context, the right to safe drinking water is enshrined in the European Convention for the Protection of Human Rights and Fundamental Freedoms (1950), the Revised European Social Charter (1996) and in the recommendations from the Council of Europe (2001) in which they asserted that everyone has the right to a sufficient quantity of water for his or her basic needs.[112] In the publication “Health and Environment in Europe” of the WHO Regional Office for Europe, it is mentioned that people in Europe are aware of, and concerned about, the importance of good water quality. Finally, the importance of water quality is also reflected by the many different measures which have been taken in Europe to supply people with safe water and good sanitation.[113]

Extent and Scope

In assessing the relevance of the DWD in addressing these needs, we discern between 1) the extent to which needs of EU citizens are addressed and 2) the scope of EU citizens whose needs are addressed.

[110] World Health Organization & Unicef (2011). Guidelines for drinking-water quality. Fourth edition: volume 1 Recommendations. Geneva.

[111] United Nations. Media brief. The Human Right to Water and Sanitation. UN-Water Decade Programme on Advocacy and Communication and Water Supply and Sanitation Collaborative Council.

[112] Recommendation Rec(2001)14 of the Committee of Ministers to member States on the European Charter on Water Resources.

[113] [113] World Health Organization (2010). Health and Environment in Europe: Progress Assessment.

The relevance of the *extent* of the DWD's intervention depends on whether the chosen indicators represent the most relevant barriers for the safety of drinking water. The safety of drinking water is determined by a number of biological and chemical contaminants, which have been shown to cause adverse health effects. Relevance of the DWD in this respect is determined by the extent to which the DWD safeguards and promotes removal of these contaminants removed.

Throughout the interviews with stakeholders (industry, regulators, academics and utilities), the following observations are relevant for evaluating the extent of to which needs are addressed:

- The DWD has caused an increased attention for drinking water policies;
- In the past twenty years, the regulatory framework throughout Europe has become much more consistent, especially in the case of connection rates and water quality levels in new Member States;
- Overall levels of contaminants have been reduced;
- The parameters in the DWD still largely address the needs. Residues of drugs and hormones were identified as possible omissions (which is addressed under question 2 below). Conversely, several respondents identified that some parameters need not be monitored (this issue is addressed under section 2.2 on efficiency).

Additionally, the Public Consultation which has been conducted in the context of the evaluation of the DWD includes the following relevant observations:

- The respondents expect that EU legislation should provide minimum levels of common standards in drinking water throughout Europe;
- The majority of the respondents (53%) indicated that new and emerging parameters should be considered, even if this leads to a significant increase in the price of water.

The relevance of the *scope* of the Directive considers whether the Directive cover the needs of all EU citizens. In this respect, it is important to note that the Directive does not include an obligation to supply water. The DWD concerns the quality of the water supplied to citizens and the coverage of water supply across the population. However, the requirements and obligations in the DWD do depend on the size of the water WSZ.

With respect to covering the needs of all EU citizens there is compliance with the DWD in case of areas where no water is supplied at all. This is one of the key issues of the ECI R2W. Smaller water suppliers have a monitoring obligation set in the DWD but no obligation to report to the EC. Very small water suppliers are either monitored at a frequency decided by the MS (subsidiarity principle) or are completely exempted from the coverage of the DWD. Experience and Treaty based requests for information have shown that both monitoring and information on the quality of smaller WSZ (< 1000 m3 a day) does not always cover the needs of all EU citizens (also refer to the reports on small WSZs from the EC and from the WEKNOW network). With the recent revision of Annex II and III of the DWD, this issue has now been addressed.

Furthermore, the Directive has no specifically adapted requirements to address needs for the very small suppliers, for example how to manage and monitor them appropriately. For these type of WSZs, the relevance (and effectiveness) of the DWD could be further improved by being more prescriptive.

Approach to the evaluation of Relevance

To assess whether the DWD is relevant to address the needs and problems in society, this section discusses several evaluation questions at once, with the aim to answer the main evaluation

question (12); whether the DWD approach is still appropriate. To recap we provide the other evaluation questions, which are evaluated simultaneously, below:

- EQ13 Which other parameters than those set currently in the DWD became more important for human health?
- EQ14 Can any obsolete provision in the Directive be identified and if yes, why are such provisions obsolete?
- EQ15 Why has the DWD not been adapted to technical and scientific progress?
- EQ 16 What are citizens' expectations for the role of the EU to ensure drinking water quality?

2.4.1 To what extent is the DWD approach still appropriate? (EQ12)

To answer this question we have selected judgment criteria related to the six provisions selected in Chapter 1.[114]

Quality standards (Art. 5): Setting parameters - a relevant approach (EQ12, 13 and 15)

The Directive lays down the essential quality standards at EU level. A total of 48 microbiological, chemical and indicator parameters must be monitored and tested regularly. In general, WHO's guidelines for drinking water and the opinion of the Commission's Scientific Advisory Committee are used as the scientific basis for the quality standards in the drinking water. In accordance with Article 11 The Commission assesses whether or not a revision of Annex I of the DWD on parameters and parametric values is needed every five years. For amendments to Annex I to be made a full co-decision procedure is required. This has not been done since the adoption of the DWD. Annexes II and III on monitoring and specifications for the analysis of parameters can be adapted by the Commission every five years and this can be done through the Committee procedure (article 12).

Setting parameters for the quality of drinking water has a positive effect on human health because there is a standard which needs to be complied with by drinking water suppliers. It contributes to the Directive's objective it offered minimum drinking water quality standard in all EU MS. If parameters would not have been provided, regulators would have had difficulties to convince the water suppliers of the need for monitoring some substances.[115]

> "The introduction of DWD has significantly contributed to having a solid and stable reference framework both for the list of pollutants (and their parametric values) and the control system. This has helped water operators to streamline monitoring procedures and increased users' confidence. Major current problems with drinking water quality derive precisely from the uncertainties related to those pollutants that are not covered by the Directive."

It has been necessary to set individual parametric values for substances which are important throughout the Community at a level that is strict enough to ensure that the Directive's purpose can be achieved in large parts of the EU and is the result of the long negotiation process between the MS. The DWD does not include parameters that are potentially a threat to human health in the EU but could not be included for various reasons, mostly the state of the art of science at the time. This comment relates to emerging substances including endocrine disrupting compounds, for which there is not sufficient evidence to include individual substances (e.g. as key indicator parameters), to set a parametric value or to have a suitable analytical method available. A complicating factor here is the unknown cocktail effect of emerging substances.

The DWD distinguishes three groups of parameters:

[114] We exclude a discussion on Article 10 under Relevance. We instead link back to the inclusive and extensive discussion on Article 10 provided under effectiveness.

[115] Stakeholder consultation on the evaluation of the DWD. (May 2015) Brussels.

1. Microbiological parameters;
2. Chemical parameters; and
3. Indicator parameters.

All three groups have a different background and different weighting. Standards for drinking water in the DWD are based on health aspects (this holds for both microbiological and chemical parameters) and on other aspects including:

- Organoleptic or consumer perception aspects (odour, taste, colour);
- Operational aspects (pH and hardness of the water);
- Indicator for possible pollutants (this holds for indicator parameters).

In view of the evaluation this grouping not very useful. Therefore, a linkage between specific parameters and the potential sources of contamination and remedial actions has been made (see section 2.1 and Annex B).

The *microbiological parameters* - Escherichia coli (E. coli) and Enterococci for tap water (there are additional parameters for water in bottles) - have been included in the DWD, not because they will affect human health, but since they act as indication for contamination of water with faecal matter and thus the potential presence of pathogens. The values in the DWD are based on the principle that these should be absent from drinking water. If either E. coli or Enterococci are detected this is an indication that something is wrong with the water supplied and urgent and immediate action is needed to find the source and take remedial action.

The *chemical parameters* have a health-related basis. In principle, health-based quality standards for chemical substances in drinking water are based on toxicity for humans through oral exposure. Considering the low concentrations of such substances in most sources of drinking water and drinking water itself, the risk of acute effects during normal operational circumstances is negligible. Health-based limit values are generally based on effects that might occur after life-long exposure such as chronic toxicity, hormone disruption and geno-toxic and carcinogenic effects.

The *indicator parameters* are not included in the DWD for their adverse effects on human health. These parameters are monitored to ascertain the proper functioning of the water production and the water supply. In the case of a non-compliance or abnormal changes, the water supplier needs to investigate the reason behind these changes and take action as and when required. Even though the parameters and their parametric values (note that some indicator parameters do not have a parametric value in the DWD colour, taste, odour etc.), do not have a health-based background, they often are the first change noticed by consumers. Wholesomeness and cleanliness of the water (organoleptic issues) are key to the consumer's perception and confidence in the water quality as supplied at the tap. Hence, parametric values are often based on perception and are best judged by the local operators. Any changes as noticed by indicator parameters should be a signal for water suppliers to make sure the water supply is still safe.

While a regular review of the Annex I has taken place, this has not lead to a revision the Annex.[116] Member States have added other parameters to this list they deemed appropriate (thus respecting the principle of subsidiarity)[117] and this has led to a differentiation of uptake of additional monitoring amongst the MS. Examples for additional parameters (for which no values have been set in the DWD) are microbiological pollutants, hardness, calcium/magnesium, legionella in drinking water systems, *chlorophenols*, taste and odour (e.g. from PEX tubes), cadmium, *trihalomethanes*,

[116] Based on an interview with a stakeholder from West Europe; not revising Annex I leads to the outcome that parameters are at a minimum e.g. when it comes to micro pollutants.

[117] European Commission (1998). DWD. ANNEX II. MONITORING, TABLE A.

microcystin, and chlorite. In other cases, MS (such as AT, NL and UK) have more strict values for parameters already included in the DWD.

According to the EU Survey, the respondents from all Member States indicated to be in favour of revision of the list of parameters set in the DWD in line with the latest scientific developments and evidence. This result was also true even if it would lead to an increase in the price of the drinking water, although it is preferable to achieve expansion of the list of observed parameters without the need to recur to price increases. Many new parameters have been suggested by the respondents to be included in the list included in Annex I of the DWD. However, majority of the respondents agreed that the substances used in the consumer products, pharmaceuticals and endocrine disrupting substances are the most important to be considered. It has been pointed out that the joint effect ("cocktail" effect) of the substances in the drinking water on human health has to be studied both in terms of their presence or absence (over-purification). The water should be regarded as a source of elements that are important for human health and therefore kept clean and natural as far as possible.

In the context of the Public Consultation, which has been a separate exercise next to the EU survey, a number of position papers have been submitted. On the basis of these papers it is noted that respondents from BE, CZ, FR, NL, and UK see a need to revise the list of parameters in the DWD to reflect new pollutants and new scientific developments. In the paper from the United Kingdom (UK), it is suggested that the Annex I of the DWD is reviewed no less often than every 5 years for keeping standards up to date and in line with technical progress and new health information. The papers from Belgium (BE) and Scotland specify the parameters to be added: uranium, Cr6+, perchlorates, disinfection by-products (BE) and viruses, naturally produced toxic substances and pharmaceutical substances including birth control chemicals (Scotland). Other institutions as well as companies (WHP, United Utilities, Dwr Cymru Welsh Water, The James Hutton Institute (UK), AquaFed, APE, SUEZ Environment) also support revision of the parameters list in the DWD based on scientific evidence and risk based approach.

Opposite to the above, the members of the Baden-Württemberg municipalities (DE) and Vienna Water (DE) are of the opinion that the current list of microbiological and chemical parameters, as well as the indicator parameters and corresponding limit values in the DWD should be maintained. According to Vienna Water all further provisions should be left to the Member States, or the competent bodies in the Member States. There are also opinions from stakeholders in agriculture (National Farmers Union (UK) or Agricultural Industries Confederation (UK)), saying that the limits of pesticides and nitrates in the water are unnecessary stringent and should be revised based on scientific evidence and actual risk on human health. A group of French farmers expressed their opinion against tightening of regulations. One of the respondents pointed out that the control of the maximum levels of minerals in the water is not sufficient as the water is a source of valuable minerals and micro-elements necessary for healthy life. Therefore, next to an upper limit of the concentrations of minerals, a minimum level should be also set.

With respect to the analytical methods pre-defined in the DWD new and more rapid methods have now been developed and implemented since the coming into force of the Directive. It is possible to deviate from the defined methods but comprehensive equivalence testing is required. Many MS have done this testing to be able to use the Colilert method, but as far as known rapid molecular methods have not yet been introduced for mandatory monitoring. This because equivalence testing is not cheap and not easily done and needs expert judgement before they are approved for mandatory purposes.

Next to the parameters included in the DWD there are some other parameters, than those currently set in the DWD, which became more important for human health. Since the 1998 DWD came into place much has happened and through new contamination sources and/or methods of analysis the following parameters are found to have become more important to safe-guarding human health:

- Chromium Cr VI (important for locations near volcanic formations, such as Greece, Italy and Slovenia);
- Perfluorinated compounds;
- Some types of endocrine disrupting compounds (estradiol); and
- Nanoparticles (in the aquatic environment)

Monitoring actions (Art.7) are considered appropriate (EQ12 and 15)

The Member States have the obligation to perform country-wide monitoring of the water quality intended for human consumption based on the parameter groups described in the Annexes of the DWD. In order to do so, they have to collect samples and analyse these data (in different ways for the different parameter groups). Where there is a potential danger to human health from the presence, of substances and micro-organisms in drinking water for which no parametric value has been set, Member States are to ensure that additional monitoring of these substances and micro-organisms is carried out, on a case by case basis.

Monitoring

The setting of quality standards is relevant if accompanied by an appropriate monitoring system. The monitoring systems and laboratories set up as a result of the DWD are is considered relevant by all stakeholders contacted for this study. The Synthesis Report on the Quality of Drinking Water in the EU for the period 2008-2010[118] highlighted information gaps but also acknowledged that if reporting on small supplies were mandatory, the resulting reporting system would put an enormous (administrative) burden on those Member States which have many small water supplies within their territories. The report therefore urged policy makers to seek an adequate solution which, on the one hand, supports the Commission and the Member States in their objective to provide safe drinking water to all European citizens, and, on the other hand, allows for compliance checking by the Commission without putting an unreasonable administrative burden on the Member States.

The risk-based approach

The concept of a **risk-based approach** (RBA)[119] all along the production and distribution of drinking water was introduced by the WHO in 2004 into the Guidelines for Drinking Water Quality under the header “Water Safety Plans“, and further developed in the 4th edition (2011) of Guidelines for Drinking Water Quality.[120] Such an approach aims at shifting drinking water surveillance from the control at the tap towards quality management along the production and distribution cycle from capture to tap. The result of a survey carried out in 2010 by COWI in the preparation of an impact assessment indicated that almost one-third of the Member States had legal requirements for risk based approaches to management of the drinking water safety, even though this approach was not (yet) included in the DWD.

The position papers from Belgium, Czech Republic, France, Norway and the UK state that monitoring should be based on a risk-based approach and take into account the local peculiarities. In addition, the position paper from France states that monitoring should cover the entire supply process (including water storage, treatment, distribution), which has an impact on the final quality of

118 Synthesis Report on the Quality of Drinking Water in the EU for the period 2008-2010.

119 The issue of Risk Based Approaches has been on the agenda of the Commission for some time and is expected to result in the formalisation of including this option in Annex II (expected before the end of 2015). Some of the statements in this section may therefore have less relevance for the actual situation.

120 http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html and http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/index.html.

the water distributed. France also considers it necessary to set a minimum check frequency for all parameters.

Risk-based monitoring is also supported by water suppliers (such as United Utilities, Dwr Cymru Welsh Water, CC Water, all based in the UK), the Health Partnership for Wales (WHP), and associations of water suppliers such as Eureau. The latter expressed its opinion to revise Annex II of the DWD to formalise the common principles of the Water Safety Plans. Acqua Publica Europe (APE) is of the opinion that the source control approach needs to be encouraged as the most cost-effective way to reduce the impact of hazardous substances.

Contrary to the above perspective is that the quantity and efficiency measures should not be within the scope of the DWD but rather additional legislative instruments should be used.[121] This process has since taken place and the recent Commission Directive (EU) 2015/1787 follows up on this. The directive is focussed on flexible monitoring frequencies, stating that "*Member States should (…) be allowed to derogate from the monitoring programmes they have established, provided credible risk assessments are performed, which may be based on the WHO Guidelines for Drinking Water Quality and should take into account the monitoring carried out under Article 8 of Directive 2000/60/EC.*"

On the **point of compliance**, there is some discussion regarding the ability of water companies or authorities to access private property. We quote from two interviews:

> "Almost all Member States use the tap as a point of compliance in accordance to Article 6. However, in some countries it has created problems to convince water companies to do so according to some regulators. In Germany, for example, the sampling point is the water meter, which is also possible according to Art. 7. Nonetheless it seems that this was not clear enough in the Directive and leads to confusion."[122]

> "The responsibility of the DWD usually ends at the water meter. The rest is the responsibility of the water owner. Mostly the property owners are not aware that it is their responsibility to ensure water quality from the water meter to the tap and monitoring will not take place".[123]

Although there is no evidence of any confusion on the side of Member State authorities or water companies regarding the point of compliance, there is evidence that different Member States have different interpretations of Article 6, and this is mostly caused by difference in legislation regarding the access to private properties by water companies. However, Article 6 explicitly states that "Member States shall be deemed to have fulfilled their obligations under this Article (…) where it can be established that non-compliance (…) is due to the domestic distribution system or the maintenance thereof" as long as "Member States shall nevertheless ensure that: (a) appropriate measures are taken to reduce or eliminate the risk of non-compliance (…); and (b) the consumers concerned are duly informed and advised of any possible additional remedial action that they should take".

The fact that owners of private buildings are not aware of their responsibility regarding water quality also has bearings on Article 10 which regulates materials in contact with drinking water. For a discussion on the relevance of this Article, we refer to the discussion on materials in contact with drinking in the chapter on effectiveness.

[121] Opinion of water provider from Western Europe.
[122] Interview. Regulator and Utility sector. Central Europe.
[123] Interview. Academics sector.

The provision for monitoring is relevant for verifying the quality standard set in Annex I of the DWD. Although monitoring practices differ between MS, the resulting data have been essential to maintain the quality of drinking water throughout the EU. The different monitoring requirements for small WSZ is seen by most stakeholders as a hindrance to guarantee the water quality for a sizable proportion of the EU population[124]. The emergence of the Risk Based Approach was fuelled by the desire to cover the complete chain of production and, more importantly, to be pro-active in identifying possible sources of contamination. This approach has now been included in the DWD (Annex II), but there is on ongoing call for a more integrated approach (both monitoring based on sampling and based on RBA), and an inclusion of this concept in the main body of the DWD. A closing remark on monitoring would be that there is some confusion regarding the point of compliance according to stakeholders, but this is not seen as an issue of the Directive itself, but rather a point of attention for MS to properly inform owners of private homes.

Derogations (Art. 9) are considered appropriate (EQ12 and 14)

It is recognised by stakeholders that the option of derogations has served its purpose and introduced an element of flexibility into the Directive. Derogations were needed for those circumstances where relatively simple and remedial actions could be performed in a short time period. In the case of derogations generally more time and often investments were needed before full compliance could be achieved. This instrument allowed the water suppliers (and the responsible authority MS) to actions as e.g. install an additional treatment step, upgrade a whole treatment plant, build a completely new treatment plant, abandon a well or well field and construct new wells. Also blending of water from different well to achieve compliance was an option. For the various solutions a derogation was needed as new treatment and similar actions are not accomplished in the short term.

In the case of major interventions e.g. refurbishment or new plant design some years were needed to prepare tender documents, set up tendering procedure, implement construction, etc. This is also the case when structural problems are caused by ageing and poorly performing (parts of) the transport and distribution system. Such major interventions also need ample preparation and execution time. Dependent on the scale of the intervention needed the full period of three or even a second period of three years was needed. MS had therefor to produce a plan of action with a timescale needed to achieve compliance. This gave water suppliers and MS the flexibility to continue to supply water while working on full compliance. The provision had the in-build risk that water suppliers would request a derogation and perhaps a second and not take the appropriate actions needed. This needs (needed) proper monitoring of the action plans submitted and actually carried out and completed.

However, both the Commission and other stakeholders are of the opinion that the article allowing derogations has become less relevant. This because the derogation instrument is no longer used unless a new country enters the EU, new sources of contamination occur in existing water supplies or when MS are forced to create a new supply e.g. water shortages. Also impacts of climate change on the available and quantity and quality of water may ask for new derogations. In fact, the EU-wide public consultation showed that one third of the respondents are in favour of abolishing the possibility for derogations, even if this requires alternative supplies at higher costs. Respondent from LT, IE, IT and RO expressed more strongly the opinion that derogations needed to be abolished, while BG, CY, ES and FI supported the extension of (a possibility or) derogations.

[124] Note: Since the evaluation is backward looking the COMMISSION DIRECTIVE (EU) 2015/1787 of 6 October is not taken into account.

A typical comment received through the online consultation which supports this view was "*The period for derogation is too long and should be shortened*". On another note, one respondent volunteered the opinion that "*the derogations system should be flexible and pragmatic, allowing for adaption to local situations and specificities*".[125] The position papers from DE, FR and the UK expressed opposing views. Where DE and FR consider that derogations are acceptable in absence of a health risk and the current provisions of the DWD should therefore not be revised, the UK considers that the derogation process should be revised.[126] The EC has recognised that there may be exceptional circumstances where in very specific cases derogations could (still) be granted in the future.[127]

Conclusion (EQ12/14)

There have been limited cases of derogation (6), which have allowed MS time to comply with the agreed quality standards without compromising the health risks of those depending on the water supply for which the derogations were issued. However, most stakeholders agree that the article allowing derogations has become less relevant over time and that having the possibility of derogating might become not needed in the near future. The few cases for which locational characteristics lead to 'natural' high, but not health impacting, concentrations of a parameter should then be dealt with on a case-by-case basis (see the box on Italy and Cyprus).

Requirement for remedial action (Art. 8) is considered appropriate (EQ12 and 13)

According to the interviews conducted for this study, Member States authorities would be significantly less powerful without the remedial actions incorporated in the Directive. Also, they would probably be less effective in coercing drinking water producers to improve their water quality to comply with the set parameters, which could form a potential danger to the health of European citizens. Remedial actions are therefor of significant relevance to the DWD since the competent authorities are required to take effective measures in case of non-compliance by the drinking water producers. When drinking water providers fail to comply with the standards set in the DWD, the overall aim of achieving safe and wholesome drinking water for citizens of the EU becomes unattainable.

In the current situation, remedial actions come into play when an undesirable situation is already in existence; water quality is already below acceptable levels. The Czech Republic and the Baden-Württemberg municipalities therefore support implementation of an additional preventive measure as a supplement to the remedial actions. These could include measures such as water safety planning and risk analyses. The opinions expressed by other institutional stakeholders note that the response to any deterioration in water quality should be proportional to the event and to the health related risks involved. This approach is also known as a risk-based approach. This approach is in contrast to the prevention based approach, currently applied in the DWD. The risk based approach is widely supported by stakeholders as a more proportional approach to the health risk involved in the production of drinking water.

Conclusion (EQ12/13)

The remedial actions form an essential link in the DWD by coercing water suppliers to improve deviating water quality, and Member States would have less enforcement authority without the remedial actions incorporated in the Directive. Remedial actions are therefor of crucial to the DWD since the competent authorities are required to take effective measures in case of non-compliance by the drinking water producers. Our evaluation of the reported monitoring data and performed

[125] Ecorys (2014) EU survey on the DWD revision.
[126] Ecorys (2014) EU survey on the DWD revision.
[127] Drinking water inspectorate (2013). Authorization of different standards. London.

remedial actions proof that it is very likely that the performed remedial actions has improved the drinking water quality in the period 2005-2013. Given that remedial actions come into play when an undesirable situation is already in existence, many stakeholders plead support implementation of additional preventive measures to supplement the remedial actions. These could include measures such as water safety planning and risk analyses.

Information and reporting to consumers (Art.13) (EQ12, 15 and 16)

Article 13 of the DWD requires that all Member States are to ensure compliance with the Directive by providing adequate and up-to-date information on water quality for human consumption to the consumers. In addition to the information to the consumers the Member States have a reporting obligation to the European Commission. The reporting to the EC covers three year periods, on the basis of which the EC publishes a synthesis report on the quality of drinking water in the Community.

Information to the consumers

The information to the consumers is handled in different ways in the various Member States of the EU. Information to consumers can be send for individual WSZ together with the water bill. Other means used are publication in local newspapers and or at the city hall. Both water supply companies and national governments make use of the internet to inform the consumers. In these cases the information can be found on the national websites and or at the water companies website. An increasing number of MS produce and make available in the public domain annual reports on the quality of the water supplied often also showing trends in water quality. Monitoring data are assessed in relation to national and European legislation and drinking water standards. A few examples of information supply are Ireland[128] and the United Kingdom [129]. In many MS the information is only available in the national language, which excludes people that do not understand the national language as e.g. tourists. The majority of Member States do not use comprehensive maps or other visualisation techniques. A list of national websites with drinking water information can be found in the 2005-2007 synthesis report.[130]

Reporting to the European Commission

The reporting obligations to the European Commission embedded in the DWD are based on a three-year reporting cycle. At the time of the adoption of the Directive, a reporting format was not yet available. Besides there were no templates for the exchange of information for various water related directives such as Fresh Water Fish Directive, Bathing Water Directive and the DWD. The format for the reporting was developed together with the Member States in accordance with article 13(4). The objective of the reporting to the European Commission is to monitor the implementation of the DWD in the various Member States. The reporting allows the EC to monitor the policy with respect to the implementation of the sampling and monitoring requirements, the remedial actions in the case of non-compliances, and the information to the public. The reporting on derogations is done separately using the format in Art.9.

There is an ongoing debate between stakeholders regarding the necessity and right to consumers to be well informed about the quality of the supplied drinking water. Where some stakeholders believe that consumers have this right[131], and they are furthermore of the opinion that consumers

128 http://www.epa.ie/pubs/reports/water/drinking/dwreport2014.html#.VkXbz3arRdg
129 http://dwi.defra.gov.uk/about/annual-report
130 https://circabc.europa.eu/sd/a/b580866d-8eb7-4937-9a97-d3d3485d046e/2005-2007%20SynthesisReport.pdf
131 This reflects the positions submitted by Belgium, Czech Republic, Germany, France and the UK.

should receive more simplified information on the main parameters,[132] there are also contradicting voices in this debate. At the stakeholder meeting for the DWD revision, held in Brussels on May 26, 2015, it was acknowledged that insufficient information does not necessarily result in people turning to other sources of drinking water, as consumers take water for granted and are generally not interested in information on the quality of water. In a position paper from the UK it is furthermore stated that information provided at the local level (supply zone) should be sufficient and that there is no need to provide information at the EU level. However, the view of the French authorities was that the choice of ways to inform consumers must belong to each MS.

Conclusion (EQ12, 15 and 16)

Information on the quality of their drinking water is a basic right of the consumers and needs to be addressed properly. The current information supply differs between MS with some good examples of accessible and up to date information on national and or water supply companies websites. On the other hand websites can be difficult to comprehend as the information consumers might be looking for cannot be found, is not understandable or not up to date and is not always available in a another language e.g. English. The reporting process under the DWD is seen as increasingly important in view of a more critical attitude of present-day consumers and the need for evidence based policy making at EU level. The EC is able to use the information supplied by the MS to monitor the implementation of the DWD in the MS. However, the EC needs other instruments e.g. the Treaty besides the DWD to collect information on the implementation in the smaller WSZ.

The information supply to the public could be improved by making information available on the internet both through visualisation and providing information for the whole European Union. Setting a mandatory level and method for providing this information is however still a 'new' and debated topic, where MS do are not uniform in their preferences.

2.4.2 *Extension to EQ14: Are provisions not directly related to actions (still) relevant?*

Not all types of (drinking) water are within the scope of the DWD and some types of water have different legislation in which reference is made to the previous (80/778/EEC) or the current directive (98/83/EC). Also some other provisions in the DWD are no longer legally part of the DWD i.e. radio-activity. To know which types of water are included and at which point these types of water have to comply with DWD Articles 3[133] and 6 are important. In this extension to EQ14 we discuss these main issues in more detail.

Natural mineral waters

There are different categories of waters intended for human consumption such as natural mineral waters and spring waters. Natural mineral waters may be distinguished from ordinary drinking water by their purity at the source and their constant level of minerals. Spring waters are intended for human consumption in their natural state and are bottled at the source. Directive 2009/54/EC regulates the marketing and exploitation of natural mineral waters. Certain provisions of this Directive are also applicable to spring waters such as the microbiological requirements and labelling requirements.

Commission Directive 2003/40/EC of 16 May 2003 establishes the list, concentration limits and labelling requirements for the natural mineral waters and the conditions for using ozone-enriched air

[132] Although the stakeholders have noted that, if consumers require this, they should also be entitled to receive detailed information about the results of the analysis, the values of every parameter and whether these values comply with the required standards.

[133] Article 3 exemptions : The Directive does not apply to natural minerals water (80/777/EC) and water which are medicinal products (65/65/EEC).

for the treatment of natural mineral waters and spring waters. Natural mineral waters and spring waters may be treated at the source to remove unstable elements and some undesirable compounds in compliance with the provisions laid down in Article 4 of Directive 2009/54/EC.

Water used in food undertakings

The DWD covers (Article 2.1.b) all water used in any food-production undertaking for the manufacture, processing, preservation or marketing of products or substances intended for human consumption unless the competent national authorities are satisfied that the quality of the water cannot affect the wholesomeness of the foodstuff in its finished form. In the legislation of food and feed safety reference is made to the provisions in the DWD. Regulation (EC) No 178/2002 of the European Parliament and the European Council of 28 January2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Article 2 in the directive on the definition of 'food' : for the purposes of this Regulation, 'food' (or 'foodstuff') means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans. 'Food' includes drink, chewing gum and any substance, including water, intentionally incorporated into the food during its manufacture, preparation or treatment. It includes water after the point of compliance as defined in Article 6 of Directive 98/83/EC and without prejudice to the requirements of Directives 80/778/EEC and 98/83/EC. Other types of water covered by the DWD as by Article 2.1.a are all water either in its original state or after treatment, intended for drinking, cooking, food preparation or other domestic purposes, regardless of its origin and whether it is supplied from a distribution network, from a tanker or in bottles or containers.

Radio-activity parameters in the DWD

In the 98/83/EC Directive provisions are made for the radio-activity in drinking water (Annex I). Two parameters are mentioned and parametric values have been set for tritium and total indicative dose. At a later stage it was decided that radio-activity is covered by the Euratom Treaty and had no place in the Directive (Article 31 (expert group) of the Euratom Treaty). The provisions on radioactive substances and radioactivity parameters are addressed in the developments in EURATOM legislation (Directive 2013/51/EURATOM). These provision and references to radioactivity are still in the DWD but no longer valid.

Conclusion EQ12

Based on the above it is concluded that the DWD still addresses the needs of EU citizens and remains fit-for-purpose when considering the overall EU objectives in terms of improved drinking water. Having in place a directive with requirements that set an overall minimum quality within the EU has actually provided a situation that in the whole EU a minimum level of drinking water quality is guaranteed. Additionally, the DWD has led to a more consistent regulatory framework when compared to 20 years ago, shown in particular through the increase in overall water quality as derived from an increase in compliance. Moreover for some MS, and especially those with a federal structure such as Germany and Austria, EU regulation is seen to be helpful by the national government to achieve compliance. Federal bodies often have a high level of independence and are more likely to comply with regulation coming from the EU or regulation based on EU legislation. Consequently, transparency has increased due to the existence of the DWD and the requirement to report to the EC and the public.

2.5 EU added value

2.5.1 What has been the EU added value of the DWD? (EQ17)

The positive contribution of the DWD towards better quality of drinking water for the vast majority of EU citizens has been discussed in Chapter 2.1. In this section it becomes apparent that without drinking water legislation in place at EU level, it would have been unlikely that the improvements described in previous chapters would have been as widespread as we witness today. We identify added value of EU legislation at four levels: i) all Member States aiming for the same level of drinking water quality; ii) building up a body of knowledge around water quality parameters and monitoring techniques based on common rules and agreements; iii) improved information to consumers; and iv) an opportunity to optimize processes and share resources, resulting in improved efficiency and cost savings; and iv) the efficiency gains for firms using tap water in their production process.

Although differences in drinking water quality still exist between Member States and even among regions within the larger Member States, we noted a gradual improvement over the last decades and have identified the DWD as a major contributor to this improvement (see section 2.1 and Annex B for a more extensive discussion on trends in water quality). Especially for those Member States that joined the EU in 2004 or later, the standards provided water authorities with clear goals and – even more important – with the opportunity to source for the financial means within the EU to upgrade their drinking water management systems.

To reach an agreement on a common set of parameters and the applicable limit values, water quality experts throughout the EU participate(d) in various fora, at both national and international level, which resulted in scientific and non-scientific articles and reports. This process continued after the adoption of the Directive and a wide body of knowledge on this topic was built up in the process. Without the EU, this process would have lacked a clear focus and would have been less efficient.

The obligation to provide consumers with information on drinking water quality increased the awareness of consumers on the need for high quality drinking water and improved their position viz-á-viz water companies in price/quality discussions. However, as has been set out in Section 2.1 on effectiveness, the present situation is very divers throughout the EU with some Member States providing detailed information on a regular basis, whereas others would only release limited information on an infrequent basis.

With the exception of Article 10, the DWD has provided Member States with a clear set of rules on how to manage the process of guaranteeing good quality drinking water. This has increased the efficiency of the management throughout the EU according to stakeholders across Europe. The DWD has further avoided duplication in the development of methods and approaches, from which national legislators have benefitted.

Finally, companies operating in more than one EU country and those exporting to one or more EU countries benefit from the minimum levels of drinking water quality in all EU countries and the standard approaches to determine this quality. Further harmonization of drinking water legislation, among others through revising Article 10, is expected to lead to future welfare gains.

Besides asking the question how EU regulation has brought change that would otherwise not have taken place (or not taken place at the same pace), we have also asked the question whether the DWD continues to have an added value, especially for those countries which already enjoy high quality drinking water for several years. Here, the most compelling argument for EU added value

came from an interview with a representative of Dutch utility companies who stated that not only did the DWD help and still helps to maintain the quality standard of water and the related water services, but if this piece of EU legislation would be taken away, national legislators would not feel as obliged to uphold the laws and regulations now in place in their respective countries which are needed to maintain these high standards. This was confirmed by the national regulators, who stated that discussions on necessary investments are easily hampered without a good European regulatory framework that reflects responsibilities. The interviewees from the national regulators furthermore indicated that it is good to have another body at European level that regulates the national regulators. Overall, the DWD provided Member States who joined the EU before the DWD became effective with a regulatory framework which allowed them to adjust their water policies and procedures and assign budgets for necessary adjustments. Next to this, the DWD provided Member States who joined the EU after the DWD became effective with guidelines for water quality standards and appropriate regulation. New Member States were also able to channel EU funds for Accession Assistance towards large scale investments in water treatment and distribution systems, monitoring laboratories and capacity building.

Conclusions EQ17

It is argued that without drinking water legislation in place at EU level, it would have been unlikely that improvement in water quality would have been as widespread as we witness today. There is a high level of EU added value through existence of the DWD. The main issues leading to benefits are:

- MS are all aiming for the same level of drinking water quality;
- MS/EU efforts build up a body of knowledge around water quality parameters and monitoring techniques based on common rules and agreements;
- Improved information to consumers has increased awareness of the importance of high quality drinking water;
- The DWD was and is an opportunity to optimize processes and share resources, resulting in various efficiencies and cost savings; and
- There are serious efficiency gains for firms, either through using tap water in their production process and/or through harmonization of production processes across borders.

2.5.2 *Is there any possibility to compare EU legislation on drinking water with what is in place in similar regions? (EQ18)*

We have compared the EU legislation on drinking water with four selected regions: USA, Canada Australia and New Zealand. We place the descriptive analysis in perspective by matching the differences across the five countries with challenges within the European context, as identified through this report. We do this for a selection of challenges where we identify relevant learning potential from the selected regions. The extensive descriptive analysis of the situation in the selected regions is provided in Annex D. An outline of the legislative regulations and general approach to drinking water is addressed in the text box below.

Legislative regulations and general approach to drinking water management

All four studied countries have legal requirements set with regard to provision of clean and wholesome drinking water, although arrangements vary. The USA and New Zealand have legislation at national level, whereas in Canada and Australia the approach is closer the European DWD. In Canada, provinces should in their legislative documents implement the requirements of the GCDWQ. In Australia, the legislative arrangements are done by the Australian states, while at national level there are only guidelines which are not legally binding.

The integrated water management approach, multi-barrier approach and preventive management approach are in the basis of the drinking water management philosophy of the studied countries. In the USA source water assessment is made and measures taken to protect water sources. In Canada the multi-barrier approach comprises an integrated system of procedures, processes and tools that collectively prevent or reduce the contamination of drinking water, from source to tap. The preventive management approach in Australia includes elements of HACCP, ISO 9001 and AS/NZS 4360:2004. In New Zealand the Multiple barriers approach includes minimising the extent of contaminants in the source water, removing undesirable soluble and particulate matter, disinfecting to inactivate any pathogenic organisms present and protecting the treated water from subsequent contamination. In contrast the DWD focuses primarily of the drinking water quality while the issues related to integrated water management are part of other legislation (Water Framework Directive)

Monitoring strategy

In the European context, variation exists amongst Member States with respect to the stringency of monitoring of substances, where some Member States move beyond the requirements of the DWD. In parallel, a large number of Member States is in favour of revising the list of parameters as set in the DWD. Additionally, introducing more year-round monitoring and risk-based monitoring are discussed.

While the DWD sets minimum requirements to monitoring, the legislation in the studied four countries is more flexible with regard to monitoring. In general, decisions about the frequency of the monitoring is left to the respective authorities in order to allow them to take into account various characteristics of the drinking water supply systems.

Several interesting approaches to sustain high water quality have emerged:

- In the USA, the central authority (EPA) is responsible for evaluating the analytical methods for determining standards and assessing drinking water quality. Moreover, States or the EPA certify laboratories who centrally conduct testing of samples. The requirements vary depending on the contaminant group, the type of source and number of people served. For large populations, more monitoring is generally required.
- In Canada, the monitoring programme for all federal drinking water systems should be developed based on a sanitary survey, combined with a vulnerability assessment and a baseline chemical analysis. This analysis should be revised every five years. The actual monitoring frequency of microbiological parameters, recommendations are made based on a.o. the size of the population served, the monitoring history, the type and quality of source water and type of treatment. For populations of more than 5,000 people, minimum intervals are prescribed.
- In Australia, sampling and analysis are required most frequently for microbial parameters and less often for organic and inorganic compounds. When after investigative research the parameters and sampling locations are identified, these are documented in consolidated monitoring plans. The procedures for sampling and testing are also documented.
- In New Zealand, water suppliers need to follow the relevant sampling and testing programmes detailed in Drinking Water Standards. Contaminants are divided in four priority classes, where priorities one and two must be monitored and three and four at the suppliers discretion. The sampling frequencies are set to give 95% confidence that the medium to large suppliers comply for at least 95% of the time. Larger suppliers are required to monitor more frequently. Accreditation of laboratories is done centrally by the Ministry of Health.

Safety of new materials

The use of new materials could significantly affect drinking water quality. In the European context, questions have been raised whether the DWD is the correct place to regulate materials, considering

that the Construction Products Directive has recently been repealed and replaced by the Construction Products Regulation (EU No 305/2011).

The legislation in Canada and Australia poses requirements to material in contact with drinking water. Both approaches consider the materials in a broader sense including treatment chemicals and additives into the water. In Canada the internal building distribution systems within federal buildings and in First Nations communities must be designed and constructed to meet the National Plumbing Code of Canada. There are no recommended specific brands of drinking water treatment devices, but it is recommended that the devices are certified by an accredited certification body to meet the NSF/ANSI health-based performance standards. In Australia materials used should comply with Australian Standard AS/NZS 4020 Products for use in contact with drinking water. The products used in water systems should be subject to an audited system of quality control.

Certification is required in Australia and recommended in Canada. In both cases, the safety of new materials is embedded in legislation related to construction standards and not in specific legislation for drinking water.

Consumer information and involvement

For the European context, several challenges have been identified;

- according to the EU-survey, there is general dissatisfaction with the information received on water quality and water service and the provisions of the DWD in this regard.
- the provided information from the Member States in many cases does not have the required quality for EU policy reviews.
- consumers would like to receive information in the context of accountability: issues such as water losses in the network, cost of supply and profit margins, investments made and monitoring activities.

The information provided to consumers and the consultation of consumers varies from country to country. This also holds for the requirements to take this up. More specifically, the following approaches are taken:

- In the USA it is required that the information is provided to the public about public health effects which is comprehensive, informative, and understandable. The public can be involved in developing source water assessment programs, state plans to use drinking water state revolving loan funds, state capacity development plans, and state operator certification programs.
- The consumer information provided by the national authorities in Canada is scarce. There are no nation-wide requirements for the provision of information and reporting. This is regulated at provinces based on their legislation.
- Development of a comprehensive strategy for community consultation is recommended in Australia as well as a consumer complaint and response programme. However this is not obligatory and how it is implemented by the states is unclear.
- In New Zealand a Drinking Water for New Zealand web portal has been developed which provides the most important information to the consumers with regard to drinking water.

Conclusions on EQ18

The evaluation compared identified DWD topics that are strongly debated with the approach of these topics the USA, Canada Australia and New Zealand. The first finding is that comparing legislation poses a challenge due to differences in legislation in general. However, we found that all selected regions have a drinking water regulatory framework in place, making some matching between the EU and other regions possible.

We found that the DWD can draw inspiration from the monitoring approaches applied in the selected regions and perhaps adapt current DWD monitoring strategy. Relevant examples are the ex-ante methodology-based approach to determine standards, the risk-based approach based local characteristics (similar to current EU developments) and the so-called '95% confidence' approach.

When looking at involving consumers the USA presents an interesting case. They actively involve the public in the various stages of water management and the EU could perhaps adopt such a method to bring providing water of high quality closer to the consumer.

3 Conclusions

Effectiveness

EQ1 To what extent has the Directive achieved its objectives?

During the investigated period of 2005 to 2013 the DWD has unambiguously contributed to a better protection of human health from the adverse effects of any contamination and has ensured clean and wholesome drinking water for citizens in the EU. This has mainly been achieved by setting parameters in Annexes I, II and III equal to WHO guidelines. The evaluation observed an increase in compliance with these parameters over the period 2005 to 2013; the DWD has been an important factor contributing to this increase. The most significant effect of the DWD was seen in the increase in compliance for parameters related to materials in contact with drinking water (the treatment and distribution networks). Less convincing evidence exists for several agricultural/catchment related parameters, such as pesticides, nitrate and arsenic. It is likely that the main drivers of change in this area are other relevant directives.

EQ2 Which provisions have been the most appropriate for protecting human health?

Parameter requirements

It is concluded that by setting parameters for microbiological substances the DWD has reduced microbiological outbreaks, because MS were obliged to enforce considerable distribution network – and treatment actions. The number of incidents of, for instance, *E. coli* contamination of water supplies has been reduced significantly. The increased powers of (environmental) protection agencies have contributed to these improvements as well.

Monitoring activities

Monitoring of parametric values in drinking water is an effective way of collecting objective and testable information if the DWD standards are met. Monitoring methods have been implemented in all MS. However, the frequency of monitoring unfortunately sometimes is below what is required. This undermines the impact of the Directive. Additional efforts in enforcement by national authorities are needed to further improve the effectiveness of the Directive.

Recently Annex II and III were revised allowing MS more freedom in monitoring frequencies and substances to monitor. This revision also led to a minimum frequency of monitoring of small WSZ. The new Annexes stipulate that deviation from the default monitoring programmes in relation to the parameter list and monitoring frequencies can only be done after a risk assessment, providing strong guarantees that the protection of human health is not compromised. Stakeholders suggested to take this one step further and integrate the risk based approach in the DWD, not as an alternative for monitoring, but to give them equal weight.

Remedial action

In the period 2005-2013 MS reported an increasing number of remedial actions. Most of the remedial actions performed are related to the microbiological parameters (*E Coli* and *C. perfringens*) and to a lesser extend to chemical parameters (lead, nitrate and arsenic). This is in line with the reported causes and show that the Article 8 has been an effective way to improve drinking water quality in the period 2005-2013, notably regarding the microbiological parameters (*E Coli* and *C. perfringens*) and the chemical parameters (lead, nitrate and arsenic).

Option of derogation

The provision of derogation has allowed MS to apply the parameter values as defined in Annex I of the DWD at a feasible pace, depending on local circumstances. This has proofed to be effective,

because otherwise specific water sources could not have been used for an extensive period of time, without having to resort to other means. We found that the need for this Article has reduced over time, mainly because the Commission has become more restrictive in allowing derogations.

Article 10

Article 10 has been effective as it applies to the treatment and to distribution of the drinking water, a phase in which considerable contamination of drinking water can occur. Article 10 asks the MS to take actions to remove substances in order to comply with the quality requirements in the Directive, but many MS experienced significant problems with the implementation of the article as no further guidance was offered. For this reason the effectiveness of Article 10 is currently low. Effectiveness can be improved by better guidelines from the Commission.

Reporting to the Commission

The compliance with the requirement of reporting to the Commission is high but the information submitted by MS is insufficient for the Commission to perform a thorough compliance check and adequately inform e.g. the European Parliament.

Information to consumers

Regarding information to consumers it can be stated that national authorities usually provide general information on the quality of the drinking water, but there are extensive differences between MS. In most of the cases MS make the national Drinking Water Directive report also available to the public. Recent reports show a large variation in the quality of reporting. According to the Public Consultation consumers satisfaction on the information provided is barely more than 20%.

Review process

The DWD review procedure process of Annex I is lengthy and time-consuming. This is however justified by the seriousness and implication of any proposed change. The adaption of the procedure of the technical requirements of Annexes II and III introduced some flexibility.

EQ3 What main factors, in particular related to water bodies, agriculture and distribution networks, have influenced or stood in the way of achieving the objectives of the DWD?

Regarding water bodies and agriculture the main factors that have influenced achieving the objectives of the DWD are related to both the impact of sources (emissions) as well as (changes in) the nature of the extraction zone itself (geology). The dynamics of these characteristics strongly differ between deep groundwater extraction zones characterized by a slow response time versus surface water bodies with a quick response time when considering the impact of emission of unwanted substances. As such, the DWD does not recognise this difference and does not discriminate in monitoring strategies to overcome this. The complex nature of the interaction of substances with the aquifer or sediment matrix hampers a clear solution of this issue. From this it can be concluded that compliance at the tap is the only viable method to guarantee the objective of wholesome and clean drinking water.

Based on available data the reduction in cases of non-compliances can almost completely be ascribed to improvements in the distribution network (mainly related to copper, lead and mixed sources for both *C.perfringens* and *E.coli*).

EQ4 What results, if any, has the DWD achieved beyond its main aim to protect human health? and EQ5 Has the Directive caused any other unexpected or unintended changes?

The DWD puts drinking water in a wider context and the DWD can be linked to a number of effects that go beyond the protection of human health. The main additional (positive) effects are:

- The increased awareness on drinking water quality at the level of national legislators;

- The DWD has contributed to the development of additional environmental legislation like the WFD and the ND resulting in, among others, decreased pesticide use;
- It played some role in improving quality of domestic wastewater and the decrease of metals in the wastewater, from metals coming mainly from plumbing installations; and
- The DWD created the attention for materials in contact with drinking water and the need for a harmonised approach for approval of materials and harmonised/comparable test methods.

Efficiency

EQ6 To what extent are the costs involved with implementing the DWD justified given the benefits which have been achieved?

Based on the top down approach it is calculated that the total cost of the EU28 drinking water sector in 2014 amounts to 46.5 billion euro of which 17 percent can roughly be attributed to the implementation of the DWD, this depends strongly on the method of attributing impacts to the DWD.

When looking at benefits it was found that the lead standard set by the DWD and as such the additional push to MS to replace lead pipes has/will le(a)d to significant welfare benefits across Europe, mainly related to having less loss of IQ for minors. Other notable benefits that can be attributed to some extent to the DWD are the aesthetic improvements with respect to drinking water, the existence of a European baseline regulatory framework and the general improvement of the quality of (drinking)water both for consumers and other users.

EQ7 Have there been technical or other developments since the elaboration of the Directive that could contribute to achieving the objective more efficiently?

There have been various technical and other developments in the last 17 years which contributed in achieving goals of the DWD. Some of the developments which contributed to achieving the goals of the DWD are:

- a different approach to monitoring leading to faster decision making if there is need for remedial actions;
- new ISO approved methods to improve the analysis of microbial quality of water;
- technical innovations making users more aware of their water consumption (such as (smart) water meters); and
- methods of monitoring related to sensor development.

EQ8 To what extent does the Directive allow for efficient policy monitoring?

The DWD obliges MS to provide a report on the quality of their drinking water. These reports have to be provided every three years by all MS. These reports are very valuable when monitoring the efficiency of the Directive, because they show if, to what extent and in what timeframe water quality improves in each Member State. However, according to stakeholders, there are some limitations to the information of these reports, which are related to inconsistency in methods of reporting for different MS and the fact that information is only provided once every three years. In general it is clear that the obligation of reporting to the Commission is valuable for policy monitoring.

Coherence

EQ9 To what extent are the DWD provisions internally coherent?

There are few issues regarding the internal coherence of the DWD. There is a small incoherence in the DWD regarding degradation –and reaction products of pesticides. Furthermore it is unclear whether Article 10 provisions for substances and materials are in accordance with parametric values of Annex I.

It is concluded that all other provisions of the DWD are internally coherent and as such are not evaluated in detail here.

EQ10 & EQ11 To what extent are the DWD provisions externally coherent? Which effects has the DWD had on areas targeted by other EU legislation -in particular legislation on food, chemicals, pesticides, fertilisers, agriculture, water abstraction, preparation and distribution, product policy?

The DWD provisions have been evaluated on the extent of external coherency and the effect the DWD has had on other areas of EU legislation. The main findings are that:

- The DWD is coherent with a number of relevant Directives and can be considered the ultimate 'defence' for the quality of drinking water;
- For the Directives targeting water quality, the emission is in general regulated through a restriction of the load and they are not based on maximum concentrations in water itself which makes a direct comparison of concentration based standards difficult;
- For a number of load-based Directives (e.g. the Sludge Directive) maximum loads are defined such that the likelihood that concentration based limits as set by the DWD will be exceeded is small;
- For most Directives regulating food quality and other agricultural products, acceptable standards are such that the likelihood of corresponding loads to the soil leading to excess concentrations in groundwater or surface water is low.
- Furthermore it is found that the coherence of the DWD with the Water Framework Directive (WFD) is especially important as the protection of drinking water resources is established as an indispensable part of the plans and measures under the WFD. Surface water is preferably of such a quality that relatively simple treatment is needed to produce drinking water that meets the requirements of the DWD.

Relevance

EQ12 To what extent is the DWD approach to protect human health from the adverse effects of any contamination of drinking water still appropriate?

Setting of quality standards

The microbiological parameters included in the DWD have been chosen for their ease of detection in routine monitoring processes. This is not a full-proof system as situations have occurred where water was contaminated with pathogenic micro-organisms where both indicator parameters were not detected. In addition it was found that even though the characteristics of aesthetic parameters are described in the DWD, many of these parameters have no numeric value, and are according to consumers not of sufficient quality.

Monitoring approach

The monitoring systems are considered relevant by all stakeholders contacted for this study. Although monitoring practices differ between MS, the resulting data have been essential to maintain the quality of drinking water throughout the EU. Looking at small WSZ it was found that reporting on these WSZ would put an enormous (administrative) burden on those MS which have many small water supplies within their territories. The newly included RBA has been found a good development, but there is on ongoing call for an even more integrated approach (both monitoring based on sampling and based on RBA), and an inclusion of this concept in the main body of the DWD.

Option of derogation

Most stakeholders agree that the article allowing derogations has become less relevant over time and that having the possibility of derogating might become not needed in the near future.

Remedial action

Remedial actions are of crucial importance to the DWD since the competent authorities are required to take effective measures in case of non-compliance by the drinking water producers. The evaluation of the reported monitoring data and performed remedial actions proof that it is very likely that the performed remedial actions has improved the drinking water quality in the period 2005 to2013.

Reporting to EC and consumers

The reporting process under the DWD is seen as increasingly important in view of a more critical attitude of present-day consumers and the need for evidence based policy making at EU level. The EC is able to use the information supplied by the MS to monitor the implementation of the DWD in the MS.

The current information supply to consumers differs between MS. There are some good examples of accessible and up-to-date information on national and or water supply companies websites. On the other hand websites can be difficult to comprehend as the information consumers might be looking for cannot be found, is not understandable or not up-to-date and is not always available in a another language e.g. English. The information supply to the public could be improved by making information available on the internet both through visualisation and providing information for the whole European Union. Setting a mandatory level and method for providing this information is however still a 'new' and debated topic, where MS do are not uniform in their preferences.

General conclusion on Relevance

Based on the above it is concluded that the DWD still addresses the needs of EU citizens and remains fit-for-purpose when considering the overall EU objectives in terms of improved drinking water. Having in place a directive with requirements that set an overall minimum quality within the EU has actually provided a situation that in the whole EU a minimum level of drinking water quality is guaranteed. Additionally, the DWD has led to a more consistent regulatory framework when compared to 20 years ago, shown in particular through the increase in overall water quality as derived from an increase in compliance. Moreover for some MS, and especially those with a federal structure such as Germany and Austria, EU regulation is seen to be helpful by the national government to achieve compliance. Federal bodies often have a high level of independence and are more likely to comply with regulation coming from the EU or regulation based on EU legislation. Consequently, transparency has increased due to the existence of the DWD and the requirement to report to the EC and the public.

EQ13 Which other parameters than those currently set in the DWD became more important for human health?

Next to the parameters included in the DWD there are other parameters than those currently set in the DWD, which became more important for human health. Since the 1998 DWD came into place much has happened and through new contamination sources and/or methods of analysis the following parameters are found to have become more important to safe-guarding human health:

- Chromium Cr VI (important for locations near volcanic formations, such as Greece, Italy and Slovenia);
- Perfluorinated compounds;
- Some types of endocrine disrupting compounds (estradiol); and
- Nanoparticles (in the aquatic environment).

EQ14 Can any obsolete provisions in the Directive be identified?

In addition to the discussions on both EQ9, EQ10, EQ11 and EQ12, we identified two provisions that have become less relevant due to new legislation (between brackets):

- Natural mineral waters (Directive 2009/54/EC);
- Radio-activity parameters in the DWD (Article 31 of the Euratom Treaty);

EQ15 Why has the DWD not been adapted to technical and scientific progress?

No adaptation of the DWD was needed to allow the use of technical developments, because the Directive is not prescriptive on, for instance, the practical approach of reporting to the Commission. Independent of changes in the legislation various technical developments, for instance related to ICT (WISE reporting), have been put in practise and led to benefits regarding efficiency.

The adaptation of the Directives with regards to scientific progress, for instance the adaptation of parameters in Annex I has been discussed, but it was found that a full revision was not (yet) needed (partly due to the lengthy and time-consuming process).

EQ16 What are citizens expectations for the role of the EU to ensure drinking water quality?

The evaluation question regarding expectation of EU citizens can be split in three parts. 1) Are the needs of EU citizens taken into account by the DWD?, 2) Do citizens feel that they are provided drinking water of high quality? and 3) Is information on drinking water provided on time and of decent (understandable) quality?

Based on views of citizens (the Public Consultation report and several (EU and MS) consumer satisfaction surveys (e.g. Eurobarometer), it is found that the DWD takes the need of EU citizens into account, although there is a growing demand to better link EU legislation on drinking water with the needs of citizens regarding information provision and participation.

According to the Public Consultation survey EU citizens feel that water provided is of good quality (some difference per MS, but no negative outliers) and generally affordable. An interesting outcome here is that consumers feel that water in other EU countries is of much less quality. According to water quality reports between 2005-2013 the water quality in all, excluding some regions and relatively newer MS, MS is safe. Apparently there is gap between consumer perception on and reality of water quality abroad.

Added value

EQ17 What has been the EU added value to the Directive?

There has been a notable improvement over the last decades in the quality of water and although it is not possible to attribute all of this to the DWD, for parameters for which exceedances are related to causes in the distribution network, the reduction of non-compliances can be attributed to the DWD. Furthermore it is argued that without drinking water legislation in place at EU level, it would have been unlikely that improvement in water quality would have been as widespread as we witness them today. There is overall a high level of EU added value through existence of the DWD, below the main arguments for this statement are given:

- Currently MS are all aiming for the same level of drinking water quality;
- MS/EU efforts build up a body of knowledge around water quality parameters and monitoring techniques based on common rules and agreements;
- Improved information to consumers has led to an increased awareness of the importance of high quality drinking water;
- The DWD was and is an opportunity to optimize processes and share resources, resulting in various efficiencies and cost savings; and
- There are serious efficiency gains for firms, either through using tap water in their production process and/or through harmonization of production processes across borders.

Based on these findings we can conclude that, if this piece of EU legislation would fall away, there will be serious negative health effects, for one because the current awareness of the importance of drinking water could fall away, the regulatory framework needs to be developed by MS separately (leading to double costs and investments) and quality differentiates between MS negatively impacting consumers perception of the quality of drinking water abroad. In addition, the platform to discuss and harmonize would fall away if the DWD is repealed and currently unresolved issues (product harmonization for instance) will continue to hamper economic growth.

EQ18 Is there any possibility to compare EU legislation on drinking water quality with that in similar regions?

The evaluation compared identified DWD topics that are strongly debated with the approach of these topics the USA, Canada Australia and New Zealand. The first finding is that comparing legislation poses a challenge due to differences in legislation in general. However, we found that all selected regions have a drinking water regulatory framework in place, making some matching between the EU and other regions possible.

We found that the DWD can draw inspiration from the monitoring approaches applied in the selected regions and perhaps adapt current DWD monitoring strategy. Relevant examples are the ex-ante methodology-based approach to determine standards, the risk-based approach based local characteristics (similar to current EU developments) and the so-called '95% confidence' approach.

When looking at involving consumers the USA presents an interesting case. They actively involve the public in the various stages of water management and the EU could perhaps adopt such a method to bring providing water of high quality closer to the consumer.

Taking into account the observations listed above, the evaluation found that the Drinking Water Directive is still fit for purpose by providing a relevant piece of legislation which protects the health of EU citizens and which provides efficient mechanisms to implement measures at EU and Member State level.

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Annex A Evaluation matrix

Table 0-1 Effectiveness

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
EQ1 To what extent has the Directive achieved its objectives, e.g. to reduce contamination of water intended for human consumption and to protect human health?			
JC1.1 Monitoring of parameters show an improvement of drinking water quality in the EU for the period under review.	% changes in compliance rates of concentrations, distinguished for relevant microbial, chemical or indicator parameters	Action: Analyse and compare trends in compliance rates for sample countries *Result: Report on role of DWD in the reduction of contamination of water intended for human consumption*	Country reports Experts and national authorities Stakeholder conference
JC1.2 The DWD can be considered the main factor in the improvement of the quality of water intended for human consumption	Other factors that are known to have an influence on drinking water quality (water abstraction zones and distribution networks)	Action: Determine possible causes for variations in parameter concentrations *Result: review of possible causes for variations in parameter concentrations*	Experts
JC1.3 The DWD has had an effect on human health	Changes in drinking water quality can be linked to improvements in human health	Action: Review of existing literature which links quality of drinking water with human health *Result: Overview of observations linking quality of drinking water to human health*	Desk research
EQ2 Which provisions have been most appropriate for protecting human health? To what extent have parameter requirements and also general ones for Member States been effective and why?			

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
JC2.1 The parameter requirements has been the most appropriate for protecting human health	MS have a clear action plan in place when a it is identified that a water source constitutes a potential danger to human health	Actions: i) Interview MS regulators regarding their approach when it is known that a water source is potentially dangerous to human health; ii) Interview water providers regarding their approach when it is known that a water source is potentially dangerous to human health. *Result: Report on how MS are responding to a possible threat to human health due to an issue with the drinking water*	Interviews with MS regulators, water utilities and experts.
J2.2 Monitoring activities are considered effective to collect information on the water quality (Art.7)	Monitoring activities as described in the DWD deliver information on the water quality that is accurate and timely	Actions: i) Identification of other approaches than monitoring to collect information on the water quality; ii) Consult with experts from water suppliers whether they knew these other approaches and how these approaches reach their goal compared to "normal monitoring". *Result: Report on what other/new approaches are possible to collect information on the water quality and to what extend these approaches are better/worse than monitoring*	Desk research (incl. results of analysis on JC2.7) and interview with experts, water utilities and Commission staff Stakeholder conference.
JC2.3 Requirement for remedial action is considered effective (Art 8)	Type, frequency and time periods of remedial actions Results of remedial actions	Actions: i) Collect information on remedial actions; ii) Analyse the effectiveness of remedial actions *Result: Report on the effectiveness of remedial actions*	Interviews with MS authorities Reporting to the EC on derogations
JC2.4 Option of derogation is considered an effective mechanism (Art 9)	Art. 9 is considered a clear and transparent legal framework to cover the remedial works required Cases where derogations have been granted comply with all the requirements of the Article	Actions: i) Assessment of legal framework; ii) Analysis of derogations and the number of derogations *Result Report on the effectiveness of this Article, based on experience and the legal framework.*.	Derogation reports, Commission staff, MS authorities
JC2.5 Article 10 has been implemented effectively	MS that have regulated the use of substances/ materials in contact with drinking water All MS are using similar norms for substances/ materials Reduction in the use of substances/ materials in contact with drinking water considered reducing the protection of human health	Actions: i) Obtain data on substances/materials that have been 'banned' by MS; ii) Analyse the consequences of using other substances/ materials for human health *Result Report on the consequences of Article 10 (mostly based on factual information)*	MS authorities Stakeholder conference

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
JC2.6 The reporting requirements are effective (Art. 13)	Information provided to consumers is accurate, up to date and easy to understand	Actions i) Analyse information contained in report on public consultation on the responses which indicate satisfaction with the reporting; ii) Analyse the EU level reports to assess their accuracy, and timeliness *Result: Synthesis of public consultation report focussed on reporting combined with expert judgement on the EU level reporting*	Public consultation report Commission staff Team expertise Desk research Stakeholder conference
JC2.7 The review process can be considered effective. (Art 11)	Amendments of Annex I, II and III of the DWD are in line with scientific and technological progress	Actions: i) Create an overview of the amendments made by the Commission; ii) Interview academia and water providers regarding scientific and technological progress made; iii) Assess whether made amendments are in line with made scientific and technological progress. *Result: Report on the effectiveness of the approach stated in Article 11*	EC documentation Interviews with experts and water utilities
EQ3 What main factors, in particular related to water bodies, agriculture and distribution networks, have influenced, or stood in the way of, achieving the objectives of the DWD?			
JC3.1 Sources of drinking water or distribution networks do not pose risks to the quality of drinking water	Sources of drinking (both ground and surface) that have become difficult to be used for intake of drinking water[134]	Actions: Analysis of causes of contamination of drinking water, as undertaken in Task 4; ii) Identify cases where companies have decided to limit or stop intake from a source *Result: Report on cases where water utilities decided to limit or stop intake from a source*	(Draft) report on Task 4 MS authorities Commission staff Stakeholder conference
EQ4 What results, if any, did the DWD achieve beyond its main aim to protect human health, for example towards environmental protection?			
JC 4.1 The DWD has led to other than human health related results	Employment Other EU regulation influenced by DWD Industry saving resources Other indicators	Actions: Carry out literature review; ii) List possible candidates for influence of DWD and describe the cause-effect relationship *Result: Report on effects other than those related to the main aim of protecting human health*	Desk research Commission staff, Experts Stakeholder conference
EQ5 Did the Directive cause any other unexpected or unintended changes?			
JC 5.1 The DWD caused other unexpected or unintended changes	Impacts on other industries, the organisation of utilities, and other economic or social impacts	Action: Identify and describe possible unexpected or unintended changes *Result: Report on other unexpected or unintended changes caused by the DWD*	Experts and desk research

[134] "Difficult" refers to a situation where water utilities have to decide to stop intake from a source of spend significant resources to produce drinking water fit for human consumption

Table 0-2 Efficiency

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
EQ6 To what extent are the costs involved with implementing the DWD justified given the benefits which have been achieved?			
JC6.1 Costs have been proportionate with benefits of DWD	Cost per provision of (€/1,000 users) (per provision, broken down by operational, capital and finance costs) Costs associated with the introduction of the DWD (administrative) Benefits, to be quantified where feasible (e.g. DALYs, avoided health care costs, etc.),	Actions: i) Gather cost estimates from a number of operators/utilities; ii) Gather data on benefits derived from (improvements in) clean drinking water; iii) Initial analysis on the relationship between compliance rates and health benefits; *Result: Report on proportionality of benefits vs costs and relative cost per provision (quantitative if feasible)*	Reports from water utilities National authorities Experts Literature
EQ7 Have there been technical or other developments since the elaboration of the Directive that could contribute to achieving the objective more efficiently?			
JC7.1 Cost of sample based monitoring are comparable to the cost of alternative approaches	Costs of regular monitoring and cost estimates of alternative approaches (€/1,000m3)	Action: Gather cost estimates of alternative approaches; *Result1: Report on costs for sample based monitoring vs cost of alternative approaches*	National authorities Experts
EQ8 To what extent does the Directive allow for efficient policy monitoring?			
JC8.1 Reporting requirements of the DWD allow for efficient policy monitoring	Timeliness of information processing Costs of data collection under the DWD (where feasible)	Actions: i) Assess the costs involved in data collection of MS and the Commission to obtain sufficient data to carry out policy analysis; ii) Describe and analyse the steps in the reporting process; iii) Gather evidence /views of the efficiency of policy monitoring *Result: Report on efficiency of policy monitoring – Based on factual information and plausible arguments*	National authorities Experts Stakeholder conference

Table 0-3 Coherence

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
EQ9 To what extent are the DWD provisions internally coherent?			

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
JC9.1 The DWD provisions are internally coherent	Provisions which overlap, or show discrepancies/ contradictions Impacts of overlaps or discrepancies	Action: i) Assess the consistency between the articles/ paragraphs/ annexes as defined in the Directive both vertically (how strong is the contribution of each provision towards the objective of the Directive) and horizontally (do provisions have an internal overlap, meaning are there contradictions or discrepancies). Next to this we will take all other information that indicates that there is internal incoherence into account (interviews, public reports and so on) *Result: Report on the coherence between the provisions*	Expert opinion (KWR) Interviews Desk research
EQ10. To what extent can effects (on quality of drinking water) be linked to provisions in other EU legislation -in particular regarding pollution prevention (for example regarding chemicals, pesticides, fertilisers) water abstraction, preparation and distribution (including materials and products used)?			
JC10.1 The DWD provisions are externally coherent (reformulated: there are synergies with other policy initiatives and areas including policies at Member State level)	EU legislation with direct relevance for (quality of) drinking water	Actions: Review EU legislation related to the DWD, in particular regarding pollution prevention (e.g. regarding chemicals, pesticides, fertilisers) water abstraction, preparation and distribution (including materials and products used). Next to this we will take information into account that indicates that there is external incoherence (interviews, public reports and so on); ii) Identify pieces of legislation that are critical for the success of the DWD; iii) Identify issues that point to external coherence of DWD *Result Report on the external coherence of the DWD provisions*	Expert opinion from Alterra Eur-Lex Interviews with Commission staff, experts
JC10.2 Gaps between the DWD and other relevant EU legislation or initiatives have prevented the objectives of the DWD to be met.	Other pieces of EU legislation that can be identified as obstructing or reducing the effective implementation of the DWD	Same approach, actions and result as above.	Expert opinion from Alterra; Eur-Lex; Interviews with Commission staff, experts
EQ11 Which effects had the DWD on areas targeted by other EU legislation -in particular legislation on food, chemicals, pesticides, fertilisers, agriculture, water abstraction, preparation and distribution, product policy?			
JC11.1 DWD legislation has had effect on other pieces of EU legislation	Number of directives and regulations on which the DWD had an effect	Actions: i) Identify potentially relevant pieces of EU legislation; ii) Assess the impact (very high to very low) the DWD had on this legislation; iii) Identify if there are gaps between the DWD and other relevant EU legislation based on interviews with MS regulators *Report: Report on effect of DWD legislation on other pieces of EU legislation*	EUR-Lex Experts MS regulators Stakeholder conference

Table 0-4 Relevance

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
EQ12 To what extent is the DWD approach to protect human health from the adverse effects of any contamination of drinking water still appropriate?			
JC12.1 Approach based on parameter setting, monitoring, etc. is relevant	Alternative approaches that have similar or better results	Actions: i) Identify alternative approaches; ii) Determine similarities and differences between the approaches *Result: Overview of the different approaches*	EUR-Lex, text of international treaties to which EU is signatory Stakeholder conference[135]
JC12.2 Setting parameters is relevant approach	Relevance of the (types) of parameters Relevance of the values set for the parameters	Action: Verify the relevance of (types of) parameters based on recent literature *Result: Analysis of the relevance per (type of) parameter*	WHO/scientific literature
JC12.3 Monitoring actions are considered appropriate (Art.7)	Number of water providers that consider monitoring relevant Monitoring procedures and methods of analysis have been adapted to technical and scientific progress Process of updating Annexes II and III are in accordance with Art. 11 and Art. 12.	Actions: i) Analyse the relevance of monitoring to ensure safety of drinking water; ii) Analyse whether monitoring has developed over the years when new methods-/techniques became available. *Result: Report on the relevance of monitoring actions to ensure the safety of drinking water*	Interviews with EC staff, water utilities, EU wide organisation and MS regulators. and experts.. Experts (KWR) Stakeholder conference
JC12.4 Option of derogation is considered appropriate (Art. 9)	Number of 1st , 2nd and 3rd derogations granted Quality of reporting on 2nd and 3rd derogations The list of parametric values for which derogations are allowed is (still) relevant	Actions: i) Collect information on derogation (#and reasons); ii) Analyse the relevance of derogations (including an assessment of the parametric values) *Result: Report on the relevance of derogations , including an opinion on their relevance*	Interviews with 10 MS authorities Reporting to the EC on derogations
JC12.5 Requirement for remedial action is considered appropriate (Art 8)	Type, frequency and time periods of remedial actions	Actions: i) Collect information on remedial actions; ii) Analyse the relevance of remedial actions *Result: Report on the relevance of remedial actions*	Interviews with MS authorities Reporting to the EC on derogations

[135] For a list a experts and organisation (to be) contacted see Annex C)

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
JC12.6 The article on substances and materials in contact with drinking water is appropriate to protect human health (Art 10)	There is EU wide agreement on the products/materials to be considered reducing the protection of human health Art. 10 has led to a EU wide availability standards for "safe products" in contact with drinking water	Action: Describe and analyse the process of standardisation of "safe products *Result: Report on the analyses and summarise present discussion on the standards for "safe products"*	Interviews with EC staff, water utilities (>10), EU wide organisation and MS regulators, Experts Stakeholder conference
JC12.7. The requirement to inform consumers is considered relevant	Type and frequency of information shared with consumers Consumer satisfaction of information on drinking water	Actions: i) Provide overview of the types and frequencies of information shared with consumers across the EU; analyse scores on consumer satisfaction (survey) *Result: Report on information to consumers*	Desk research Reports on public consultation and CI
JC12.8 Reporting requirements are considered appropriate. (Art 13)	Quality and completeness of reporting by MS is considered relevant to Commission	Actions: i) Analyse the relevance of reporting requirements to improve water safety; ii) Analyse the quality and completeness of the reports *Result: Report on the relevance of reporting requirements to improve water safety.*	Interviews with EC staff, water utilities (>10), EU wide organisation and MS regulators .
EQ13 Which other parameters than those set currently in the DWD became more important for human health?			
JC13.1 Parameters currently not included in the DWD that have become more important to human health	Parameters have been identified (in scientific literature) which are important to human health	Action: Analyse (recent) literature on the existence of other parameters for which a (scientific) consensus was reached that they can have (negative) effects on human health *Result: List of parameters with explanation on why they can have important (negative(effects on human health*	Desk study Interviews with water quality experts
EQ14 Can any obsolete provision in the Directive be identified and if yes, why are such provisions obsolete?			
JC 14.1 Provisions of the DWD can be identified as being obsolete	Provisions mentioned by stakeholders to be less or not relevant (have lost their relevance)	Actions: i) Analyse interviews with water providers, regulators and academics and provide an overview of issues, not linked to DWD actions, which are deemed less or irrelevant; ii) Assessment whether above issues are related to a provision on the DWD (combination of desk research and checking the Directive). *Result: Report on the irrelevance of provisions of the DWD (if any), which are not directly related to actions.*	Interviews with water providers and regulators Desk research Experts
EQ15 Why has the DWD not been adapted to technical and scientific progress?			

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
JC 15.1 The DWD has not been adapted to technical and scientific progress	Provisions in the DWD that have not been adapted to technical and scientific progress	Action: Identify provisions in the DWD that have not been adapted to technical and scientific progress *Result: List of provisions in the DWD not adapted to technical and scientific progress*	Interviews with water providers and regulators Desk research Experts
EQ16 What are citizens' expectations for the role of the EU to ensure drinking water quality?			
JC 16.1 Citizens' expectations go beyond what is currently regulated in the DWD	Issues or actions currently not regulated by the DWD have been identified by the Citizens' Initiative or through other fora	Action: Identify issues or actions currently not regulated by the DWD identified by the Citizens' Initiative or other fora *Result: List issues or actions currently not regulated by the DWD identified by the Citizens' Initiative or other fora*	Interviews with water providers and regulators Desk research Experts

Table 0-5 EU added value

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
EQ17 What has been the EU added value of the Directive?			
JC17.1 The DWD has achieved objectives that could not have been achieved through national legislation (or: the establishment of the DWD has conferred additional value to the EU compared to what would have been achieved without the DWD)	List (and if possible monetize) MS effects that would not have occurred without the EU legislation on drinking water quality.	Actions: i) Identify what could be possible effects (added value) of having EU legislation on Drinking Water quality through conducting interviews and collecting evidence off these effects; ii) Identify through interviews within the six sample countries if these effects would have been achieved without EU legislation. *Result: Report on the EU added value of the Directive*	Regulators/water utilities Stakeholder conference
JC172 Withdrawing the DWD would lower the standards of drinking water quality across the EU	Number of MS authorities that confirm that legislators will push for lowering of quality standards if DWD is repealed	Actions: i) Development of interview questions regarding impact of repealing the DWD; ii) Analyse responses from Member State representatives. *Result: Overview of responses and reasoning of MS what the effect of a repealing of the DWD would have on standards of drinking water protection*	Interviews with MS regulators-/ authorities
EQ18 Is there any possibility to compare EU legislation on drinking water quality with what is in place in similar regions?			

Evaluation questions Judgement criteria	Indicators	Actions to obtain evidence and expected results	Information sources
JC18.1 There are similarities between DWD and drinking water legislation in similar regions or countries	Standards of health protection in other countries (values of parameters) Effectiveness of drinking water regulation in other countries in terms of compliance rates	Actions: i) Identify relevant countries for comparison drinking water legislation in mentioned countries (USA, Canada, Australia and New Zealand); ii) Interview with water quality experts on effectiveness of the drinking water legislation in other countries *Result: Report on comparison between (effectiveness of) EU legislation and legislation in other counties*	Desk research Drinking water legislation in the respective countries Expert opinion from WHO

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Annex B Changes in drinking water contamination and their causes

B.1 Introduction

This text focuses mainly on the Evaluation question: To what extent has the DWD achieved its objectives, e.g. to reduce contamination of water intended for human consumption and to protect human health? This is evaluated by

1. Collecting non-compliances (drinking water contamination data) of selected parameters in time;
2. Collecting information on causes reported by Member states (MS);
3. Evaluate the information on causes in view of expert judgement and assess whether the changes in non-compliances in time (improvement in water quality when number of non-compliances decrease) can be assigned to the DWD.

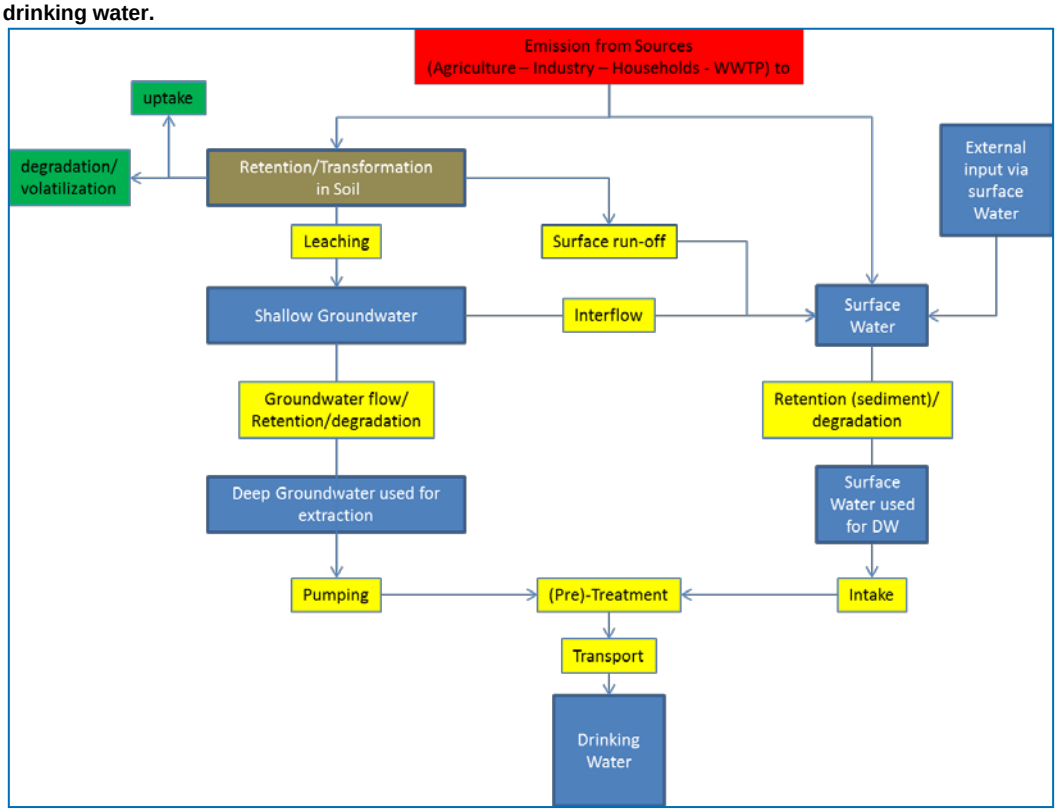
Below, we first describe the overall approach (Section 1), followed by an overview of the change in non-compliances (drinking water contamination data) of all parameters and in more detail for selected parameters in time (Section 2), ending with an overview of causes reported by MS with an evaluation whether changes can be assigned to the DWD (Section 3).

B.2 Approach

B.2.1 SPR approach

To assess whether the DWD actions has improved the drinking water quality, it is crucial to assess dominant causes of the contamination of drinking water sources (groundwater or surface water) by a source, pathway and receptor analysis. Figure 1 describes the various sources and pathways of substances.

Figure B.1 Source, pathways and receptors of (microbial, chemical and indicator) parameters in drinking water.



In Figure B.1, we present an overview of sources, pathways/processes and receptors of drinking water, distinguishing:

- Sources: Diffuse and point sources where relevant for surface and groundwater quality. Here we include:
  - Inputs via atmosphere (e.g. industrial emissions and air-borne pesticides from agriculture);
  - Intended (nutrients) and unintentional (metals, pharmaceuticals, nano-particles) application to (arable) land via fertilization, manure application and or use of secondary nutrient sources (sludge, compost etc.);
  - Application of pesticides and other agro-chemicals;
  - Direct inputs to surface waters via WWTP's and other industrial activities resulting in emission to surface waters;
  - Input via leaching and run-off from historic terrestrial sources including waste collections sites, (abandoned) industrial sites etc.;
  - Internal sources of contamination (e.g. lead and copper) that occurs during treatment and/or transport.
- Pathways and Processes: this includes the main pathways and processes therein that are in control of the magnitude of the flux of substances from source to receptor. Examples of pathways and processes considered here are:
  - Volatilization after application to soil;
  - Plant uptake;
  - Surface run-off;
  - Leaching to lower soil layers and aquifers;
  - Interflow connecting shallow groundwater and surface water systems;
  - Retention/release processes in soils, sediments and aquifers e.g. adsorption, precipitation including redox controlled precipitation or dissolution;
  - Degradation processes in soils, sediments and aquifers mainly related to organic substances and nitrate.

- Receptors: here we distinguish between two main types of receptors i.e. groundwater and surface water. Each of these is used directly for preparation of drinking water, but both are also linked as a result of interflow.

The concentrations of parameter is also largely influenced by the entire water balance which can be affected by e.g. precipitation, flooding. These processes will affect the size of the flux and need to be considered accordingly, partially under 'additional factors. Additional factors that need to be included in the source-receptor-pathway analysis are those that affect the flux of substances via an impact on processes and/or pathways and hence affect the quality of water (ground- or surface waters). Examples of such factors are:

- Soil properties that affect uptake (nitrogen, metals), retention (metals and organic pollutants) and degradation (nitrogen and organic pollutants) processes;
- Climatic conditions and foreseen changes therein that affect the water balance at the surface and hence surplus, dilution of substances, and travel time. Examples of such factors are precipitation and flooding;
- Size of the WSZ due to its impact on travel time and differences in (cleaning) technology applied in the abstraction and distribution process.

NB: this approach does not (yet) cover new parameters and emerging parameters not regulated by the DWD. Based on comparable characteristics, risk may, however, be identified.

B.2.2 Selected parameters

The 'guide' parameters to be selected for the qualitative and semi-quantitative comparative approach will be decided on the basis of the input from Task 3, taking into account the suggestions presented by the European Commission. Based on that we selected 10 parameter for the in-depth analysis in this study (see table below).

Table B.1 Parameters with parameters for which the evaluation was carried

Group parameters	Suggested by EC (minimum)	Selected parameters for study
Microbial parameters	*E.coli*	**E.coli, Cl. perfringens**
Chemical parameters (geogenic)	--	**Chromium (VI), Arsenic**
Chemical parameters (anthropogenic) Pharmaceutical and Endocrine Disrupting Chemicals	Diclofenac, E2 or EE2	
Related to fertilization	--	**Nitrate**
Related to plant protection	A pesticide	**Atrazin, desethylatrazine, terbutylatrazine**
Related to materials in contact with drinking water	Lead	**Lead, Copper**

Rationale behind the selection is relevance and expertise:

- For the substances in italic, there is expertise at Alterra (in bold within the consortium group and in italic in Alterra in general). Microbial parameters is not their expertise;
- KWR has expertise and data on emerging substances and pesticides and on release of materials in water distribution systems, especially lead, copper and chromium VI (local problem in volcanic soils near the Mediterranean Sea (Slovenia, Italy etc.).

B.2.3 Qualitative approach

1. Collect non-compliances (drinking water contamination data) of the selected parameters in time (e.g. 1998-2001 and 2008-2010) and the generic information on causes by MS (data in excel sheets);
2. Present likely dominant reason (e.g. in in picture above or tables etc.; just as indication from expert knowledge). This will be evaluated based on information provided by member states on the likely cause of reported non-compliances.

In this analysis we used the following main categories of causes of non-compliances:

- Catchment related, resulting from either application to soil or water systems (e.g. nutrients, pesticides);
- Treatment plant related;
- Public distribution network related;
- Domestic distribution network related;
- Other causes (not specified);
- Combined (not specified);
- Unknown.

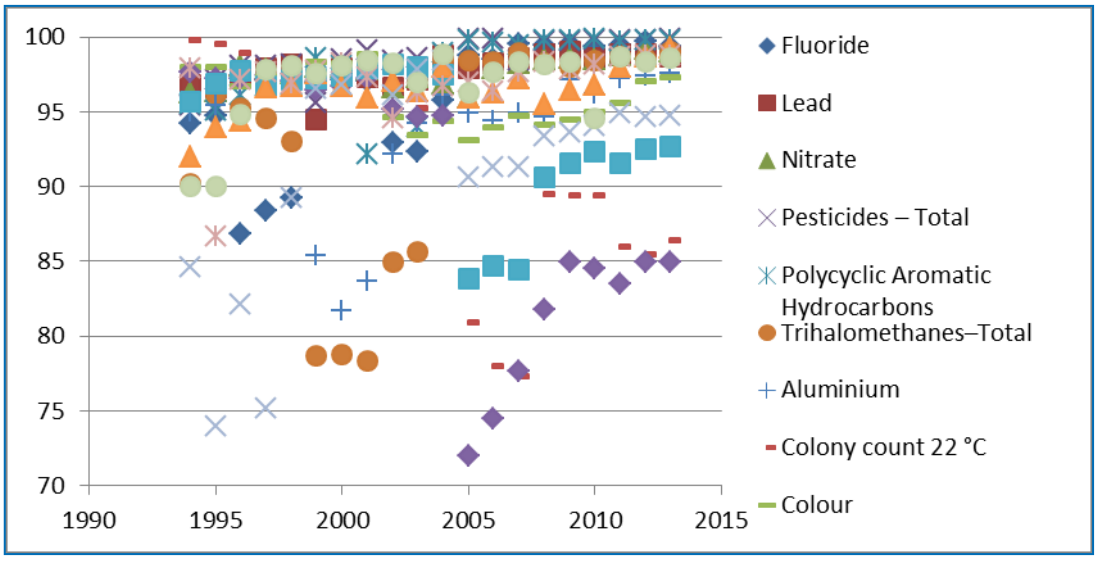
This in agreement with reports from MS during the period 2005-2013.

B.3 Trends and spatial variation in water quality

B.3.1 Trends in compliance in water quality between 1993-2013 at EU level

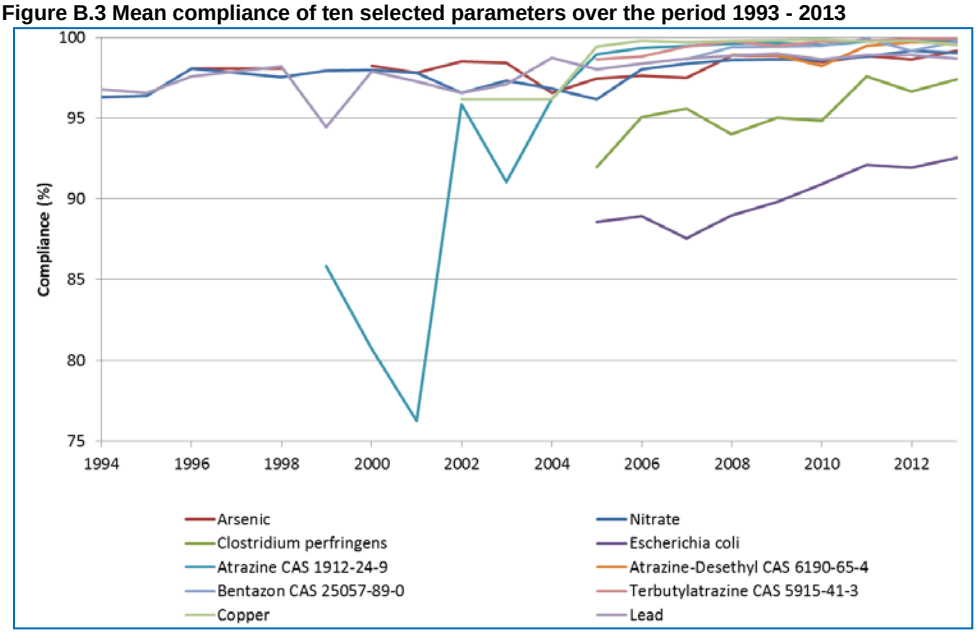
Based on summary reports at MS level (1993-2005) and more detailed information since 2005 in excel sheets (see http://rod.eionet.europa.eu/obligations/171), including the period 2005-2013, trends of the water quality at EU level was evaluated in terms compliance of parameters that have been monitored during the whole period 1993 – 2013. This was only the case for 9 parameters in about 2-4 countries. We took the mean for all MS (each value represents a parameter). Results are presented in Figure B.2. All parameters showed an increase in compliance with time.

Figure B2 Mean compliance of nine parameters over the period 1993 – 2013 that were all continuously monitored



We also evaluated the trends in mean compliance for the ten selected candidate parameters (see Table 1). Results (Figure B.3) show again an increase in compliance with time for all parameters, changes being largest for E.coli, Cl. Perfringens, and Atrazine. For all other parameters it changed from ca 95% to near 100% compliance.

Figure B.3 Mean compliance of ten selected parameters over the period 1993 - 2013



B.3.2 Trends in water quality between 2005-2013 at MS level

Trends in mean compliance of all parameters and selected parameters

Based on excel sheets, scatter plots are given of trends of the water quality at MS level (each value represents a member state) for the period 2005-2013 in terms of mean compliance of (i) all parameters (Figure B.4) and (ii) ten selected candidate parameters (Figure B.5).

Figure B.4 Mean compliance, in % of total, of all (available) parameters over period 2005 – 2013

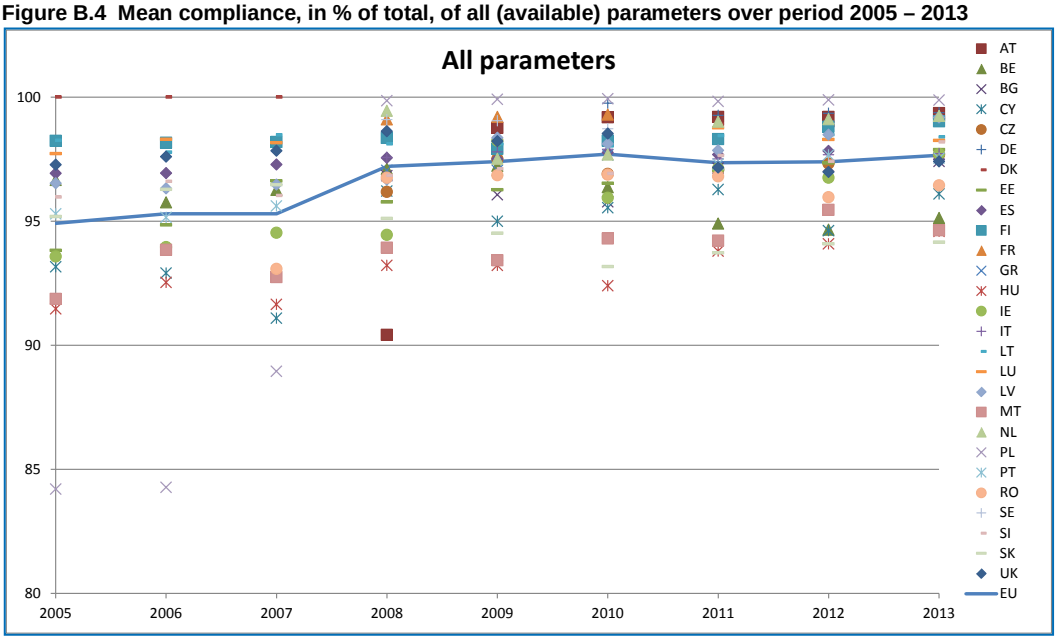
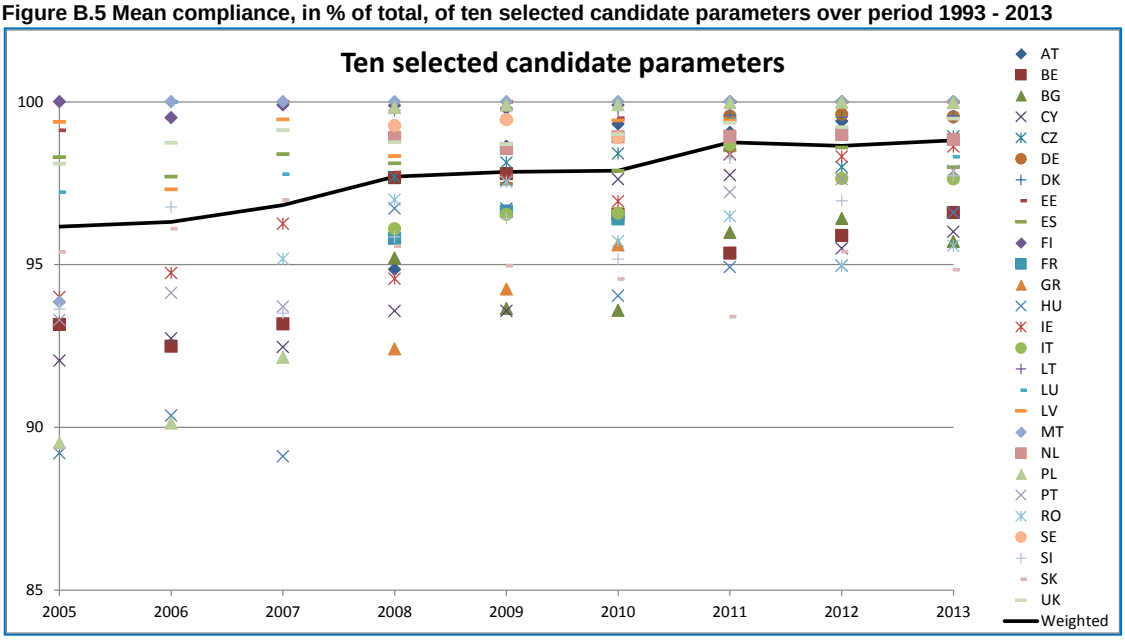


Figure B.5 Mean compliance, in % of total, of ten selected candidate parameters over period 1993 - 2013

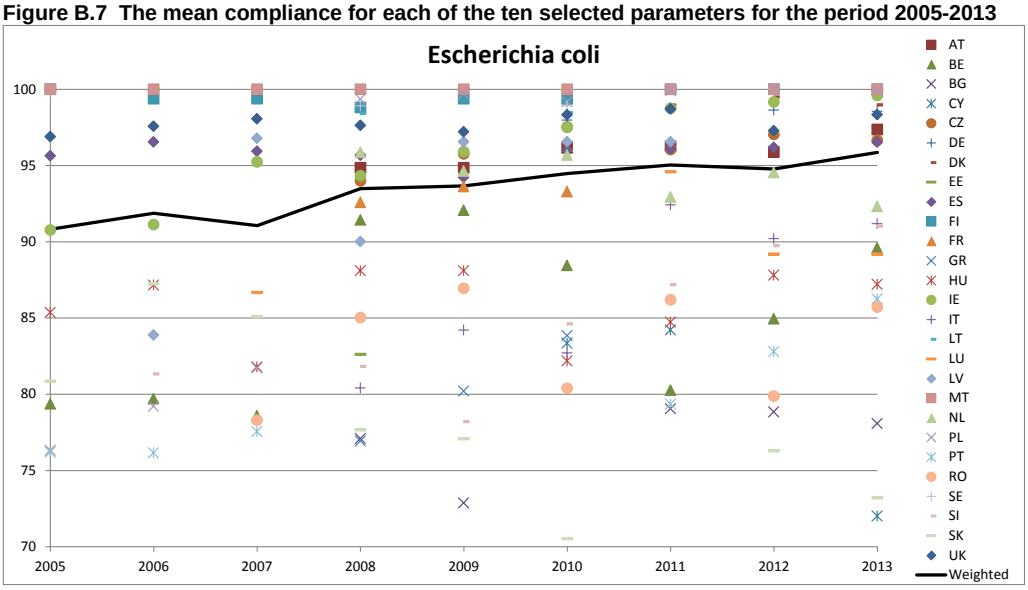


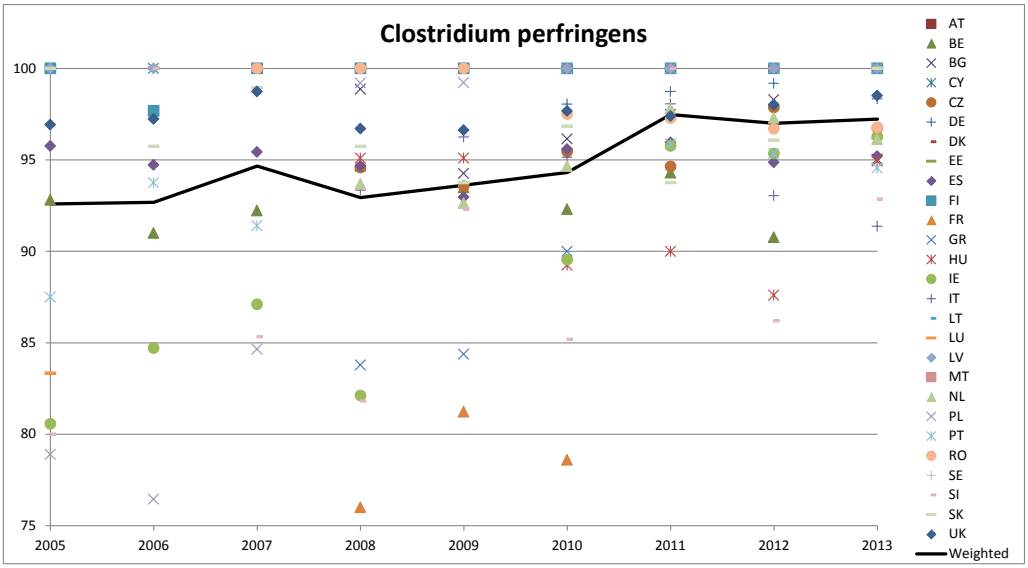
As with the mean compliance of nine parameters over the period 1993 – 2013 (Figure B.1), results show an increasing mean compliance with time over the period 2005-2013, both in the whole EU and in each separate MS, both for all parameters (Figure B.4) and the ten candidate parameters (Figure B.5). The mean compliance for each of the ten candidate parameters separately is given in Figure B.6.

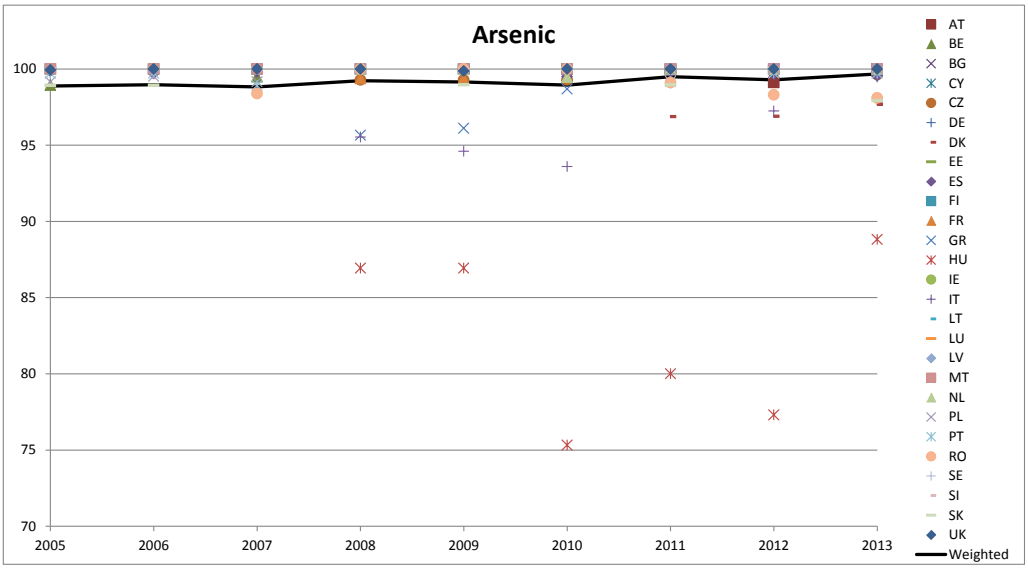
Relative large exceedances, up to 15-20% even recently, occur for the microbial parameters (E.coli and Cl. Perfringens), arsenic, nitrate and lead, while the exceedances for organic compounds (pesticides) is always below 5%.

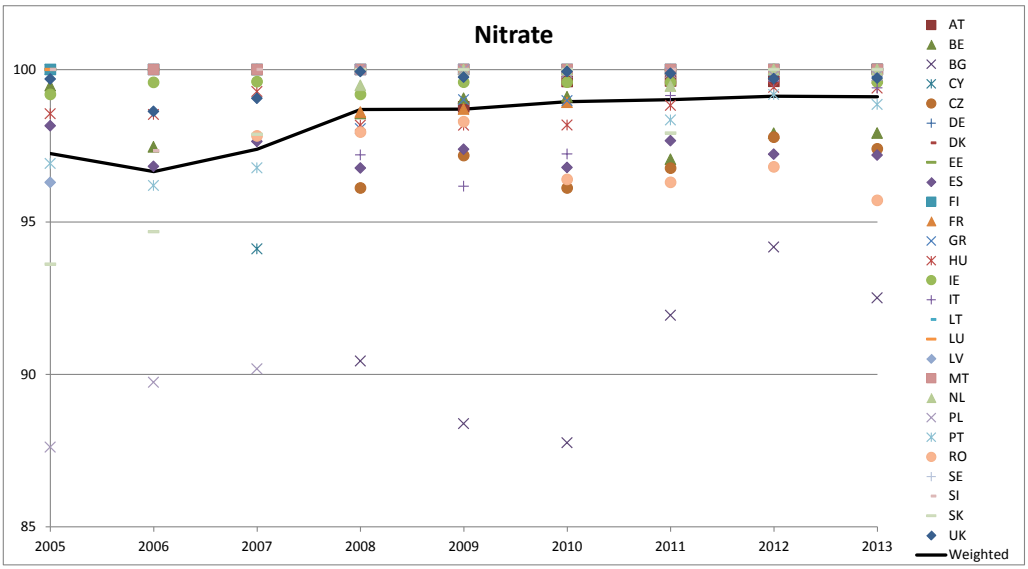
An overview of the total number of reported non-compliances and the contribution of selected member states with relatively high contributions is given in Table B.2

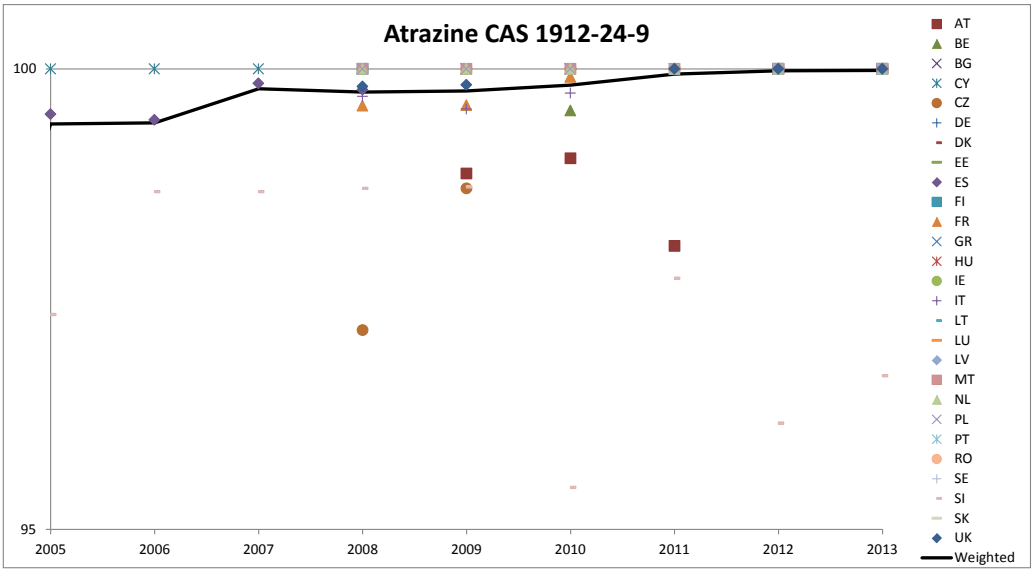
Figure B.7 The mean compliance for each of the ten selected parameters for the period 2005-2013

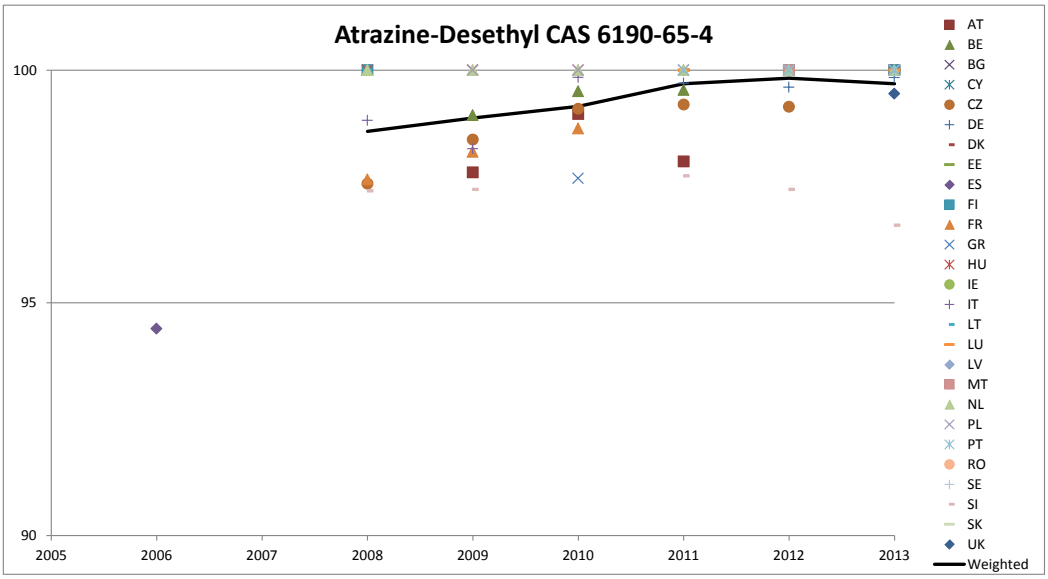


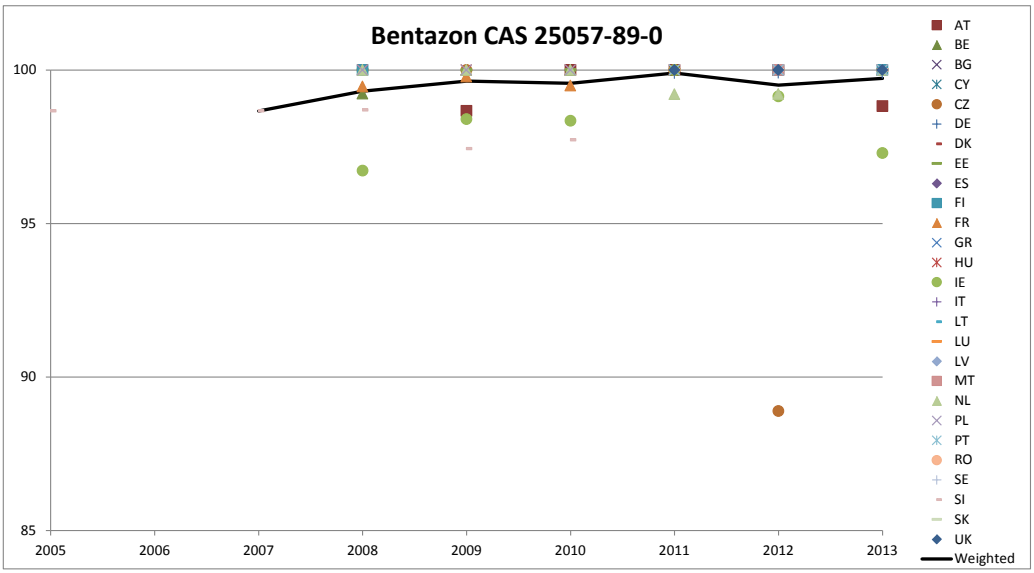

Clostridium perfringens
100
95
90
85
80
75
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted

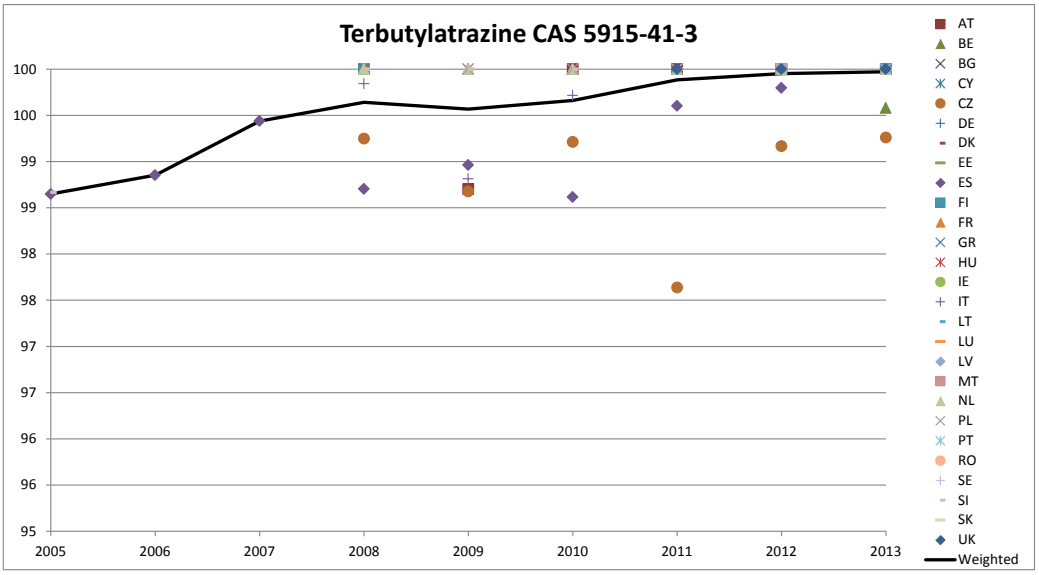

Arsenic
100
95
90
85
80
75
70
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted

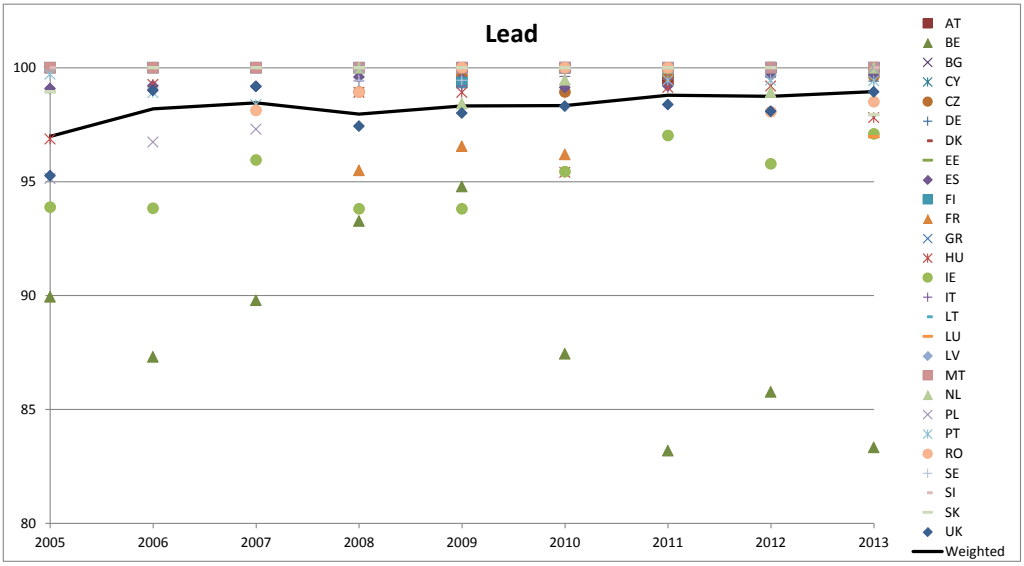

Nitrate
100
95
90
85
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted


Atrazine CAS 1912-24-9
100
95
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted


Atrazine-Desethyl CAS 6190-65-4
100
95
90
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted


Bentazon CAS 25057-89-0
100
95
90
85
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted


Terbutylatrazine CAS 5915-41-3
100
100
99
99
98
98
97
97
96
96
95
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted


Lead
100
95
90
85
80
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted

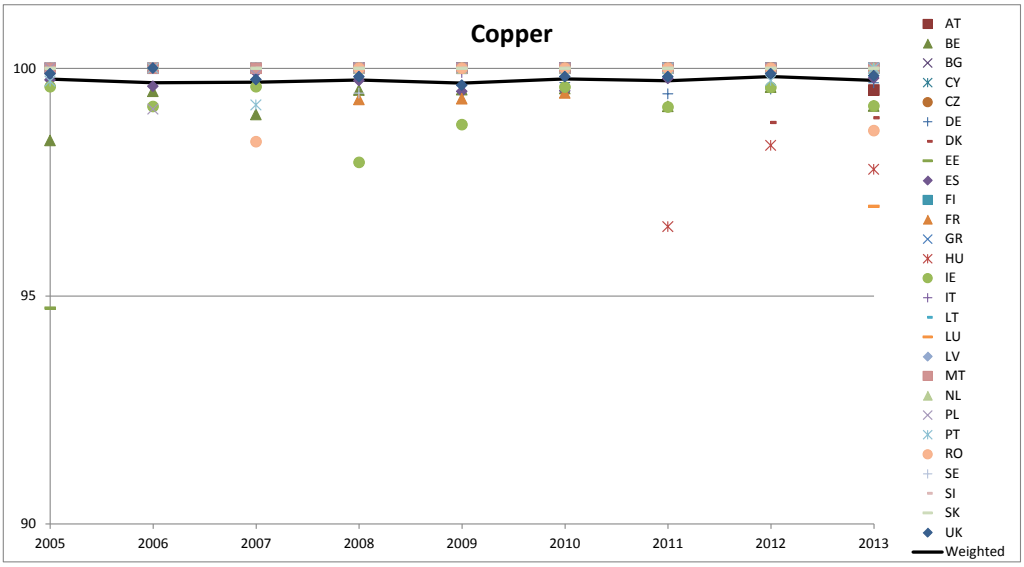

Copper
100
95
90
2005
2006
2007
2008
2009
2010
2011
2012
2013
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
GR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
UK
Weighted

Table B2 Number of reported non-compliances (NC) for the ten selected candidate parameters at EU level, including selected member statesMS with relatively high contributions. For the latter both the absolute number (NC) as the percentage (NP) of reported non-compliances are given.

Parameter	MS	NC	NP	Parameter	MS	NC	PB
Arsenic Total	HU	192	72%	Escherichia coli	BE	185	7%
	EU	268			BG	300	12%
					DE	156	6%
Atrazine CAS 1912-24-9	ES	6	15%		ES	238	9%
	FR	12	30%		HU	183	7%
	SI	12	30%		IT	181	7%
	EU	40			PT	186	7%
					RO	394	15%
Atrazine-Desethyl CAS 6190-65-4	FR	88	70%		SI	107	4%
	SI	18	14%		SK	192	7%
	EU	126			UK	100	4%
					EU	2561	
Bentazon CAS 25057-89-0	FR	8	35%				
	SI	6	26%	Lead	BE	207	29%
	EU	23			DE	52	7%
					ES	99	14%
Clostridium perfringens	BE	76	7%		FR	57	8%
	ES	278	24%		IE	106	15%
	FR	78	7%		UK	130	18%
	HU	82	7%		EU	707	
	IE	238	21%				
	UK	112	10%	Nitrate	BG	111	22%
	EU	1153			ES	146	29%
					RO	78	16%
Copper	DE	34	30%		EU	503	
	IE	18	16%				
	EU	112		Terbutylatrazine CAS 5915-41-3	ES	16	76%
					EU	21	

Changes in numbers of water supply zones in EU with exceedances per parameter

Another way of presenting the improvement in water quality is the trend in the number of WSZ (WSZ) with water quality concentrations that exceed the parametric value. This trend is shown in Table 2 at EU level for all distinguished DWD parameters for the period 2005-2013. Overall, the number of exceedances decreased between 2005 and 2013 for the sum of all microbial parameters, chemical parameters and indicator parameters. For some parameters there are no clear trends, i.e. large fluctuations over the years, but some show clear trends, including cadmium, nitrate, clostridium perfringens, colour, iron, manganese and turbidity.

In Table B.3, results are given of trends in the number of WSZs between 2005 -2013 at MS level with water quality concentrations that exceed the parametric value for the selected 10 candidate parameters. Overall, there is an improvement, especially in countries with initial large (IE, PT, UK)

or very large (PL) exceedances. In many countries with small exceedances in 2005, there is hardly any trend. In ES, exceedances are comparatively high and they remain so.

Table B.3 Number of water supply zones with water quality concentrations that exceed the parametric value for all distinguished parameters in the DWD at EU level.

Type	Parameter	2005	2006	2007	2008	2009	2010	2011	2012	2013
Microbiol.	Enterococci	307	307	710	260	261	306	302	365	328
	Escherichia coli	653	631	669	344	341	416	480	487	476
Chemical	1,2-dichloroethane	1			1		1	0	0	0
	Antimony	30	10	5	7	8	2	5	9	4
	Arsenic	19	77	91	41	44	70	79	80	68
	Benzene	1	1	3				1	1	1
	Benzo(a)pyrene	16	18	23	20	17	14	8	8	10
	Boron	5	29	12	4	17	8	12	15	6
	Bromate	17	19	7	25	33	13	12	10	7
	Cadmium	29	24	15	1	2		3	5	1
	Chromium	3	4	4	3	3		3	1	2
	Copper	8	12	15	15	20	19	24	17	24
	Cyanide	1						0		
	Fluoride	32	35	46	25	28	20	61	51	50
	Lead	170	179	148	102	89	119	103	99	157
	Mercury	5	8	9	5	1	2	4	4	6
	Nickel	64	53	62	82	101	94	98	111	106
	Nitrate	235	224	211	93	92	95	84	80	89
	Nitrate/nitrite formula3	211	180	176	56	59	58	30	30	28
	Nitrite ex water works	93	83	71	23	23	29	15	17	11
	Nitrite in distribution at the tap	7	30	47	54	58	53	59	55	50
	Pesticides – Total	5	7	15	11	20	8	0	34	6
	Polycyclic Aromatic Hydrocarbons	10	22	11	10	8	4	3	4	3
	Selenium	1	4	3	21	26	18	1	7	7
	Tetrachloroethene and Trichloroethene	2	6	4	14	10	4	10	10	7
	Trihalomethanes–Total	104	74	93	68	138	113	71	102	74
Indicator	Aluminium	284	290	319	274	256	259	235	226	207
	Ammonium	98	219	393	154	166	161	153	141	158
	Chloride	90	107	112	94	82	72	71	69	70
	Clostridium perfringens	239	230	203	210	200	196	150	164	154
	Coliform bacteria	1936	2049	2203	1201	1265	1411	1545	1522	1536
	Colony count 22 °C	639	727	726	277	314	377	595	638	606

Type	Parameter	2005	2006	2007	2008	2009	2010	2011	2012	2013
	Colour	693	591	565	181	180	184	206	170	138
	Conductivity	18	16	19	5	8	6	4	2	2
	Hydrogen Ion Concentration	414	381	400	157	156	142	264	247	203
	Iron	1700	1762	1800	670	653	702	883	841	807
	Manganese	1377	1476	1446	334	333	363	448	393	392
	Odour	256	282	265	138	131	119	178	131	118
	Oxidisability	93	59	80	26	30	29	38	34	20
	Sodium	41	94	115	82	75	81	70	67	74
	Sulphate	150	185	191	133	147	127	140	144	155
	Taste	122	120	74	103	93	102	134	114	101
	Total Indicative Dose	13	5	2	6	6	5	1	1	1
	Total organic carbon (TOC)	13	44	35	314	313	304	26	22	38
	Turbidity	1416	1498	1539	349	350	390	420	413	368
Pesticides	2,6-dichlorbenzamide CAS 2008-58-4	1	1	1	2	2	1	1	3	1
	2.4 D CAS 94-75-7			1		3	2		1	4
	Atrazine CAS 1912-24-9	4	4	2	11	12	5	3	4	1
	Atrazine-Desethyl CAS 6190-65-4				42	39	27	8	7	3
	Bentazon CAS 25057-89-0	1	1	2	3	6	5	2	4	2
	Bromacil CAS 314-40-9				1	3	3	2	2	1
	Desethylatrazine [1)]	4	3	2		3	2	0	0	1
	Diuron CAS 330-54-1		2		1	1		1		
	Isoproturon CAS 34123-59-6						2	1		1
	MCPA CAS 94-74-6		1		3	4	1	4	11	6
	Mecoprop CAS 93-65-2 (US EPA 2014); former CAS 7085-19-0								2	1
	Pesticides CAS xxx	4	1	3	22	15	25	23	17	5
	Simazine CAS 122-34-9	8	3		2	2		0	0	3
	S-Metachlor CAS 87392-12-9				2	1		1		1
	Terbutylatrazine CAS 5915-41-3	6	5	3	6	7	7	5	2	2

Type	Parameter	2005	2006	2007	2008	2009	2010	2011	2012	2013
	Acrylamide	1								
	Colony count 37 °C	2	2	6				54	49	55
	Disinfectant residual							2		
	Hardness							6	3	3
	Hydrocarbons							1		
	Nitrite	13	15	6	9	8	7	1	4	2
	Non Volatile Organic Carbon	4	4	4						
	residual free chlorine			30						
	Vanadium							5	6	0
	Vinylchloride							0	0	0
Total number of WSZ [2)]		4170	4388	4764	5838	5861	6357	6894	7001	7195

[1]This pesticide is equal to Desethylatrazine (is synonym of Atrazine-Desethyl CAS 6190-65-4), see e.g. http://www.restek.com/catalog/view/6305.

[2]Note that the number of WSZ that is monitored varies per parameter not all parameter. So this number can only be used as an indication.

Table B.4 Number of WSZ with water quality concentrations that exceed the parametric value for all the selected 10 candidate parameters at MS level

MS	2005	2006	2007	2008	2009	2010	2011	2012	2013
AT					9	15	16	13	10
BE	16	29	25	46	44	74	108	95	80
BG				83	81	97	58	53	62
CY	7	8	8	1	1	5	3	6	7
CZ				41	26	25	36	21	25
DE							72	63	79
DK	9	9	9				6	6	6
EE	1			4		1			
ES	113	153	143	111	141	118	107	116	177
FI		2	1	2	3	1			
FR				121	105	86			
GR				22	20	18			
HU	11	103	122	80	80	144	74	73	52
IE	90	77	57	80	51	43	23	24	20
IT							128	138	140
LU							2	3	3
LV	1	5	1	3	1	1	1		
MT	4								
NL	29	50	48	17	25	19	18	17	19
PL[1]	**686**	**593**	**535**	8	5	9	3	2	3
PT	142	136	140				101	87	74
RO			82	68	61	81	55	101	101
SE				4	1	2			

MS	2005	2006	2007	2008	2009	2010	2011	2012	2013
SI	39	17	38	32	28	24	12	17	11
SK	26	22	17	25	27	31	35	25	30
UK	161	159	118	122	102	83	80	84	77
Grand Total	**1335**	**1363**	**1344**	**870**	**811**	**877**	**938**	**944**	**976**

1 These numbers for PL could be an artefact due to data quality.

Table B.4 provides, the results for the ten candidate parameters per MS. There is overall an improvement in all countries, but the variation is large especially in the exceedance of Escherichia coli and Cl. Perfringens that show a rather erratic behaviour, sometimes increasing and then decreasing in several countries.

Table B.5 Number of WSZ (or percentage of WSZ were we can also scale to water supply) at MS level with water quality concentrations that exceed the parametric value for each of the selected 10 candidate parameters

Par.	MS	2005	2006	2007	2008	2009	2010	2011	2012	2013
Arsenic	AT								1	
	BE						1			
	CZ				2	2	2			1
	DE					1	1	3	2	2
	DK	4	4	4				4	4	3
	ES	1	3	2		1	4	2	3	4
	FR				7	8	4			
	GR				3	2				
	HU	2	62	69	29	29	57	28	32	17
	IT							36	35	35
	NL						1			
	PL	9	6	11				1		
	PT	1	1	4				3	1	1
	RO			1				1	2	3
	SK	1	1			1		1		2
	UK	1								
		19	77	91	41	44	70	79	80	68
Atrazine CAS 1912-24-9	AT					1	1	2		
	BE						1			
	CZ				3	2				
	DE					2				
	ES	2	3	1	1					
	FI					1				
	FR				6	5	1			
	IT							0	1	0
	SI	2	1	1	1	1	2	1	3	1
		4	4	2	11	12	5	3	4	1
Atrazine-Desethyl CAS 6190-65-4	AT					2	1	2		
	BE					2	1	1		
	CZ				2	2	1	1	1	
	DE							3	4	2
	FR				38	31	19			
	SI				2	2	5	1	2	1

Par.	MS	2005	2006	2007	2008	2009	2010	2011	2012	2013
				42	39	27	8	7	3	
Bentazon CAS 25057-89-0	AT					1				1
	BE				1					
	CZ								1	
	DE							1	1	1
	FR				1	3	4			
	IT								1	
	NL		1	1				1	1	
	SI	1		1	1	2	1			
		1	1	2	3	6	5	2	4	2
Clostridium perfringens	AT									1
	BE	3	2	2	9	11	14	11	18	7
	BG				1	5	4	3	2	7
	CZ							11	4	6
	DE					7	18	10	6	14
	ES	38	57	52	42	58	37	37	48	46
	FI		1							
	FR				29	22	27			
	GR				4	4	4			
	HU				11	11	24	13	16	7
	IE	49	37	32	44	22	24	10	11	9
	IT							2	1	2
	NL	8	15	20	9	12	8	4	4	6
	PL	50	53	37	2	2				
	PT	44	23	32				15	17	19
	RO				2	1	3	3	3	6
	SI	14	0	10	14	6	4		4	2
	SK		4	1	4	5	3	3	2	
	UK	33	38	17	39	34	26	28	28	22
		239	230	203	210	200	196	150	164	154
Copper	AT									1
	BE			2	1	1	1	2	1	2
	DE					1	6	11	9	7
	DK	1	1	1					1	1
	EE	1								
	ES	2	4	1	2	4	4	2		2
	FR				3	5	5			
	HU							4	2	3
	IE	1	2	1	5	3	1	2	1	2
	IT							0	0	0
	PL		1	1						
	PT	1	4	3					1	
	RO			2						3
	SE				1					
	UK	2		4	3	6	2	3	2	3
		8	12	15	15	20	19	24	17	24
Escherichia coli	AT					4	12	10	11	7

Par.	MS	2005	2006	2007	2008	2009	2010	2011	2012	2013
	BE	7	4	4	18	17	26	47	37	25
	BG				58	53	69	39	40	41
	CY	7	8	7	1	1	5	3	6	7
	CZ				17	12	7	11	8	9
	DE					22	42	28	29	35
	DK	4	4	4				2	1	2
	EE				4		1			
	ES	43	40	49	34	49	34	36	36	34
	FI		1	1	2	1	1			
	FR				2	2	2			
	GR				13	13	13			
	HU	8	36	51	33	33	49	26	21	21
	IE	23	22	12	14	10	6	3	2	1
	IT							83	89	94
	LT				1					
	LU							2	3	3
	LV		5	1	3	1	1	1		
	NL	20	33	25	7	10	9	13	10	13
	PL	369	326	292	6	3	8	1		1
	PT	84	90	83				75	63	48
	RO			69	56	46	62	40	78	73
	SE				2		2			
	SI	21	14	26	14	17	12	10	8	7
	SK	18	12	14	21	21	28	29	23	26
	UK	49	36	31	38	26	27	21	22	29
		653	631	669	344	341	416	480	487	476
Lead	AT							1		
	BE	5	19	17	14	11	28	40	34	40
	BG							1		
	CZ				3	1	3	1		1
	DE					2	13	16	8	13
	ES	7	8	9	3	4	7	7	3	65
	FI					1				
	FR				23	14	20			
	HU		1		2	2	9	1	1	3
	IE	15	15	11	15	15	11	7	10	7
	IT							1	3	1
	NL	1		1		3	1		2	
	PL	69	48	39						
	PT	1	4	6				2	2	2
	RO			3					6	4
	SE				1	1				
	SK	1								2
	UK	71	84	62	41	35	27	26	30	19
		170	179	148	102	89	119	103	99	157
Nitrate	AT						1	1	1	
	BE	1	4		3	2	2	7	5	5

Par.	MS	2005	2006	2007	2008	2009	2010	2011	2012	2013
	BG				24	23	24	15	11	14
	CY			1						
	CZ				9	7	11	9	6	7
	DE					2	2		4	5
	ES	15	33	26	24	21	26	21	25	26
	FR				12	15	4			
	GR				2	1	1			
	HU	1	4	2	5	5	5	2	1	1
	IE	2	1	1	2	1	1	1		1
	IT							6	8	8
	LV	1								
	MT	4								
	NL		1	1	1					
	PL	189	159	155			1	1	2	2
	PT	11	14	12				6	3	4
	RO			7	10	14	16	11	12	12
	SI		2							
	SK	6	5	2				2		
	UK	5	1	4	1	1	1	2	2	4
		235	224	211	93	92	95	84	80	89
Terbutylatrazine CAS 5915-41-3	AT					1				
	BE									1
	CZ				1	2	1	3	1	1
	ES	5	5	3	5	4	6	2	1	
	SI	1								
	Total	6	5	3	6	7	7	5	2	2

Trends in concentrations of selected candidate parameters

The excel sheets since 2005 do not only give information on non-compliances but also on actual concentrations, but only in terms of annual minimum, median and maximum concentrations. Trends in annual minimum, median and maximum concentrations over the period 2005-2013 thus derived for the ten candidate parameters at EU level are given in Figure B.8.

Results show a decrease in the median concentration of both lead and Escherichia coli. The mean non-compliance value for lead in the period 2008-2013 is about 40 µg/l, a fourfold exceedance of the standard (10 µg/l).

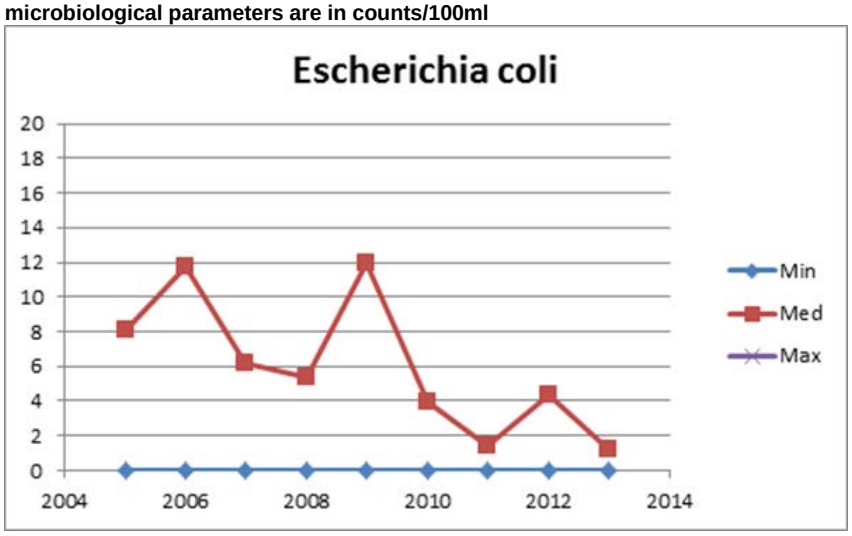
Beware that median concentrations are not always calculated in national databases. For example, in the NL, the database only contains minimum, average and maximum concentrations at a given sampling location and in the dataset, the average concentration is thus provided instead of the median.

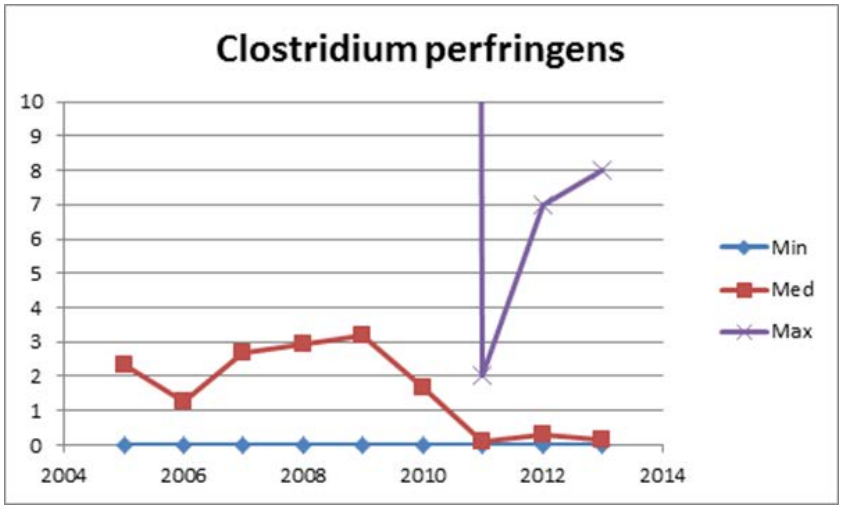
B.3.3 Variation in current water quality in large and small WSZs (mean 2010-2013)

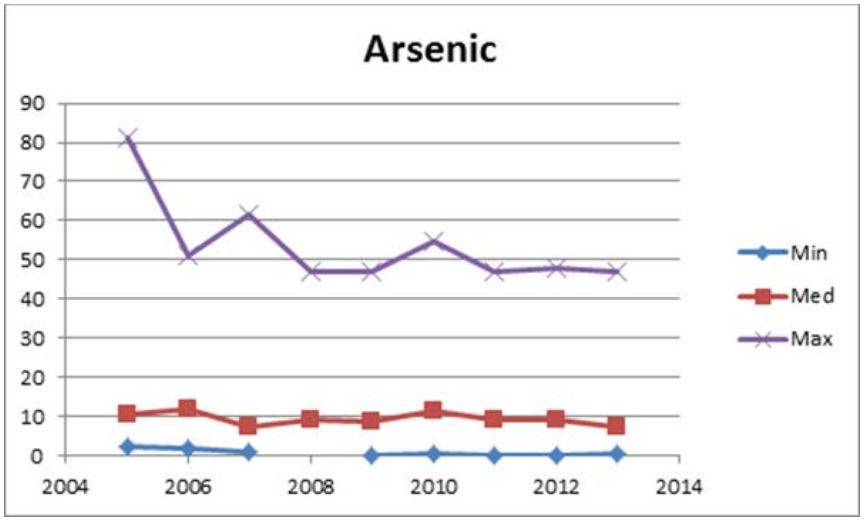
In general water quality is poorer in small than in large WSZs. This is illustrated in Figure B.8 for the ten candidate parameters, in terms of percentage non-compliance based on an analyses of all individual large and small WSZs at EU level for the period 2010-2013. Results are based on the ten

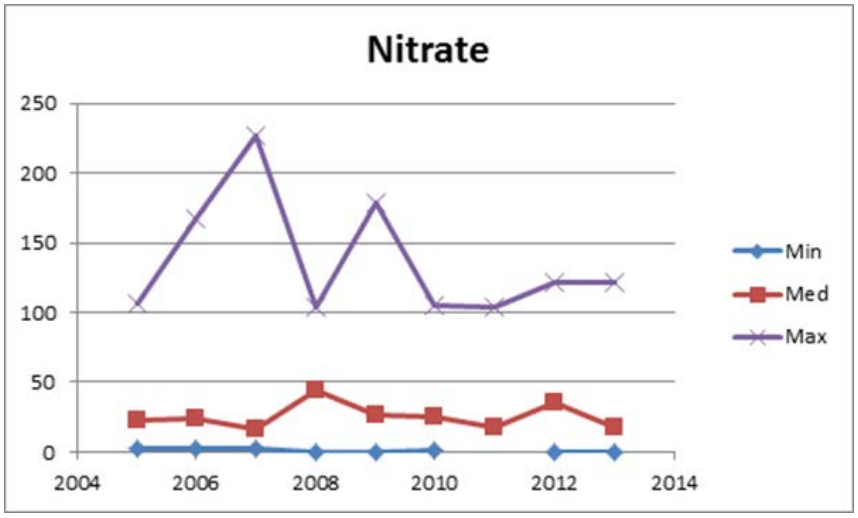
MS for which data were available for both WSZs, i.e. BG (Bulgaria), CY (Cyprus), ES (Spain), HU (Hungary), LU (Luxemburg), MT (Malta), PT (Portugal), RO (Romania), SI (Slovenia) and SK (Slovakia). While non-compliance is always less than 2% and mostly near negligible for all ten parameters in large WSZs, it is up to 12% for E Coli in small WSZs (Figure B.9)

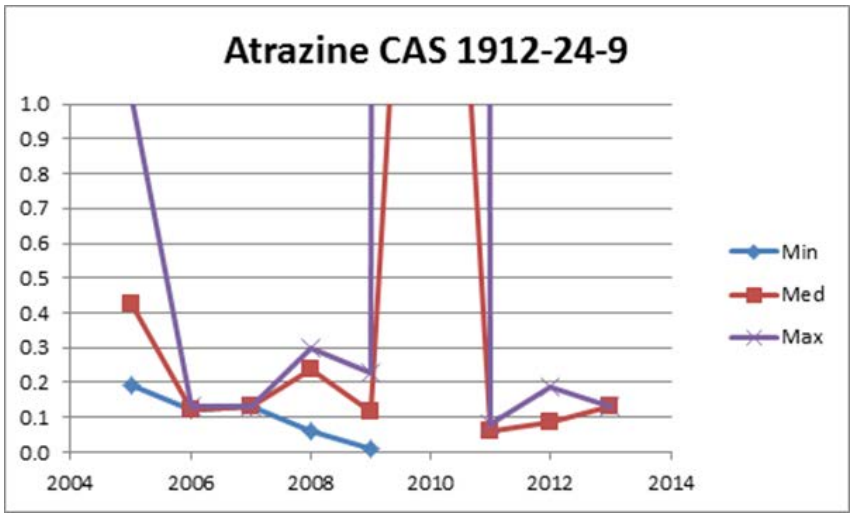
Figure B.8 Trends in water use weighted minimum, median and maximum concentration at EU level of the ten selected parameters over the period 2005 – 2013. All chemical parameters are given in µg/l. The microbiological parameters are in counts/100ml

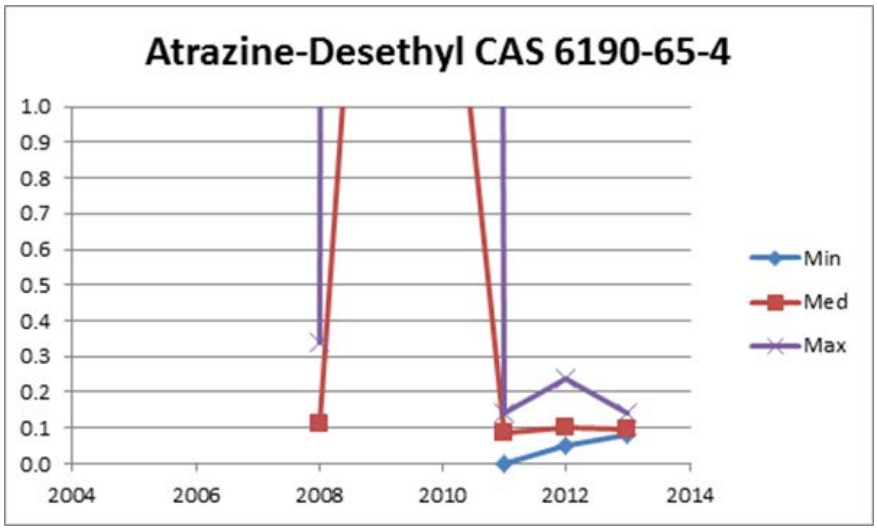


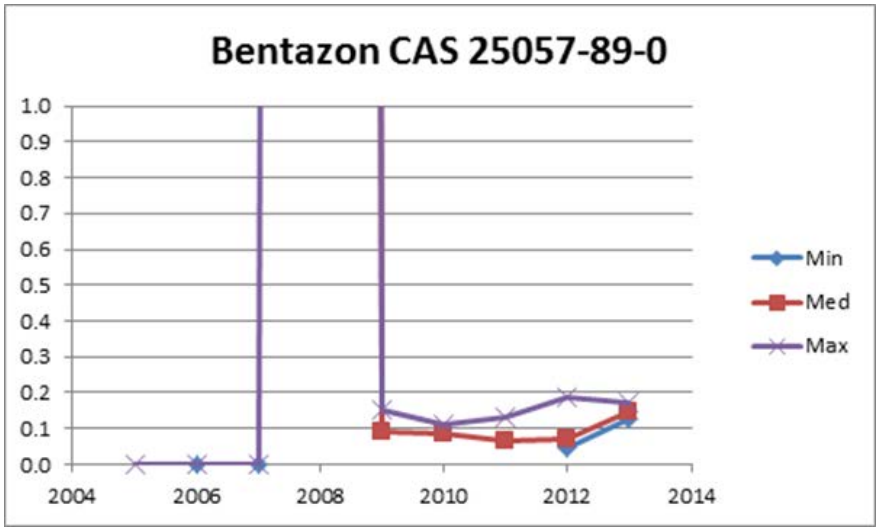


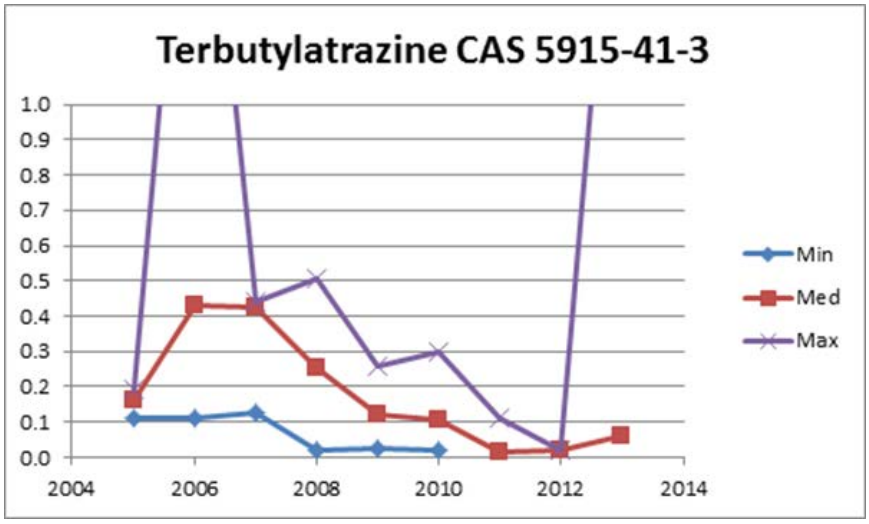


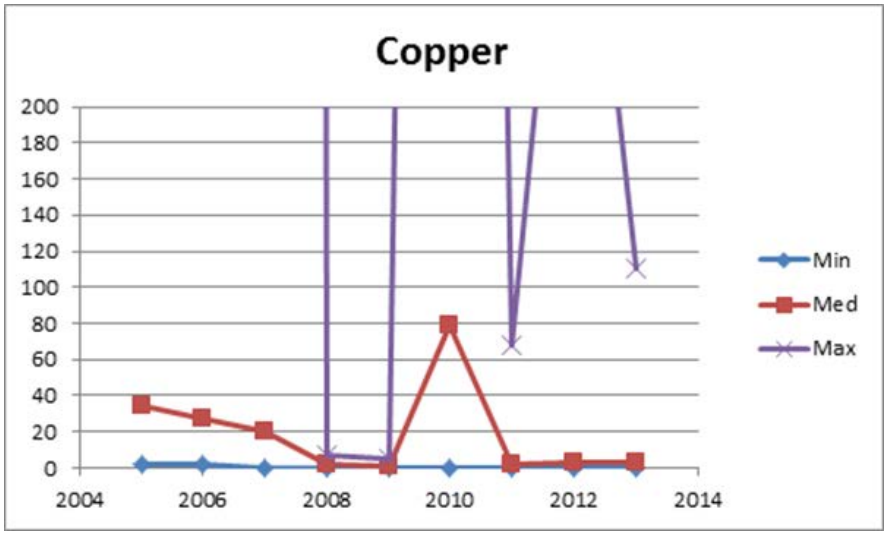

Nitrate
250
200
150
100
50
0
2004
2006
2008
2010
2012
2014
Min
Med
Max


Atrazine CAS 1912-24-9
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2004
2006
2008
2010
2012
2014
Min
Med
Max


Atrazine-Desethyl CAS 6190-65-4
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2004
2006
2008
2010
2012
2014
Min
Med
Max


Bentazon CAS 25057-89-0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2004
2006
2008
2010
2012
2014
Min
Med
Max


Terbutylatrazine CAS 5915-41-3
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2004
2006
2008
2010
2012
2014
Min
Med
Max


Copper
200
180
160
140
120
100
80
60
40
20
0
2004
2006
2008
2010
2012
2014
Min
Med
Max

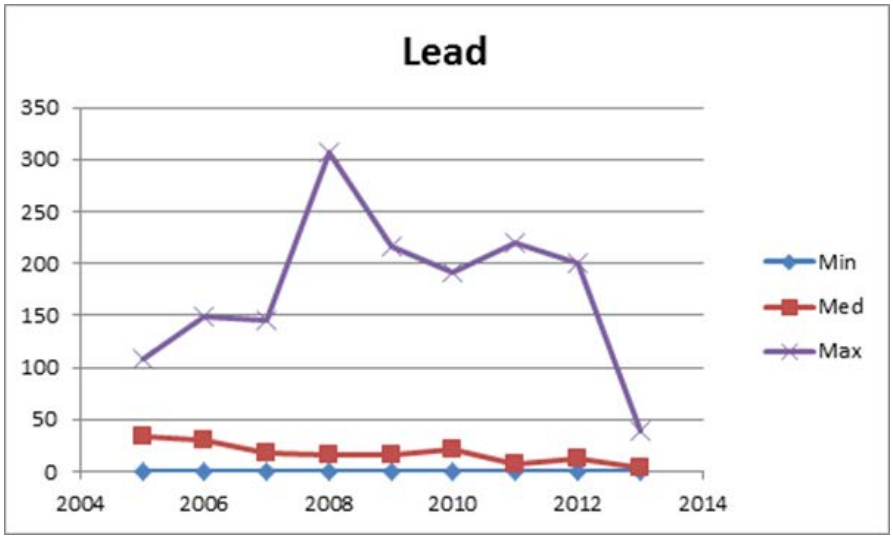
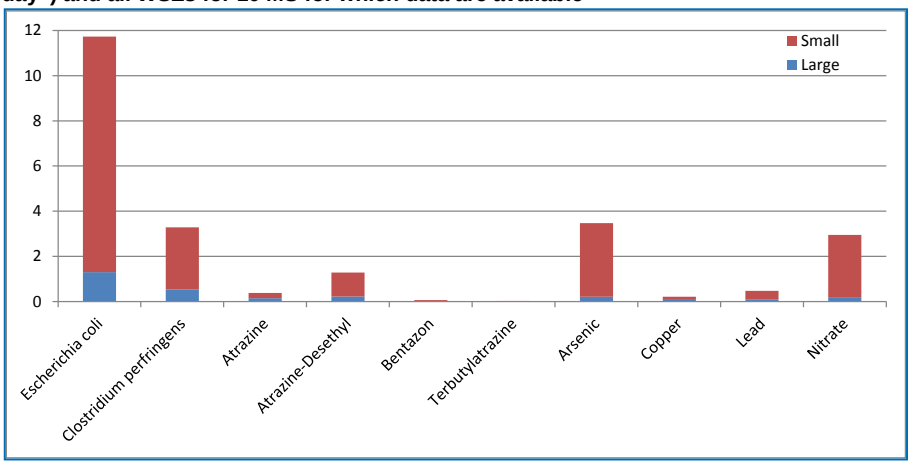
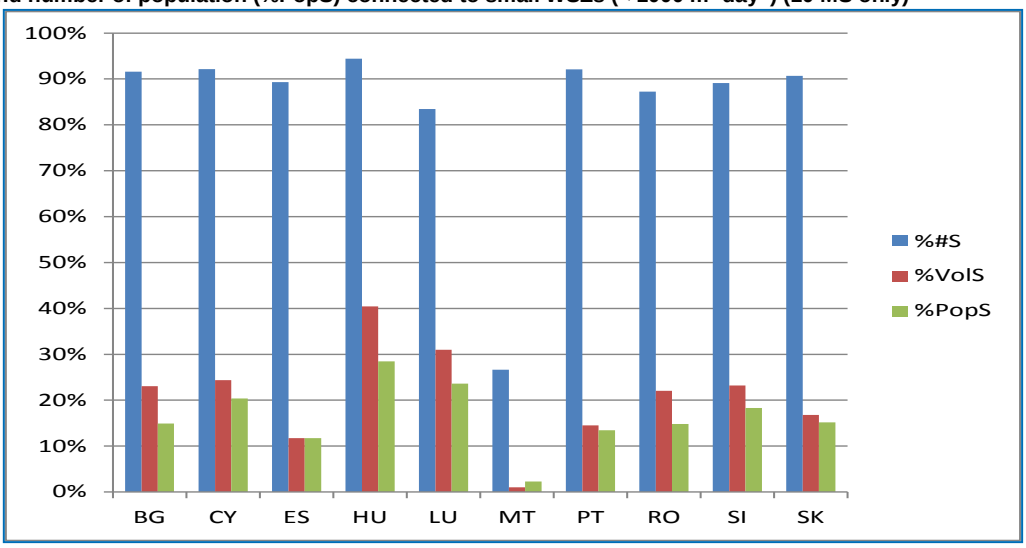


Figure B.9 Percentage compliance of the ten candidate parameters for large and small WSZs (< 1000 m^3 day^{-1}) and all WSZs for 10 MS for which data are available



Although the total number of small WSZs is much larger than that of the large WSZs, the total water production and the population depending on it is much smaller compared to large WSZs as illustrated in Figure B.10.

Figure B.10 Relative number of small WSZs (%#S), share of water production by small WSZs (%VolS) and number of population (%PopS) connected to small WSZs (< 1000 m^3 day^{-1}) (10 MS only)



In each of the ten MS, except for MT (Malta), nearly 90% of the WSZs are small, but in most cases less than 20% of the water production comes from these small WSZs and similarly mostly less than 20% of the population depends on those small WSZs.

Apart from the occurrence of exceedance, also the level of exceedance is of interest. This is illustrated in Table 6 presenting the percentage of large WSZs (as % of total) where the median concentration exceeds the limit of the ten candidate parameters. The results show that the percentage is mostly less than 1% except for Escherichia coli and Clostridium perfringens that was exceed in more than 50% of the measurements in nearly 5% of the WSZs in Denmark.

Table B.6 Percentage large WSZs (% of total based on annual water intake) per MS where there is a non-compliance in more than 50% of the measurements (the median concentration exceeds the limit) for each of the ten candidate parameters. NB: for 2 pesticides this never occurred

MS	% WSZs at which median concentration exceeds the limit							
	Escherichia coli	Clostridium perfringens	Atrazine-Desethyl	Bentazon	Arsenic	Lead	Copper	Nitrate
BG								0.54
CZ								0.11
DE	4.67	4.23		0.01	0.02	1.36	0.51	0.05
DK					1.21		0.77	
ES		0.04			0.03	0.47	0.27	0.42
HU		0.29			1.10			0.12
IT					0.01	0.00		
PL								0.02
PT					0.12	0.04		
RO					0.07			0.54
SI			1.06					
UK								0.04

B.4 Analysis of the causes of non-compliances

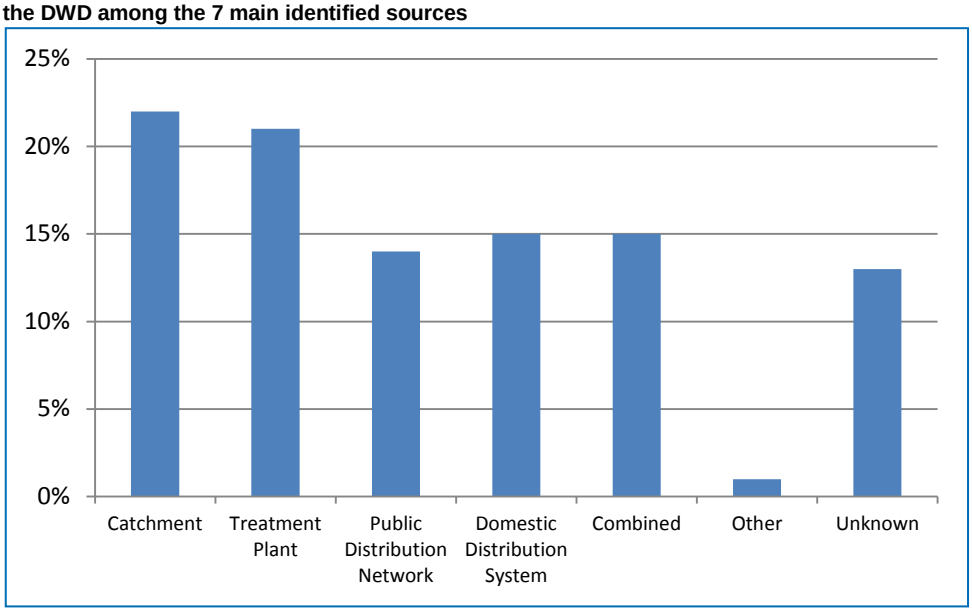
B.4.1 Reported causes by the member states

Based on the inventory of member states in 2013 non-compliances for all parameters and indicators were listed as well as for the 10 selected substances. In addition, the causes underlying the non-compliance as reported by member states were included. Here a distinction between 7 different causes was made:

1. Catchment related; representing the impact of geology, land use, soil type and hydrology;
2. Treatment plant related, representing the impact of the installations used to treat the water after abstraction from either groundwater of surface water;
3. Public distribution network related; representing the impact of the distribution network between the treatment plant and the domestic system;
4. Domestic distribution systems; representing the impact of the quality of the water distribution systems after supplying the water to the private home-owners;
5. Combined sources;
6. Other sources not specified;
7. Unknown.

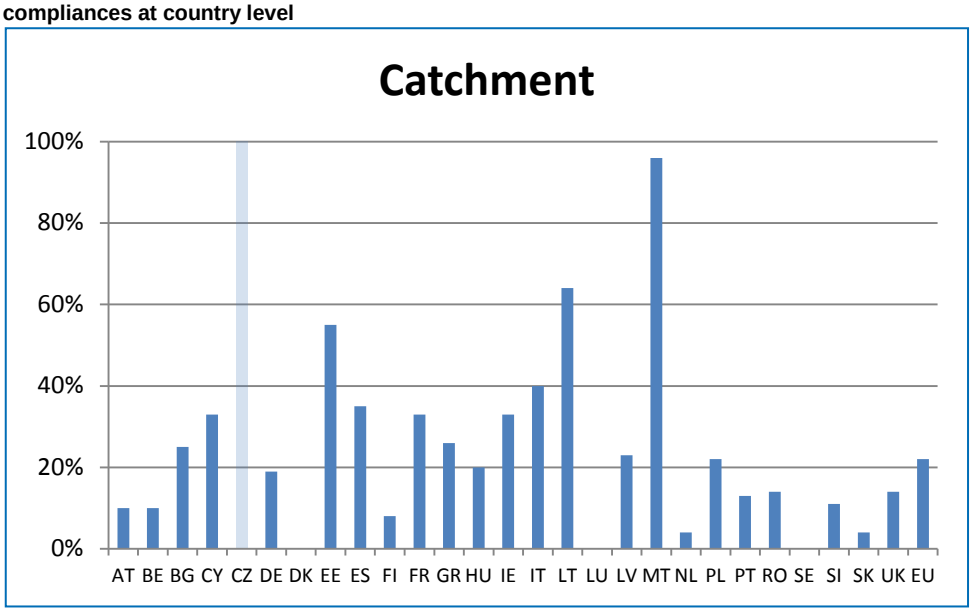
In figure B.11 the overall distribution of all reported non-compliances for all parameters included in the DWD at EU level (40695 in total) among the 7 groups distinguished is shown. Figure A.C.10 shows that the contribution of catchment related sources and treatment plant sources combined contribute to approx. 45% of all non-compliances. The sum of the distribution networks, including public and domestic distribution amounts to approx. 29% of the sum of all non-compliances. The remaining part is equally distributed among combined sources (15%) and unknown sources (13%).

Figure B.11 Overview of distribution of causes for the non-compliances of all parameters monitored in the DWD among the 7 main identified sources



Obviously significant differences in the distribution between countries and parameters exist. Figure B.12 shows for example the relative contribution of catchment related sources to the total number of non-compliances at country level. In some cases the total number of non-compliances is low (e.g. CZ, 18 in total) and these appeared to be all catchment related. For most countries the contribution of catchment related causes ranged between 10 and 25% with the exception of EE, LT, IT and MT where catchment related causes are higher than 40% of the total number of observed non-compliances.

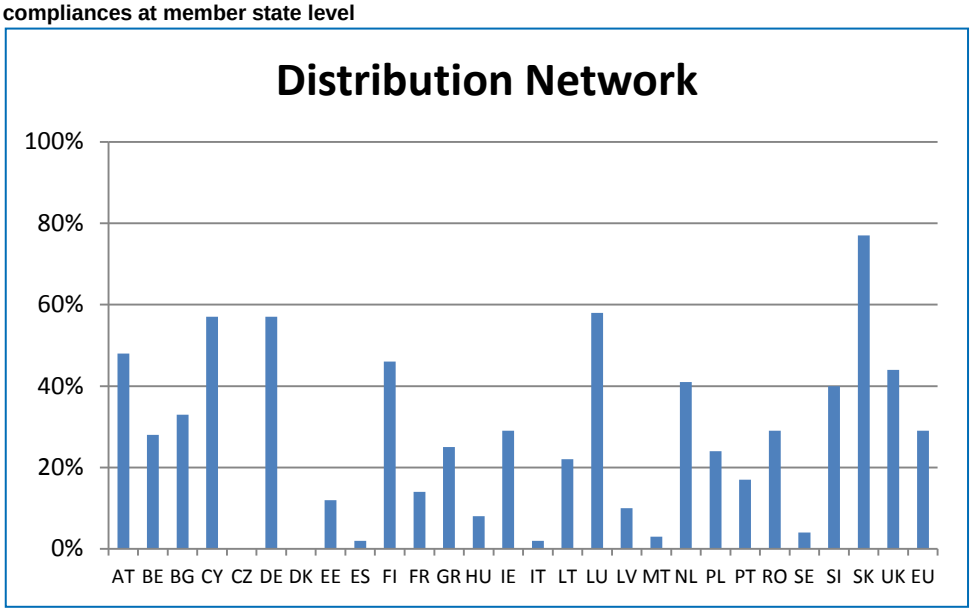
Figure B.12 Contribution of catchment related non-compliances relative to the total number of non-compliances at country level



Obviously, the overall number of non-compliances for the 10 selected parameters is less (5514) compared to all parameters (40695). The overall distribution of causes for non-compliances for the 10 selected parameters is, however, more or less equal to that of the all parameters (see Annex I).

Noteworthy exceptions to average values include (data shown in Appendix 1) a relatively high contribution of the domestic supply system in CY, DE, IE, LU, SLI, SK, UK, which partly (for LU, DE, SK) corresponds with relatively high contributions of the public distribution system. This is illustrated in Figure B.13 that shows the contribution of the combined effect of private and public distribution networks at country level

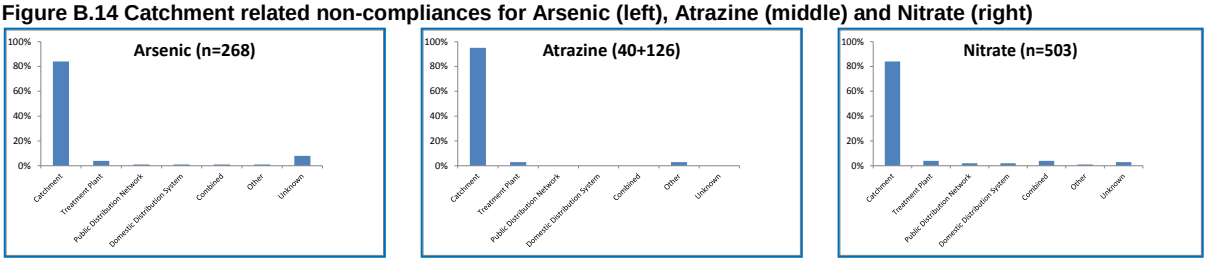
Figure B.13 Relative contribution of private and public distribution network to the total number of non-compliances at member state level



Differences between member states can have difference reasons including differences in land use (e.g. intensity of agriculture related to catchment controlled sources versus the quality of the distribution network). The results from the 10 selected substances shows three different main causes, depending on the substance considered:

1. Non-compliances related to *catchment*. This is the case for arsenic, nitrate, and all pesticides. For these substances more than 80% of all non-compliances are related to catchment as shown in Figure B.14. For Arsenic, this can be related the combined impact of geology and hydrology and for both pesticides and nitrate, this can be assigned to land use; more specifically the impact of agriculture, being the main source of these substances through application of manure, fertilizer and pesticides.

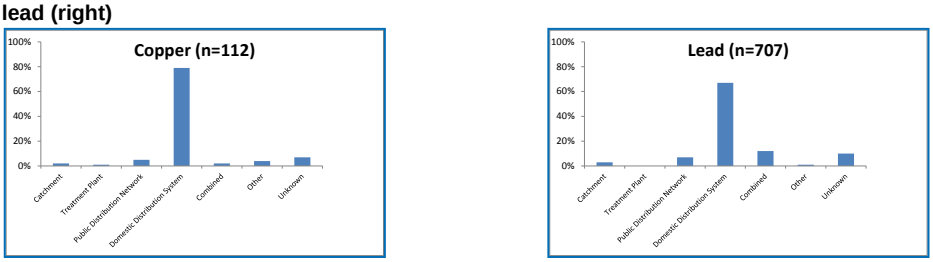
Figure B.14 Catchment related non-compliances for Arsenic (left), Atrazine (middle) and Nitrate (right)



The distribution for the other pesticides included here is similar to that of Atrazine and dominated by catchment related sources.

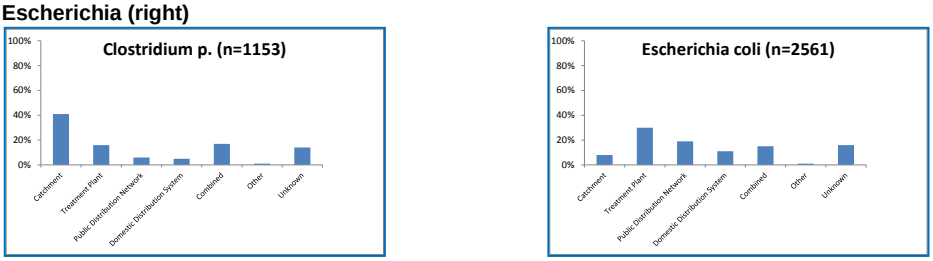
2. Non-compliances related to *the distribution network*. For both copper and lead the contribution of the distribution networks, and largely the domestic distribution network is the main reason for the observed non-compliances (Figure B.15). For lead approximately 10% of all non-compliances is of mixed origin probably including the impact of catchment as well.

Figure B. 15 (Private) distribution network dominated causes of non-compliances for copper (left) and lead (right)



3. *Mixed sources.* For both Clostridium perfringens and Escherichia coli, there appears to be no clear single factor that controls the presence of these indicators (Figure B.16) even though the contribution of the catchment (for Clostridium) and treatment plant (for Escherichia) are clearly higher than the other identified causes.

Figure B. 16 Contribution of difference sources to non-compliances for Clostridium (left) and Escherichia (right)



B.4.2 Analyses of trends in non-compliances in relation to causes as reported by MS

As shown by the overall trends in Section 2, a substantial increase in water quality has been documented when looking at the trends in water quality as such. As shown in the previous paragraph 3.1, a clear link with causes can be identified for specific parameters. Nitrate, arsenic and pesticides largely are controlled by catchment conditions, lead and copper are largely related to distribution systems and both clostridium and Escherichia coli have no dominant cause of non-compliance. Especially in the situation of lead and copper, where a reduction in non-compliances occurred with the cause mainly being to distribution system related, it is clear that the actions carried out within the DWD is the main cause for this improvement. This is most likely also, at least partly true for both Clostridium and Ecoli. For nitrate, arsenic and pesticides, it may be an improvement due to other directives regulating the application.

An additional question is to assess to what extent *trends* in causes related to non-compliances can be identified. In order to perform the trend analysis the data were first screened on the continuity of the data for all countries. It was decided to only use data from countries that, for an individual parameter, have delivered a continuous record of analyses. This limits the number of countries included to 12 (BE, CY, ES, HU, IE, LV, NL, PL, RO, SI, SK, UK). Here we used the remaining data for the period 2005 – 2013. In Appendix 1 the full results are shown.

Results from the data analysis show that:

- For both Clostridium and Escherichia coli there is a clear decrease in non-compliances for the 12 selected countries with an increase in treatment plant related causes in time;
- For all pesticides there is no real trend and the data show that the main cause of non-compliance remains catchment related. The remaining number of samples however is too small to derive meaningful trends in causes of non-compliances;
- For arsenic the data are dominated by non-compliances reported by Hungary (325 out of 388) which largely appear to be catchment related although 133 cases are not related to any cause (blank);
- For lead a substantial number of non-compliances are still reported for the UK, B, IE, Pl and ES. Despite a trend towards a lower number of non-compliances, the non-compliances related to domestic distribution networks increased from 2010 onwards. This shows that regional (or even national) data and trends derived from this are not necessarily in line with the overall trends observed at EU level.

Since the number of data remaining after screening for complete records is limited some results are clearly biased (e.g. in case of arsenic) by the number of countries and or (low) number of non-compliances. These data therefore do not allow for an in depth analysis of trends in causes and hence cannot be used to further evaluate the effectiveness of the DWD in relation to the quality of drinking water.

B.4.3 Analyses of trends in non-compliances in relation to causes as reported by MS

An overview of trends in remedial actions for the period 2005-2013 based on Eionet data from 12 countries with a continuous monitoring record for the parameters are presented in Annex B-2.

Results show that:

- By far most of the most of the remedial actions are related to the microbiological parameters E Coli (for 2561 WSZ) Clostridium perfringens (1153), followed by lead (707), nitrate (503) and arsenic (268).
- The remedial actions for Clostridium perfringens are mainly catchment related (292) (Action performed: terminate or mitigate the cause), whereas the remedial actions for E Coli are mainly treatment-related.
- The remedial actions for lead are mainly distribution related, but remarkably also catchment related.
- The remedial actions for nitrate are mainly catchment related with an emphasis on replacing source.

In the period 2005-2013 more and more MS reported remedial actions. Most of the performed are related to the microbiological parameters (E Coli and Clostridium perfringens) and to a lesser extend to chemical parameters (lead, nitrate and arsenic).

B.4.4 The contribution of the DWD to the observed changes in water quality

The overall trends as reported in Section 2 of this annex illustrate the substantial increase in water quality. Furthermore, as shown in the previous Section 3.2, a clear link with causes can be identified for specific parameters. In short, non-compliances for land use related substances (including nitrate and pesticides) as well as substances controlled by geogenic processes such as arsenic largely are controlled by catchment conditions, whereas non-compliances of lead and copper are largely related to distribution system functioning. For some of the microbial indicators including clostridium and Escherichia coli no single dominant cause of non-compliance could be identified.

The question now arises to what extend the DWD can be held responsible for the observed increase in drinking water quality as illustrated in the previous chapters. The rationale for this is based on logic reasoning and expert judgement as presented below

Impact of DWD on substances controlled by land use and geology (nitrate, arsenic and pesticides)

For parameters such as nitrate, arsenic and pesticides where *catchment related causes* dominate, it can be deducted that that other directives regulating the inputs (e.g. the nitrates directive and pesticides directive; DIRECTIVE 2009/128/EC) could be held responsible for the observed trends in water quality especially if acceptable levels as regulated by those directives are equal to or lower than those imposed by the DWD. However, one has to consider, among others, the travel time and decay rate of such substances in relation to the timeframe during which the DWD has been in place. Considering the long time-delay in case of abstraction of *deep groundwater* for drinking water it is highly unlikely to observe impacts of measures reducing inputs in deep aquifers within a time scale of 1 to 2 decades. The travel time of water on average equals 1 meter per year which implies that it takes more than 20 years for dissolved nitrate to reach deep groundwater wells. This holds even more for arsenic that interacts with the solid phase resulting in retention (notably via sorption to oxides) . This line of reasoning suggests that for *deep* groundwater, observed changes in concentrations must have been due to the DWD, e.g. by mixing of waters or closing wells rather than a relation with reduced inputs as imposed by other Directives.

Since the impact of land use (emission) clearly will become noticeable in shallow groundwater (let alone surface water) it is likely that, such as in the Netherlands, several water abstraction zones using shallow groundwater have been closed due to increased levels of nitrate which was considered unacceptable because of the installation of the DWD. .In those cases, the Nitrates Directive was not able to prevent non-compliances for nitrate and an additional improvement of water quality was achieved due to the DWD. Despite the observed improvements in water quality, nitrate concentrations in subtracted (shallow) groundwater may still exceed the DWD standard. In order to prevent this, it is more effective to monitor the nitrate concentrations in shallow groundwater rather than in subtracted water.

In case of abstraction of shallow groundwater, however, or inlet of surface water for drinking water purposes it cannot be ruled out that reductions in concentrations and in non-compliance have resulted from increased efforts to reduce inputs of nitrate and pesticides as well. For nitrate in surface waters other Directives (in casu the Water Framework Directive) are more stringent than the DWD so here the DWD may have had an added effect in reducing surface water levels in addition to the WFD but the DWD is likely not to be the main driver for the observed increase in water quality .

An absolute scaling of the impact of the DWD relative to that of other directives that have become active during this timeframe (including Nitrates Directive, Pesticides Directive) is not possible since all of these Directives share to some extend the level of regulation (for nitrate and pesticides both the DWD and related Directives regulate drinking water quality at the same level)

Impact of DWD on lead and copper

For copper and lead, for which *distribution network related causes* dominate the exceedances, the DWD has clearly been one of the main drivers that has resulted in the decrease of the non-compliances. This holds in general for all parameters for which exceedances are related to causes in the distribution network, since the DWD is the single most important Directive addressing these

substances after the water has been processed and enforces remedial action in case of non-compliances. A reduction of non-compliances can thus be attributed to the DWD.

On the other hand, the DWD has had limited or no impact on the quality of water *prior to* the interaction of water with the distribution network. Water quality in aquifers, either deep or shallow as well as that of surface water are largely controlled by natural processes (retention of metals by sediments and soils whereas inputs to the system are regulated to directives targeting environmental quality. This includes: (i) the Water Framework Directive, in which the acceptable Cu level in surface water is much lower than the acceptable level in drinking water regulated by the DWD and (ii) the Nitrates Directive and the Directive regulating additives in feeding stuffs (70/524/EEC), which both regulate application rate and quality of manure which indirectly also regulates supply of copper and zinc). Considering the allowed input levels either via fodder, manure or water and the strong retention of copper and lead to the solid matric it is highly unlikely that concentrations of copper in aquifers (i.e. before interaction with the distribution network) would reach levels at which the DWD becomes effective. Normal observed ranges of copper in shallow or deep groundwater are in the order of magnitude of 1 to several 10's of microgram per litre whereas the DWD regulates copper at levels in excess of 2000 microgram per litre.

Impact of DWD on mixed causes

For some parameters in the DWD, notably the microbiological parameters no clear main cause for the observed non-compliance was found. Based on the data supplied other than the chemical substances discussed earlier (nitrate, pesticides, copper, lead), increased levels of microbiological parameters are not so much related to land use or slow processes (infiltration to groundwater), but related to (partly unpredictable) incidents such as shortcuts in distribution systems leading to the accidental contamination of the drinking water distribution system with (treated) sewage effluent. The latter may also catchment related in case of contaminated surface water used for drinking water. Having a DWD in place clearly accelerates the chances of early detection even though the frequency of the monitoring periods can be such that outbreaks can occur and lead to widespread infections. It is thus very likely that the DWD has contributed to the decrease in microbiological parameters. An indicative illustration of an qualitative assessment of the likelihood that DWD has an impact on the drink water quality is given in the table below. It is, however, not possible to determine the extent to which the DWD indeed has resulted in a decline in exceedances of the non-compliances of microbiological parameters.

Table A.B. .0.1 Illustration of an indicative qualitative assessment of the likelihood that DWD has an impact on drinking water quality in the catchment and distribution system and on the reduction of non-compliances

Parameter	Likelihood that DWD has an impact on water quality in a specific aquifer			Likelihood that the DWD has an impact on water during distribution	Likelihood that the DWD resulted in a reduction of non-compliances
	Surface water	Shallow GW	Deep GW		
Nitrate	+?	+	0	0	+
Pesticides	+	+?	0	0?	0
Arsenic	-?	-	0	0	+[136]
Microbial indicators	+	0	0	+	+
Copper	0	0	0	++	++
Lead	0	0	0	++	++

++ very likely that the DWD has an impact
+ likely that the DWD has an impact
0 likely that the DWD has no impact
- very likely that the DWD has no impact

[136] This effect is due to monitoring (an actions, most likely closing wells)

? Not sure

B.5 Conclusions

Trends in mean compliance for all parameters and in more in detail for ten selected candidate parameters showed an increase in compliance with time for all parameters, changes being largest for E.coli, Cl. Perfringens and Atrazine. For all other parameters it changed from ca 95% to near 100% compliance. The causes of non-compliances varied from: (i) almost completely *catchment related* for arsenic (combined impact of geology and hydrology) pesticides and nitrate(application of manure, fertilizer and pesticides) to almost completely *distribution network* related for both copper and lead and *mixed sources* for both Clostridium perfringens and Escherichia coli. The increase in drinking water quality can unequivocally be described to DWD actions for *distribution network* related contamination by both copper and lead, and partly in case of Clostridium perfringens and Escherichia coli, while in case of pesticides and nitrate, adjacent directives may have played an important role.

Appendix 1 to B. Overview of trends in non-compliances for the period 2005-2013 based on data from 12 countries with a continuous monitoring record for the parameters listed here

PARA	NCI_Year	-	(blank)	Catchment	Treatment plant	Public Distr.	Domestic distr.	combined	other	unknown	Grand Total
Arsenic	2005	9	3	2							14
	2006	6	62	3	1						72
	2007	11	70	2							83
	2008			28					1		29
	2009		1	29					1		31
	2010		4	58						1	63
	2011			24	1			1		7	33
	2012			29						8	37
	2013			19	2					5	26
Arsenic Total		**26**	**140**	**194**	**4**			**1**	**2**	**21**	**388**
Atrazine CAS 1912-24-9	2005			4							4
	2006			4							4
	2007		1	1							2
	2008		1	1							2
	2009			1							1
	2010			3							3
	2011			1							1
	2012			3							3
	2013			1							1
Atrazine CAS 1912-24-9 Total			**2**	**19**							**21**
Atrazine-Desethyl CAS 6190-65-4	2005			4							4
	2006			2				1			3
	2007		2								2
	2008			2							2
	2009			4							4
	2010			6							6

PARA	NCI_Year	-	(blank)	Catchment	Treatment plant	Public Distr.	Domestic distr.	combined	other	unknown	Grand Total
	2011			1	1						2
	2012			2							2
	2013			1							1
Atrazine-Desethyl CAS 6190-65-4 Total			**2**	**22**	**1**			**1**			**26**
Bentazon CAS 25057-89-0	2005			1							1
	2006		1								1
	2007		1	1							2
	2008			2							2
	2009			2							2
	2010			1							1
	2011			1							1
	2012			1							1
Bentazon CAS 25057-89-0 Total			**2**	**9**							**11**
Clostridium perfringens	2005	50	42	52	1	3	5	42			195
	2006	53	46	43	5	2	3	65			217
	2007	37	43	33	1	2		55			171
	2008		79	49	21	2	3	3	1	18	176
	2009		91	24	19	6	7			15	162
	2010		38	51	14	3	5	3		29	143
	2011			58	5	3	22	3		18	109
	2012	1		69	12		8	13		31	134
	2013	1		55	21	1	2	1	1	23	105
Clostridium perfringens Total		**142**	**339**	**434**	**99**	**22**	**55**	**185**	**2**	**134**	**1412**
Copper	2005		2				1	2			5
	2006	1				4	2				7
	2007	1	5			1	4				11
	2008		5				5			1	11
	2009		10				4				14
	2010		4	2			1			1	8
	2011	1					10			2	13

PARA	NCI_Year	-	(blank)	Catchment	Treatment plant	Public Distr.	Domestic distr.	combined	other	unknown	Grand Total
	2012						5			1	6
	2013						10		3	2	15
Copper Total		**3**	**26**	**2**		**5**	**42**	**2**	**3**	**7**	**90**
Escherichia coli	2005	369	75	20	16	11	21	53			565
	2006	326	105	27	7	12	12	47			536
	2007	292	147	15	24	15	12	76			581
	2008		71	20	51	20	22	9		52	245
	2009		69	13	45	26	27	8		46	234
	2010		38	37	57	26	30	11		68	267
	2011	6		8	57	45	30	40		44	230
	2012	7		5	61	67	19	40		44	243
	2013	2	1	3	51	75	25	34	3	43	237
Escherichia coli Total		**1002**	**506**	**148**	**369**	**297**	**198**	**318**	**3**	**297**	**3138**
Lead	2005	69	63		1	1	20	15			169
	2006	48	77			1	32	17			175
	2007	39	55			1	28	19			142
	2008		37			3	17	8		10	75
	2009		32			2	28	4		4	70
	2010		10	18		4	24	10		17	83
	2011	7				6	54	1		13	81
	2012	2				10	60	6	2	6	86
	2013					12	105	6		17	140
Lead Total		**165**	**274**	**18**	**1**	**40**	**368**	**86**	**2**	**67**	**1021**

PARA	NCI_Year	-	(blank)	Catchment	Treatment plant	Public Distr.	Domestic distr.	combined	other	unknown	Grand Total
Nitrate	2005	189	6	23		1		1			220
	2006	159	6	41		1	2	1			210
	2007	155	10	31	2	1					199
	2008		25	12	1		3	3		2	46
	2009		22	14	4			2		2	44
	2010		27	16	1			5		3	52
	2011	2		41	1					3	47
	2012	3		41		1	1			1	47
	2013	4		41	4					2	51
Nitrate Total		**512**	**96**	**260**	**13**	**4**	**6**	**12**		**13**	**916**
Terbutylatrazine CAS 5915-41-3	2005			6							6
	2006			5							5
	2007			3							3
	2008		5								5
	2009		4								4
	2010		6								6
	2011			2							2
	2012			1							1
	2013									1	1
Terbutylatrazine CAS 5915-41-3 Total			**15**	**17**						**1**	**33**

Appendix 2 to B. Overview of trends in remedial actions for the period 2005-2013 based on data from 12 countries with a continuous monitoring record for the parameters listed here. An explanation of the used codes is given below

PARA	NCI_Year	C1	C2	T	P1	P2	D1	D2	S	E	E1	E2	O [1]	None	Grand Total [2]
Arsenic	2005	1													2
	2006												1		4
	2007														2
	2008	29	1	7	1		1						1		40
	2009	31		8	2										42
	2010	57	1	5										1	65
	2011	3	2	3		1	1						3	7	42
	2012	2	4	7				1						3	41
	2013	1		19	1								6		30
Arsenic Total		124	8	49	4	1	2	1					11	11	268
Atrazine CAS 1912-24-9	2005	1	1												4
	2006														4
	2007														1
	2008		1	2			1				1		2		8
	2009	2	1	4									3		10
	2010	1	2	1											5
	2011		1										1		3
	2012	1											3		4
	2013												1		1
Atrazine CAS 1912-24-9 Total		5	6	7			1				1		10		40
Atrazine-Desethyl CAS 6190-65-4	2005	2	1								1				4
	2006														3
	2008	6	2	18	1						2	1	8		40
	2009	4	2	14								2	10		37
	2010	2	5	8								3	5		26
	2011	2	1	1									2		7
	2012	2											4		6

PARA	NCI_Year	C1	C2	T	P1	P2	D1	D2	S	E	E1	E2	O [1)]	None	Grand Total [2)]
	2013	1											2		3
Atrazine-Desethyl CAS 6190-65-4 Total		19	11	41	1						3	6	31		126
Bentazon CAS 25057-89-0	2005											1			1
	2007	1													1
	2008		1	1											3
	2009		2	2											6
	2010		1	3											5
	2011												1	1	2
	2012	2												1	3
	2013	2													2
Bentazon CAS 25057-89-0 Total		5	4	6								1	1	2	23
Clostridium perfringens	2005	49		2		3					3		5		103
	2006	38		3		3					5		5		118
	2007	32		1		2									91
	2008	53		28	1	9		4					15	6	131
	2009	37		17	1	10		5			1		17	4	109
	2010	45		20		5	18	4			1		23	6	158
	2011	13		54	1	17	1	7					37	5	139
	2012	13		64	2	26		4			1		30	12	158
	2013	12	1	60		14	4	1	13				19	8	146
Clostridium perfringens Total		292	1	249	5	89	23	25	13		11		151	41	1153
Copper	2005						1				1				4
	2006										2				6
	2007						1				1				5
	2008										5		4	1	10
	2009						1				3		4	1	10
	2010				3		6	2			1		1	1	15
	2011			2			6	2			4		3	2	23
	2012						1	5			2		5	1	16
	2013			2			4	5	1		2		4	2	23

PARA	NCI_Year	C1	C2	T	P1	P2	D1	D2	S	E	E1	E2	O [1]	None	Grand Total [2]
Copper Total				4	3		20	14	1		21		21	8	112
Escherichia coli	2005	18		8		12		16			1		4		121
	2006	23		4		5		11			3		3		105
	2007	34		14	8	3	1	15					2		143
	2008	55		54	11	66	2	22			2	2	3	15	256
	2009	49	1	45	6	69	1	23			15		9	14	260
	2010	50	3	61	10	92	20	35		1	13	2	13	20	371
	2011	10		141	18	91	3	28		5	4	1	63	31	434
	2012	14		163	20	84	2	28			16		44	26	450
	2013	15	1	156	20	68	1	18	22		5		42	22	421
Escherichia coli Total		268	5	646	93	490	30	196	22	6	59	5	183	128	2561
Lead	2005			1							15				37
	2006					1	6				15				50
	2007						7				11				48
	2008				2		6				17		17	8	62
	2009	2			3		6				19		16	2	56
	2010		7	1	3	1	26				19		16	9	106
	2011				4		43	8			7		10	17	95
	2012		1		8	2	28	8			10		11	15	97
	2013	1		61	4	4	13	5	8		12		7	10	156
Lead Total		3	8	63	24	8	135	21	8		125		77	61	707
Nitrate	2005	5	2										6		29
	2006	2	2										6		45
	2007	5	1										1		34
	2008	17	7	10		8	3				1		3		61
	2009	13	20	10							6		5	1	64
	2010	23	9	8		1							2	1	57
	2011	21	11	26			1						5	4	73
	2012	8	1	29		6							6	5	66
	2013	11	10	32		1							3	8	74

PARA	NCI_Year	C1	C2	T	P1	P2	D1	D2	S	E	E1	E2	O [1)]	None	Grand Total [2)]
Nitrate Total		105	63	115		16	4				7		37	19	503
Terbutylatrazine CAS 5915-41-3	2005											1			6
	2006														5
	2007														3
	2009														1
	2011			3											3
	2012			1											1
	2013			1		1									2
Terbutylatrazine CAS 5915-41-3 Total				5		1						1			21
Grand Total		821	106	1185	130	605	215	257	44	6	227	13	522	270	5514

[1)] We skipped: C (15), P(21), D (11), s1 (3), E (6), Multiple (501), mv (540) and Unknown (22). Values in bracket refer to the number of WSZ for which the RA was reported.

[2)] Includes the number of RA from the RA that were skipped.

Code RA	Description remedial action (RA)
C	catchment related
C1	Action(s) to terminate or mitigate the cause
C2	Action(s) to replace source
D	domestic distribution system
D1	Replacement, disconnection or repair of defective components
D2	Cleaning, scouring and/or disinfecting contaminated components
E	Emergency actions for the consumers' health and safety
E1	Notification of and instructions to consumers for example, prohibition of use, boil water order, temporary limitations on consumption).
E2	Provision of a temporary alternative drinking water supply (for example, bottled water, water in containers, tankers)
Multiple	Multiple
mv	no data
None	None
O	Others
P	public distribution network related
P1	Replacement, disconnection or repair of defective components
P2	Cleaning, scouring and/or disinfecting contaminated components
S	Security measures to prevent unauthorised access
S1	Security measures to prevent unauthorised access
T	Establishing, upgrading or improving treatment
unknown code	unknown code

These results show that: according to the Eionet data for the period 2005-2013:
By far most of the RA are related to the microbiological parameters E Coli (for 2561 WSZ) Clostridium perfringens (1153), followed by lead (707), nitrate (503) and arsenic (268);
The RA for Clostridium perfringens are mainly catchment related (292) (C1: terminate or mitigate the cause);
The RA for E Coli are mainly treatment-related;
The RA for lead are mainly distribution related, but remarkably also catchment related;
The RA for nitrate are mainly catchment related with an emphasis on replacing source (C1).

In the period 2005-2013 more and more MS reported remedial actions. Most of the performed are related to the microbiological parameters (E Coli and Clostridium perfringens) and to a lesser extend to chemical parameters (lead, nitrate and arsenic).

Annex C Outbreaks and incidents in drinking water in the EU

C.1 Introduction

C.1.1 Aim

Apart from the question: has the DWD improved drinking water quality, there is also the question: has the DWD led to a reduction in health incidents, that are (partly) related to drinking water. Trends in microbiological and chemical compliance in the various Member States have already been identified in Annex B by analysis of the official reported data to the European Commission, and the likely contribution of the DWD to improved drinking water quality has been assessed there. The objective of this chapter is to identify any trends in microbiological outbreaks and chemical incidences and the impact (if any) the DWD has had.

C.1.2 Approach

Incidents and outbreaks reported in literature and obtained through contacts with drinking water regulators are presented. The information on outbreaks and incidents thus collected will be judged as being related to drinking water or not as for many microbiological outbreaks there is not always a single cause or the cause is unknown (and could be either drinking water and/or food). Then the impact of the DWD on the occurrence and frequency of events and outbreaks will be assessed.

In general a distinction is made between microbiological outbreaks and chemical incidents.

Microbiological outbreaks through drinking water include events in which two or more people must be linked epidemiologically by time, location of exposure to water and illness characteristics and the epidemiological evidence must implicate drinking water as the probable source of illness.

Chemical incidents include events in which there is unintended (or sometimes deliberate) release to the (aquatic) environment of chemicals with potential to cause harm to human health through drinking water. In the case of a microbiological outbreak the effects on human health are most acute and obvious. Chemical incidents will only become clear when there are acute physical effects or when consumers reject the tap water because of organoleptic aspects (taste, appearance, odour). Chronic effects of chemical incidents are much more difficult to notice.

C.2 Diseases due to chemicals

In the search for chemical incidents (through Member States regulators, researchers and WHO), we were told by various experts that unless there is a 'major' event that is reported in the public press most incidents go unnoticed. Water companies are rather hesitant to report on such incidents and also if it is for a short period of time and they can restore the normal situation quickly such events do not have to be reported to the authorities. No national or European records are kept on chemical incidents. One EU regulator when asked for frequency and details of chemical incidents said that he could not remember any in the last ten years. When asked if that was the result of having the DWD in place he mentioned that that conclusion could not be made, but this was because of better environmental legislation and better practice.

There are some examples of incidents that can be mentioned and the remedial action that was taken to prevent (further) pollution of drinking water. When surface water used for the production of drinking water is polluted as is the case in the River Meuse example below, remedial action is taken by temporarily closing the water intake.

In August 2015 the River Meuse water used for the production of drinking water in the Netherlands did not meet the quality criteria and the intake by the water companies WML, Evides and Dunea was stopped. This remedial action was taken because the source of the pollution the wastewater treatment plant at a chemical factory did not operate properly and pyrazoles were discharged on the surface water and ended up in the Meuse. Temporary closure of the intake of river water is a common remedial action taken by surface water companies to protect the quality of drinking water. Since 2010 there have been five intake stops of River Rhine water due to the too high presence of pesticides. Communication Harry Römgens (Director RIWA Maas, TAPES conference September 2015). When a borehole is polluted they are often abandoned and alternative sources are exploited. In some cases groundwater does not comply with values for the chemical parameters in the DWD and alternative solutions are not readily available. Such examples are generally addressed through derogations and mostly concern, arsenic in some areas of the EU, fluoride or chromium VI. These are not incidents but structural problems. Here the DWD will have an impact as Member States have to take remedial actions to comply with the requirements of the DWD.

However with respect to the chemicals incidents, it is, in general, not likely that the DWD has an impact on their occurrence. These incidences are mostly not related to the implementation of the DWD. Something goes wrong and this does not depend on having standards in place. Combined with the fact that no records are kept on occurrence of chemical incidents we decided to restrict the study to microbiological outbreaks.

A new approach to drinking water protection through a risk based safety plans however, will have an impact on incidents as all critical contamination points are systematically identified and protocols to safeguard the quality will be in place.

C.2.1 Likeliness of diseases due to non-compliances of chemicals

We evaluated the possible health impacts of exceedances of chemical parameters, as discussed in Annex D, by comparing the reported median exceedance concentrations and maximum concentrations with the parametric value and comparing the ratio of both with the safety factor for the relevant chemical. results thus derived are given below. The total number of WSZs in the EU27 is and the criteria used for the assessment of the risk level in the WSZs is as follows:
When ratio of median exceedance/PM > SF: high risk for the related WSZ
When ratio of median maximum /PM > SF: median risk for the related WSZ
When ratio of maximum /PM > SF: low risk for the related WSZ
When ratio of maximum /PM < SF: no risk

It is not possible to assess the risk level in WSZs for non-threshold parameters, mostly carcinogenic substances. I will check that again with our toxicologist. Most case of non-compliance for the chemical parameters cause no or a low risk. The exceptions are WSZ's were fluoride is exceeding the value in the DWD as there is not really a safety margin and non-compliance could result in adverse effects in humans. The other exception are WSZs with exceedance of nitrate and nitrite levels as there is no safety margin but the strict limit is already based on protection of the most vulnerable groups (pregnant women and infants) and the allocation to drinking water.

Table on median and maximum values in the EU Member States and the risk of values found for chemical parameters

Chemical element	Nr. of WSZs with non-compliance	Parametric value (PM)		Ratio of average median exceedance/PM	Ratio of average maximum/PM	Ratio of absolute maximum/PM	Safety factor (SF) (n.t. non threshold)	Risk
Antimony	6	5	µg/l	1.7	1.8	2.9	>1000	No risk
Arsenic	76	10	µg/l	1.6	2.2	12.3	6/10.000 n.t.	Check with toxicologist
Benzene	1	1	µg/l	3.2	48	48	1/1.000.000 n.t.	Check with toxicologist
Benzo(a)pyrene	9	0.01	µg/l	16	48	436	<1/1.000.000 n.t.	Check with toxicologist
Boron	11	1	mg/l	1.2	1.3	1.7	30	No risk
Bromate	10	10	µg/l	2.6	3.1	9.6	5/100.000 n.t.	Check with toxicologist
Cadmium	3	5	µg/l	1.7	1.5	3.1	<10	No to low risk (smokers)
Chromium	2	50	µg/l	1.3	1.5	1.5	precautionary	No risk
Copper	22	2	mg/l	14	10	128	No tox based value	No risk bad taste
Cyanide	0	50	µg/l	0	0	0	n.a.	
1,2-dichloroethane	0	3	µg/l	0	0	0	n.a.	
Fluoride	54	1.5	mg/l	1.2	1.4	8.1	No safety factor S.F. = 1	Above 1.5 high risk of fluorosis
Lead	120	10	µg/l	6.2	8.0	110	Little of no S.F.	High risk
Mercury	5	1	µg/l	2.8	2.5	4.5	100	No risk
Nickel	105	20	µg/l	3.0	4.2	65	200-300	No risk
Nitrate	84	50	mg/l	1.3	1.5	6.1	Little or none but based on vulnerable groups	Low- medium risk for vulnerable groups
Nitrite	2	0,50	mg/l	1.3	1.9	3.2	Little or none but already based on vulnerable groups	Low-medium risk for vulnerable groups

Chemical element	Nr. of WSZs with non-compliance	Parametric value (PM)		Ratio of average median exceedance/PM	Ratio of average maximum/PM	Ratio of absolute maximum/PM	Safety factor (SF) (n.t. non threshold)	Risk
Pesticides — Total	13	0.5	µg/l	2.9	3.0	48.1	n.t. source protection not health based	Low risk
Polycyclic aromatic hydrocarbons (sum four compounds)	3	0.1	µg/l	4.0	4.9	10	n.t. precautionary	
Selenium	5	10	µg/l	1.4	1.5	1.9	WHO 40 ug/l	No risk
Tetrachloroethene and Trichloroethene	9	10	µg/l	3.1	8.7	42	100-1000	No risk
Trihalomethanes — Total	82	100	µg/l	1.2	1.3	3.6	n.t. 25-1000 for individual substances	Low risk
Vinyl chloride	0	0.5	µg/l	0	0	0		

C.3 Microbiological outbreaks

To collect information on microbiological outbreaks we both studied information available in literature, information supplied by Member States regulators and microbiological experts from our network. In this chapter epidemiological information on outbreaks of mostly food and water borne diseases is addressed (3.1) and next we look at examples of trends in waterborne outbreaks (3.2). Finally we try and assess the impact of the DWD and other legislation on microbiological outbreaks (3.3).

C.3.1 Epidemiological information on outbreaks of food- and water borne diseases

The two microbiological parameters mentioned in the DWD E.coli and Enterococci, are mere indicator organisms that normally do not cause any threats to human health. They just indicate the possible contamination of the drinking water. Microbiological incidences causing disease are often reported for bacteria e.g. pathogenic E.coli also known as STEC/VTEC, Campylobacter, Shigella, Salmonella, Legionella pneumophila, and viruses as Calicivirus, Rotavirus, Norovirus and parasites as Cryptosporidium and Giardia. These organisms pose the most significant health risks associated with contaminated drinking water. In the case of an outbreak it is not always possible to find out what the contribution of drinking water is or has been. Epidemiological information for the abovementioned organisms does often not specify the actual source of contamination (food or water.

The European Centre for Disease Prevention and Control (ECDC) collects information on infectious disease outbreaks, including those for which water was confirmed as route of exposure. ECDC is currently working on a report with outbreak data for the entire WHO European Region, on the basis of a review of available databases and literature. All EU Member States and three EEA countries (Iceland, Liechtenstein and Norway) send information at least annually from their surveillance systems to ECDC relating to occurrences of cases of the 52 communicable diseases and health issues under mandatory EU-wide surveillance. Reports are sent according to case definitions established by the EU[137].

The Annual Epidemiological Report 2014 gives an overview of the epidemiology of communicable diseases of public health significance in Europe, drawn from surveillance information on the 52 communicable diseases and health issues for which surveillance is mandatory in the European Union (EU) and European Economic Area (EEA) countries.

Most surveillance systems capture only a proportion of the cases occurring in their countries. Some cases of disease remain undiagnosed ('under-ascertainment'), and some are diagnosed but not reported to public health authorities ('underreporting'). The pattern of this under-ascertainment and underreporting varies by disease and country, involving a complex mix of healthcare-seeking behaviour, access to health services, availability of diagnostic tests, reporting practices by doctors and others, and the operation of the surveillance system itself. The direct comparison of disease rates between countries should therefore be undertaken with caution. In most cases differences in case rates reflect not only differences in the occurrence of the disease, but also in systematic differences in health and surveillance systems as described here.

The epidemiological information as collected and reported by ECDC does not concern DWD parameters. This is obvious as the DWD only has indicator organisms in the list of microbiological parameters. Information on microbiological outbreaks that might be casued by drinking water

[137] 2002/253/EC: Commission Decision of 19 March 2002 laying down case definitions for reporting communicable diseases to the Community network under Decision No 2119/98/EC of the European Parliament and of the Council. Official Journal, OJ L 86, 03.04.2002, p. 44–62.

besides other routes are shortly summarised for pathogenic coliform bacteria, Cyrptosporidium, Giardia, Campylobacter, Shigella and also for Legionella.

Pathogenic E.coli

Infection with pathogenic E.coli is mainly acquired by consuming contaminated food, such as undercooked contaminated beef or contaminated vegetables, or water, but person-to-person and direct transmissions from animals to humans may also occur. The main reservoirs for STEC/VTEC bacteria are ruminants such as cattle, goats and sheep. In 2012 10 EU countries reported 51 outbreaks from food and 10 waterborne outbreaks to ESFA (European Food Safety Authority), caused by pathogenic VTEC Strains. This represented 0.9% and 63% of all the reported food- and waterborne outbreaks in the EU. All 10 VTEC waterborne outbreaks were reported by Ireland and seven were reported to be linked to private water supplies or wells. In 2011 there was a large German outbreak, that was associated with contaminated food. The EU/EEA notification rate about 1.0 cases per 100 000 population has been reported since 2007 until 2010 (see figure A.E.1 and table A.E.1). However, a year after the outbreak a 1.5 fold increase in the EU/EEA notification rate and an increasing trend was observed compared with previous years. This is most likely due to the increased public health interest and detection of the STEC/VTEC cases as a response to the 2011 outbreak. There was an increasing EU trend for STEC/VTEC in 2008–2011. After removing the outbreak cases in year 2011, a statistically significant increasing EU trend could still be observed in 2008–2010. An increasing number of confirmed STEC/VTEC cases were observed in 2012 in the EU/EEA countries compared to previous years.

Figure A.E.1

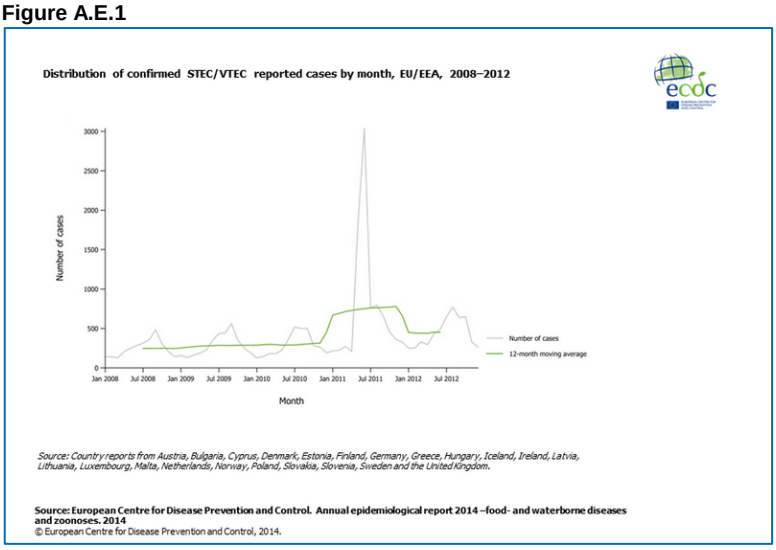


Table A.E.1 Number and rates of confirmed STEC/VTEC reported cases, EU/EEA, 2008–2012

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
Austria	69	91	88	120	131
Belgium	103	96	84	100	105
Bulgaria	0	0	0	1	0
Cyprus	2	0	0	0	0
Czech Republic	-	-	-	7	9
Denmark	161	160	178	215	214
Estonia	3	4	5	4	3
Finland	8	29	21	27	30

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
France	85	93	103	221	208
Germany	876	887	955	5 558	1 587
Greece	0	0	1	1	0
Hungary	0	1	7	11	3
Ireland	213	237	197	275	554
Italy	26	51	33	51	68
Latvia	0	0	0	0	0
Lithuania	0	0	1	0	2
Luxembourg	4	5	7	14	21
Malta	8	8	1	2	1
Netherlands	92	314	478	845	1 049
Poland	2	0	4	5	5
Portugal	-	-	-	-	-
Romania	4	0	2	2	1
Slovakia	8	14	10	5	9
Slovenia	7	12	20	25	29
Spain	24	14	18	20	32
Sweden	304	228	334	477	472
United Kingdom	1 164	1 336	1 110	1501	1 337
EU Total	**3 163**	**3 580**	**3 657**	**9487**	**5 870**
Iceland	4	8	2	2	1
Liechtenstein	0	-	-	-	-
Norway	22	108	52	47	75
EU/EEA Total	**3 189**	**3 696**	**3 711**	**9 536**	**5 946**

C.3.2 Cryptosporidium

Cryptosporidiosis is an important cause of acute diarrhoeal disease worldwide, and the burden of illness in childhood can be important. Cryptosporidiosis is caused by the intracellular protozoan parasite Cryptosporidium spp. Transmission is through the faecal-oral-route via contaminated water, soil or food products and the most common identified vehicles are contaminated drinking water and contaminated recreational water. Cryptosporidium oocysts excreted in the faeces are robust and can survive in the environment for extended periods. The oocysts are resistant to chlorine at the concentrations normally used for treating drinking water and swimming pools. There are well documented large outbreaks of cryptosporidiosis caused by the contamination of drinking water. Cryptosporidium oocysts are sensitive to ultraviolet (UV) light treatment.

Out of the 21 EU/EEA countries reporting data on cryptosporidiosis, seven countries reported zero cases, three countries reported just one case and only seven reported 50 or more cases (see Table A.E.2 and Figure A.E.2). In addition, nine countries did not report data on cryptosporidiosis at all. It is therefore likely that cryptosporidiosis is underreported in most of the EU/EEA countries. The reason for this is most likely a lack of laboratory diagnosis of cryptosporidiosis in laboratories diagnosing diarrhoeal diseases. The number of cases reported has increased in several EU

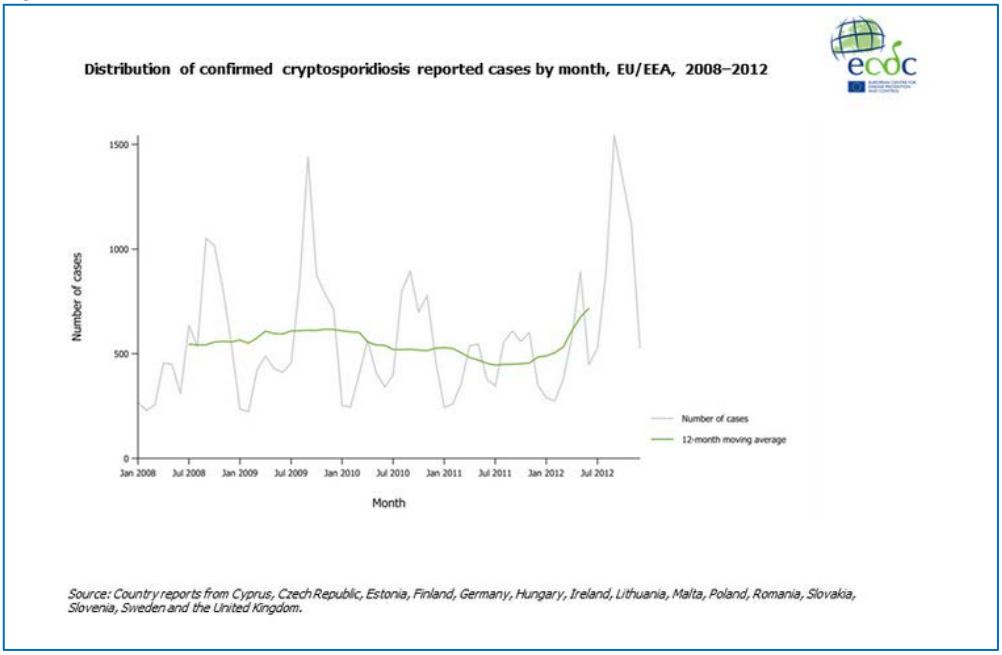
countries in 2012. Epidemiological situation in 2012 Cryptosporidium cases in 2012 were 68% higher than in 2011, with 9 591 cases reported.

Although outbreaks caused by contamination of drinking water or recreational water may happen at any time of the year, without primary diagnostic testing of faecal samples through recognised methods these outbreaks are unlikely to be detected. Human activities, such as drinking untreated water, recreational water activities, and contact with farm animals, increase the risk of becoming infected with Cryptosporidium.

Table A.E.1 Number and rates of confirmed cryptosporidiosis reported cases, EU/EEA, 2008–2012

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
Austria	13	0	3	18	4
Belgium	397	470	275	244	495
Bulgaria	0	1	1	0	4
Cyprus	0	0	0	0	0
Czech Republic	0	0	1	0	4
Denmark	-	-	-	-	-
Estonia	0	0	0	0	0
Finland	11	11	19	22	50
France	-	-	-	-	-
Germany	1 014	1 106	918	930	1 385
Greece	-	-	-	-	-
Hungary	10	15	34	14	10
Ireland	412	445	294	413	558
Italy	-	-	-	-	-
Latvia	0	9	23	14	3
Lithuania	0	0	2	1	1
Luxembourg	0	0	1	1	0
Malta	0	0	1	0	0
Netherlands	-	-	-	-	-
Poland	1	5	0	1	2
Portugal	-	-	-	-	-
Romania	0	8	8	0	0
Slovakia	0	0	0	0	1
Slovenia	6	3	7	10	12
Spain	75	197	57	79	291
Sweden	148	159	392	379	238
United Kingdom	4 941	5 587	4 569	3571	6 533
EU Total	**7 028**	**8 016**	**6 605**	**5 697**	**9 591**
Iceland	-	-	-	-	-
Liechtenstein	-	-	-	-	-
Norway	-	-	-	-	4
EU/EEA Total	**7 028**	**8 016**	**6 605**	**5 697**	**9 595**

Figure A.E.2



C.3.3 Campylobacteriosis

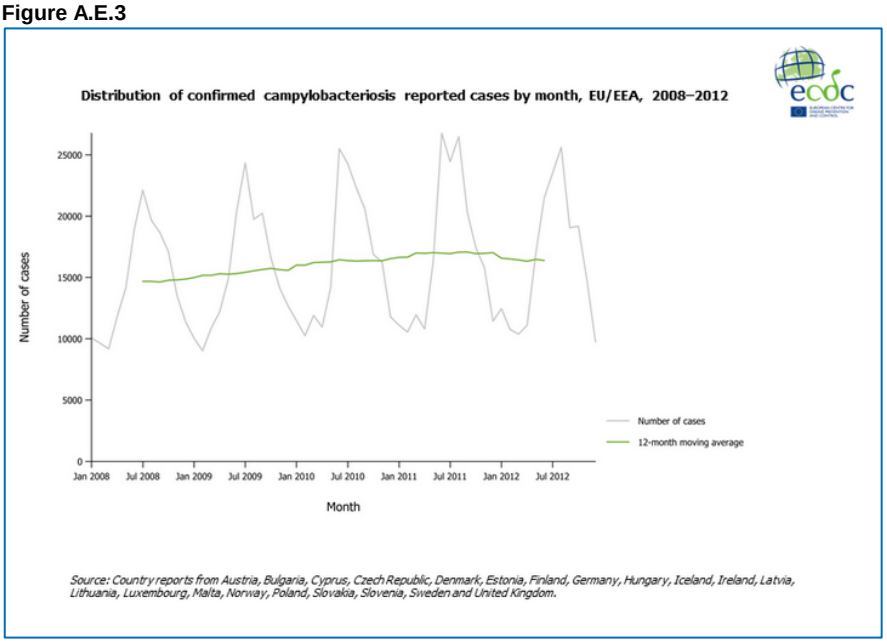
Human campylobacteriosis has remained the most commonly reported gastrointestinal disease in Europe since 2005. Handling, preparation and consumption of broiler meat has been estimated to account for 20%–41% of human campylobacteriosis cases. Campylobacter also has the potential to cause large waterborne outbreaks. In Belgium, 64 children at a youth camp became ill after using water from a local source contaminated by C. jejuni. Denmark reported a waterborne outbreak due to C. jejuni in a Danish town with over 400 cases recorded. The sources of infection causing sporadic disease seem to derive from chicken, but the routes of transmission remain unclear, as do the drivers for increases in the elderly, the seasonality and the urban-rural differences (that are not accessible with this data). Outbreaks of Campylobacteriosis occur, but most diseases appear as sporadic cases and the main route of transmission is rarely identified. Outbreaks are associated with the ingestion of contaminated food (mainly chicken or unpasteurised milk) or water. At the EU level, the rate of human campylobacteriosis increased between 2007 and 2011 but has reduced slightly in 2012.

Table A.E.2 Number and rates of confirmed campylobacteriosis reported cases, EU/EEA, 2008–2012

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
Austria	4280	4502	4 404	5129	4 992
Belgium	5 111	5 697	6 047	7 716	6 607
Bulgaria	19	26	6	73	97
Cyprus	23	37	55	62	68
Czech Republic	20 067	20 259	21 075	18743	18 412
Denmark	3470	3 353	4 037	4060	3 720
Estonia	154	170	197	214	268
Finland	4 453	4 050	3 944	4 267	4 251
France	3 424	3 956	4 324	5 538	5 081
Germany	64 731	62 787	65 110	70 812	62 880
Greece	-	-	-	-	-
Hungary	5 516	6 579	7 180	6 121	6 384

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
Ireland	1 752	1 810	1 660	2 433	2 392
Italy	265	531	457	468	774
Latvia	0	0	1	7	8
Lithuania	762	812	1 095	1 124	917
Luxembourg	439	523	600	704	581
Malta	77	132	204	220	220
Netherlands	3 341	3 782	4 322	4 408	4 248
Poland	270	359	367	354	431
Portugal	-	-	-	-	-
Romania	2	254	175	149	92
Slovakia	3 064	3813	4 476	4 565	5 844
Slovenia	898	952	1 022	998	983
Spain	5 160	5 106	6 340	5 469	5 488
Sweden	7 692	7 178	8 001	8 214	7 901
United Kingdom	55 609	65 043	70 298	72 150	72 578
EU Total	**190 579**	**201 711**	**215 397**	**223 998**	**215 217**
	98	74	55	123	60
Liechtenstein	2	-	-	-	-
Norway	2 875	2 848	2 682	3 005	2 933
EU/EEA Total	**193 554**	**204 633**	**218 134**	**227 126**	**218 210**

Figure A.E.3



C.3.4 Giardiasis

Giardia lamblia is a flagellated, cyst-producing intestinal parasite able to infect humans and animals. Giardiasis is the most common cause of parasitic diarrheal disease worldwide. Individuals become infected through ingesting contaminated food, soil, or water or by person-to-person transmission. Giardia cysts can survive for extended periods of time in the environment and a major reservoir of the parasite is contaminated surface water. Waterborne outbreaks due to inadequate treatment of drinking water are frequently reported and infants and children are at a particularly

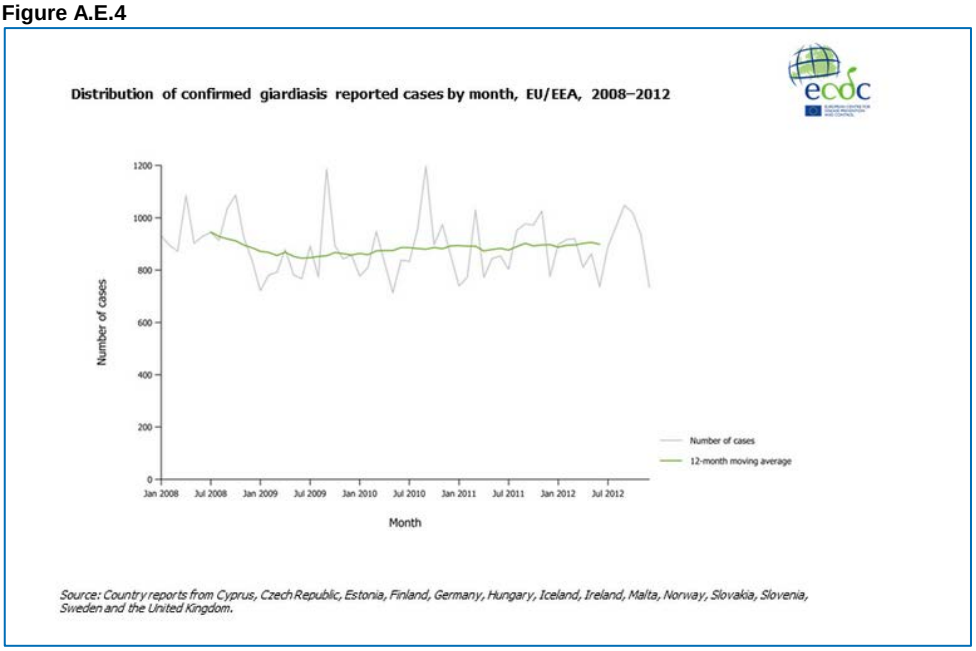
increased risk for infection. Infected individuals can remain asymptomatic or develop fatigue and bloating followed by acute or chronic diarrhoea that can lead to dehydration and malabsorption.

Cases of giardiasis were reported in 23 out of 31 EU/EEA countries (see Table A.E.4 and figure A.E.4). Out of these, three countries do not have surveillance systems covering the whole population and one potential high burden country is in the process of improving data completeness. In order to clarify the epidemiology of giardiasis further, improvement of the national surveillance systems is needed. The case rate of reported confirmed cases of giardiasis in EU and EEA countries has been relatively constant over the past five years. In 2012, no outbreaks of giardiasis or related public health events relevant at an EU level were recorded and monitored by ECDC in 2012.

Table A.E.3 Number and rates of confirmed giardiasis reported cases, EU/EEA, 2008–2012

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
Austria	47	31	59	74	50
Belgium	1 213	1 218	1 212	1 383	1 244
Bulgaria	2 141	2 096	2 234	1 959	1 560
Cyprus	7	2	12	2	4
Czech Republic	79	47	51	45	49
Denmark	-	-	-	-	-
Estonia	264	207	257	245	254
Finland	427	378	373	404	394
France	-	-	-	-	-
Germany	4 763	3 962	3 980	4 230	4 228
Greece	-	-	-	-	-
Hungary	138	100	87	85	81
Ireland	70	62	57	56	54
Italy	-	-	-	-	-
Latvia	28	18	21	15	17
Lithuania	15	13	18	8	13
Luxembourg	1	2	0	0	2
Malta	2	2	5	10	2
Netherlands	-	-	-	-	-
Poland	3 096	2 184	2 271	1 670	1 655
Portugal	-	-	-	-	-
Romania	-	296	106	315	260
Slovakia	125	139	169	162	243
Slovenia	14	9	19	31	35
Spain	683	869	578	530	859
Sweden	1 529	1 210	1 311	1 045	1 081
United Kingdom	3 632	3 719	4 024	3 938	4 138
EU Total	**18 274**	**16 564**	**16 844**	**16 207**	**16 223**
Iceland	33	27	24	34	22
Liechtenstein	-	-	-	-	-
Norway	270	308	262	234	179
EU/EEA Total	**18 577**	**16 899**	**17 130**	**16 475**	**16 424**

Figure A.E.4



C.3.5 Shigellosis

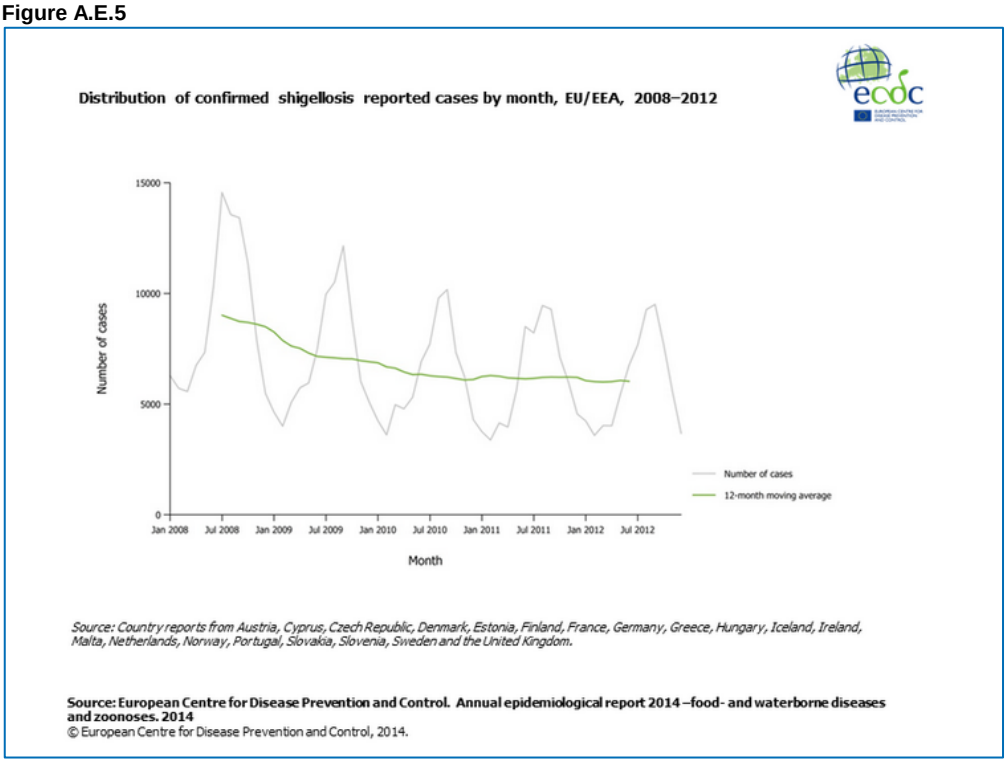
Shigellosis is caused by bacteria of the genus Shigella. Although a relatively uncommon and mostly travel-related infection in the EU, it remains the fifth most frequently reported cause of enteric infection. Outbreaks occur frequently but no public health threats associated with Shigellosis were reported at the EU level during 2012. In 2012, 7 336 confirmed cases of Shigella infection were reported from 28 EU/EEA countries. The reporting of cases has remained relatively stable in the previous five years (see Table A.E.5 and Figure A.E.5). Infections with some species may cause severe illness and death; most cases are less severe. Humans are the only significant reservoir. Transmission occurs by the faecal-oral route, either through person-to-person contact, including sexual contact, or through contaminated food or water. In 2012, the confirmed case rate for shigellosis was 1.6 per 100 000 population. Shigella is most common in children under five years of age, and very high rates in this age group are reported from some EU countries. Shigella infection, while relatively uncommon, remains of concern in some countries, and for some population groups within the EU/EEA. Bulgaria and Slovakia, in particular, continue to report high rates of infection, particularly among young children.

Table A.E.4 Number and rates of confirmed shigellosis reported cases, EU/EEA, 2008–2012

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
Austria	120	80	98	36	58
Belgium	418	348	342	317	340
Bulgaria	1 094	751	596	798	777
Cyprus	1	2	0	2	0
Czech Republic	227	177	387	157	266
Denmark	90	106	91	91	105
Estonia	69	52	46	22	34
Finland	124	118	162	126	93
France	848	1042	774	641	686
Germany	575	617	697	664	526
Greece	19	37	33	47	91

Country	2008	2009	2010	2011	2012
	Cases	Cases	Cases	Cases	Cases
Hungary	43	42	63	43	32
Ireland	63	71	60	42	29
Italy	-	-	-	-	30
Latvia	91	36	11	10	4
Lithuania	81	37	42	40	52
Luxembourg	9	18	22	16	14
Malta	3	1	2	4	0
Netherlands	343	438	523	550	708
Poland	31	21	24	18	13
Portugal	7	3	6	3	11
Romania	371	414	293	371	354
Slovakia	446	370	370	536	480
Slovenia	44	42	31	18	26
Spain	133	216	76	81	264
Sweden	596	469	557	454	328
United Kingdom	1 595	1 568	1 881	2 070	2 021
EU Total	**7 441**	**7 076**	**7 187**	**7 157**	**7 342**
Iceland	3	2	2	1	1
Liechtenstein	-	-	-	-	-
Norway	134	153	132	163	77
EU/EEA Total	**7 578**	**7 231**	**7 321**	**7 321**	**7 420**

Figure A.E.5

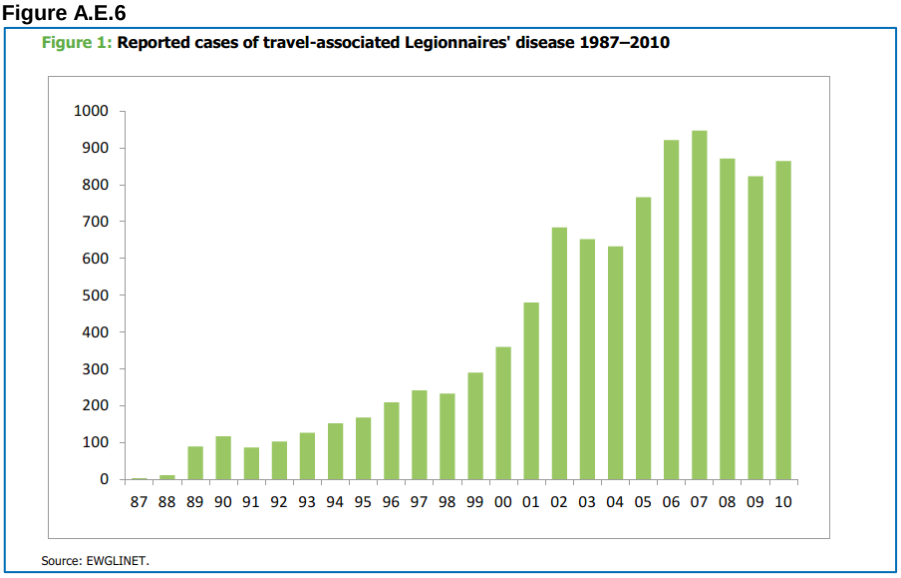


C.3.6 Legionella

For all parameters mentioned in the above it is not always obvious what the cause of the outbreaks is and which part of the outbreaks is water borne. For Legionella the link with water is always present. Legionella cases are caused by cooling towers and all kinds of water systems (hot tubs,

whirl pools, air conditioning systems, decorative fountains, showers and in general water systems in sport facilities, hotels, hospitals and nursing homes). Data on Legionella cases have been collected for many years by the European Legionnaires' Disease Surveillance Network (coordinated bt the ECDC) since 1987. Figure A.E.6 represent the travel related legionnaires disease cases reported in Europe since then. Even though the cases only reflect travel related cases it shows a significant increase within the European countries from less than 100 in 1987 till more than 900 per year in 2010. The disease does not relate to the consumption of water but often has a relationship with the drinking water supply system. Cases of Legionella are caused by poor design, maintenance and operation of the water supply system and the quality of the water supplied. This significant increase seen in figure A.E.6 almost certainly reflects increased ascertainment of cases through improved national surveillance schemes and can also be attributed to improved collaboration and reporting by participating countries.

Figure A.E.6



C.3.7 Examples of trends in waterborne outbreaks.

In 2005 an inventory was made by the Microrisk project on outbreaks in public water supplies in the EU. Outbreaks of intestinal illness through drinking water in Europe are notoriously difficult to detect. Much of what is known about the burden of disease has been generated through outbreak documentation. What is evident from outbreaks involving public supplies is that harmful pathogens have the potential to reach a large body of consumers resulting in substantial economic and health-related costs, which is shown by the April 1993 Cryptosporidium outbreak in Milwaukee. As a result of a filtration failure at a public water supply many people suffered illness, many were hospitalised and a number died. In addition to public supplies waterborne outbreaks are often related to private supplies and recreational water. The Microrisk project summarised the outbreaks featuring enteric waterborne pathogens (E.coli, Campylobacter, Cryptosporidium, Giardia, Shigella, Salmonella, Norovirus and gastroenteritis of unknown aetiology) related to drinking water derived from public supplies in the European Union (EU). This survey excluded outbreaks related to recreational and private water source outbreaks. Reported outbreaks were omitted if the water source (public or private), year, or country of the outbreak was not reported, or if published material documenting the outbreak was not available. 30 additional Swedish outbreaks were identified via personal communication with Torbjorn Lindberg (SE regulator). Twenty-five of these outbreaks implicated groundwater supplies and five surface water supplies. In these outbreaks, the aetiological agent involved was often unknown (77%), in 20% of the outbreaks a viral agent was implicated, and in 3% Campylobacter was isolated from patients. These data were not incorporated as it was not possible to differentiate between small supplies which are part of a commercial/public activity and public

drinking water supplies. In the years from 1990 to 2004 a total of 86 enteric disease outbreaks associated with EU public drinking water supplies. Outbreaks were identified in 10 of the 25 countries of the EU (table A.E.6).

Table A.E.6 Microrisk project (FP5)[138] Intestinal illness through public drinking water supplies in Europe between 1990 and 2014

Intestinal illness through drinking water in Europe

Table 2: Number of Outbreaks by Country, Pathogen and Water Supply, and Maximum Cases by Pathogen and Water Supply.

Country	No. Outbreaks	Pathogen Isolated in Cases								Water Supply			
		Bacterial		Protozoal		Viral		Mixed Pathogen	Gastroenteritis				
		Campylobacter	*Shigella*	*Cryptosporidium*	*Giardia*	*Norovirus*	Viral (undetermined)			Ground-water	Surface Water	Mixed	Not Reported
Finland	12	4	-	-	-	6	1	-	1	10	2	-	-
France	7	-	-	2	-	-	-	3	2	5	-	-	2
Germany	2	-	-	-	1	1	-	-	-	1	-	-	1
Greece	3	-	2	-	1	-	-	-	-	2	1	-	-
Italy	1	-	-	-	-	-	-	-	1	-	-	-	1
Netherlands	1	-	-	-	-	-	-	-	1	1	-	-	-
Rep. Ireland	2	-	-	1	-	-	-	-	1	1	1	-	-
Spain	6	1	1	1	-	-	-	-	3	1	-	1	4
Sweden	7	3	-	-	-	1	-	1	2	3	3	-	1
UK (England)	29	-	-	28	-	-	-	-	1	5	14	4	6
UK (N.Ireland)	3	-	-	3	-	-	-	-	-	-	3	-	-
UK (Scotland)	6	-	-	5	-	-	-	1	-	-	6	-	-
UK (Wales)	1	1	-	-	-	-	-	-	-	-	-	-	1
UK (unspecified)	6	-	-	6	-	-	-	-	-	3	2	1	-
No. Outbreaks	86	9	3	46	2	8	1	5	12	32	32	6	16
Cases	72546	16222	531	7772	232	11408	2500	2511	31370*	43571	23047*	906	5022

* One outbreak did not report case numbers.

According to the Microrisk project levels of endemic waterborne disease are probably low in most Member States. However, public supplies serve very many consumers and as such contamination, even if causing illness in a small proportion of consumers, can pose a significant threat to public health. Although private water supplies serve a smaller population, they are frequently prone to faecal contamination and probably pose a greater risk to people reliant on them for their primary drinking water source. Heavy rainfall and livestock activity are frequent contributory factors involved in the occurrence of outbreaks. Although the probability of occurrence is less, the magnitude of effect is greater for distribution system incidents. Increased awareness of the public health hazard associated with illegal cross-connections and source water contamination could ameliorate these issues. The detection and investigation of outbreaks is important for the protection of public health, yet detection and reporting varies from one European Member State to another making comparison across Europe difficult.

C.3.7.1 Case of the Nordic countries Denmark, Sweden, Norway and Finland

From 1998 to 2012 a total of 175 waterborne outbreaks affecting 85,995 individuals (see table A.E. 7) were notified to the national outbreak surveillance systems in Denmark, Finland, Norway and Sweden (SE 1998 to 2011). Between 4 and 18 outbreaks were reported each year during this period. Outbreaks occurred throughout the countries in all seasons, but were most common between June and August. Viruses belonging to the ***Caliciviridae*** family and ***Campylobacter*** were the pathogens most frequently involved, comprising 41% and 29% of all 123 outbreaks with known aetiology respectively. Although only a few outbreaks were caused by the parasites Giardia and/or ***Cryptosporidium***, they accounted for the largest outbreaks reported during the study period, affecting up to 53,000 persons. Most outbreaks, 124 (=76%) of those with a known water source were linked to groundwater.

A large proportion of the outbreaks (76%) affected a small number of people (less than 100 per outbreak) and were linked to single-household water supplies. However, in 11 (6%) of the outbreaks, more than 1,000 people became ill. Although outbreaks of this size are rare, they highlight the need for increased awareness, particularly of parasites, correct water treatment

[138] Intestinal illness through drinking water in Europe December 2005 Microrisk.

regimens, and vigilant management and maintenance of the water supply and distribution systems. In the period concerned there does not seem to be a trend in the number of outbreaks reported.

Table A.E.7 Waterborne outbreaks in the Nordic countries between 1998 and 2012 (2011) (in brackets number of people affected)

TABLE 3

Waterborne outbreaks by microorganism involved and year, Denmark, Finland, Norway and Sweden, 1998–2012[a] (n = 175)

Year	Number of outbreaks (number of patients involved) by microorganism											
	Caliciviridae	Campylobacter	Cryptosporidium	*Escherichia coli* (pathogenic)	Giardia	Rotavirus	Salmonella	Shigella	Francisella tularensis	Multiple microorganisms	Unknown	Total
1998	2 (2,500)	2 (2,216)	–	1 (unknown)[b]	1 (3)	–	–	–	–	–	1 (13)	7 (4,732)
1999	4 (238)	2 (14)	–	–	–	–	1 (55)	–	–	–	7 (664)	14 (971)
2000	5 (5,944)	4 (1,063)	–	–	1 (37)	–	–	–	–	1 (300)	5 (167)	16 (7,511)
2001	3 (698)	4 (1,069)	–	–	–	–	1 (3)	–	–	–	2 (37)	10 (1,807)
2002	5 (746)	4 (114)	–	–	–	–	–	–	1 (11)	1 (50)	5 (520)	16 (1,441)
2003	7 (291)	1 (3)	–	1 (8)	–	1 (140)	–	–	–	–	3 (101)	13 (543)
2004	3 (259)	3 (13)	–	–	1 (6,000)	–	–	–	–	–	4 (32)	11 (6,304)
2005	1 (45)	2 (300)	–	1 (16)	–	–	–	–	1 (2)	–	5 (144)	10 (525)
2006	1 (150)	2 (45)	–	1 (10)	–	–	–	1 (18)	1 (5)	2 (35)	4 (38)	12 (283)
2007	3 (90)	3 (1,613)	1 (28)	–	1 (13)	–	–	–	3 (27)	2 (6,513)	5 (2,431)	18 (10,715)
2008	1(2,000)	2 (20)[b]	–	1 (20)	1 (2)	–	–	–	–	–	4 (110)	9 (2,152)
2009	4 (436)	2 (210)	–	1 (4)	–	–	–	–	–	–	3 (67)	10 (717)
2010	5 (401)[b]	2 (275)	2 (27,000)[b]	–	–	–	–	–	–	1 (40)	2 (30)	12 (27,746)
2011	5 (57)[b]	3 (56)	1 (20,000)	1 (8)	–	–	–	–	–	1 (27)	2 (15)	13 (20,163)
2012	2 (170)	–	–	1 (15)	–	–	–	–	–	1 (200)	–	4 (385)
Total	**51 (14,025)**	**36 (7,011)**	**4 (47,028)**	**8 (81)**	**5 (6,055)**	**1 (140)**	**2 (58)**	**1 (18)**	**6 (45)**	**9 (7,165)**	**52 (4,369)**	**175 (85,995)**

Dashes indicate that there were no such outbreaks.

[a] For Sweden, 1998 to 2011.

[b] There was an outbreak with an unknown number of people involved. There were five such outbreaks in total

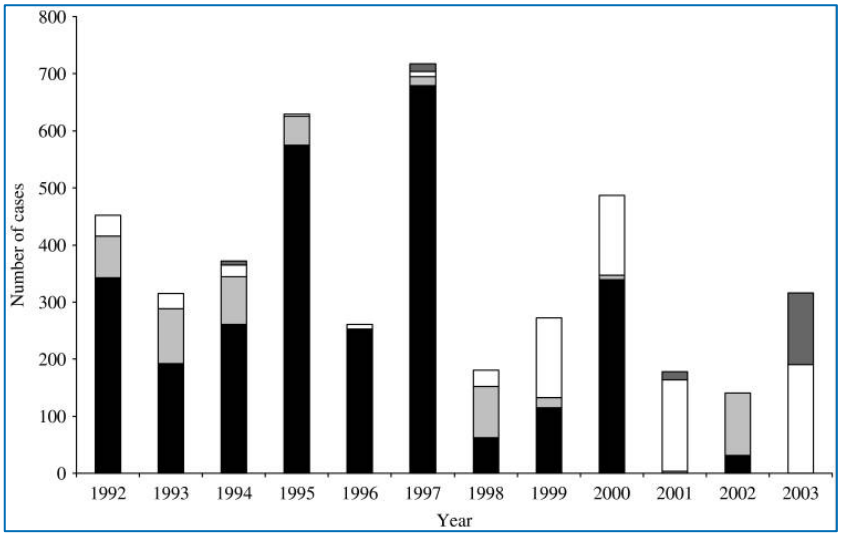
C.3.7.2 Case of England and Wales

The Communicable Disease Surveillance Centre (CDSC) and local health authorities in England and Wales have conducted structured surveillance of outbreaks of infectious intestinal disease (IID) since 1992. They reviewed the epidemiological and microbiological features of the subset of outbreaks of IID in which water was the reported vehicle of transmission in England and Wales in the period 1992–2003 utilizing the CDSC classification system for categorizing the strength of association with water.

Between 1 January 1992 and 31 December 2003, CDSC received 89 waterborne IID outbreak reports affecting 4321 people. Public water supplies were implicated in 24 outbreaks (27%), private water supplies in 25 (28%), swimming pools in 35 (39%), and other sources in five outbreaks (6%), three involving recreational river use and two involving fountains. There was an average of 119 case patients per public water outbreak and 22 cases per private water outbreak (Figure A.E.7).

Cryptosporidium was implicated in 69% of outbreaks, *Campylobacter* sp. in 14%, *Giardia* in 2%, *E. coli* O157 in 3% and *Astrovirus* in 1%. From 2000, there was a consistent decline in the number of outbreaks of waterborne disease associated with public water supplies. The incidence rate of outbreaks in recipients of private water supplies may be as high as 35 times the rate in those receiving public water supplies (1830 *vs.* 53 per million population). Private water suppliers need to be aware of the importance of adequate treatment and the prevention of faecal contamination of storage water.

Figure A.E.7 Total number of case patients associated with waterborne outbreaks of infectious intestinal disease. ▩, Other water supplies; □, swimming pools; ▨, private water supplies; ■, public water supplies



A number of common themes emerged as possible contributory factors to the outbreaks reported. These included an inadequate or a transient failure of water treatment measures, overloading of the treatment process through gross contamination of the water source, contamination of water source with animal or human faeces.

There was a consistent decline in the number of outbreaks of waterborne disease associated with public water supplies, particularly noticeable since 2000. Private water supplies, on the other hand, are an ongoing concern. The microbiological quality of many private water supplies is poor. Outbreaks of waterborne disease associated with private water supplies increased in number during the period of the study. If a large private water supply becomes contaminated it can pose a substantial risk to public health. The regulatory framework for private water supplies needs to be strengthened and that this should include an obligation on suppliers to inform recipients that they are consuming water from a private supply.

C.3.7.3 Case the success story of Ireland (personnel communication Darragh Page Ireland regulator)

In Ireland the majority of drinking water comes from surface water supplies for several reasons. In addition to the large amount of surface water available, groundwater resources are not as suitable for use as most other Member States as Ireland has large areas of karst geology as well as a fractured pattern of geology around the country. This means that many of our groundwater resources are heavily influenced by surface water. As a result most of our raw waters contain E. coli as it is ubiquitous in surface waters everywhere. This means considerable treatment for drinking water supplies has to be put in place, as disinfection alone will not be sufficient in many of our groundwater sources. This is the reason for historically having high levels of non-compliance with E. coli compared to other MS which have better quality groundwater resources.

In summary, since the Directive came into force in 2004:

- The number of incidents of E. coli contamination of water supplies in Ireland has reduced by around 90% in public water supplies and private group water schemes (see figure A.E.8 and A.E.10). For example in 2004 there were 91 public water supplies where E. coli was detected at least once during the year compared to 10 in 2013 (figure A.E.9). Similarly in private group water schemes the numbers of schemes contaminated with E. coli dropped from 282 in 2004 to

32 in 2013. Data for 2014 (which is currently being analysed) shows a further drop in the number of public water supplies and private group water schemes contaminated with E. coli. This data will be published in November;

- The real improvements in public water supplies took place after 2007. This is because in 2007 the EPA was given enforcement powers over the public water supplies and took several initiatives to reduce the number of incidents (e.g. setting minimum standards for disinfection systems including mandatory process alarms) and started to take enforcement action (including prosecutions) where action was not being taken. The Irish government also published a Remedial Action List which is a list of supplies are in need of improved operation/management, replacement or upgrading. This has focussed investment on supplies that need it most. Thus, while the DWD set the standards improvements only occurred due to active enforcement of the DWD. This is a very important point to note. Darragh Page suspects other MS where there is active direct enforcement (e.g. Portugal and the UK) will also show improvements;
- In relation to the private group water schemes (which are community run local water supplies), a massive programme of improvement took place to reduce the number of incidents. Many of these plants had no treatment in 2004. The majority of these have now been upgraded or amalgamated with nearby schemes. This has resulted in a significant drop in the number of such schemes (698 were monitored in 2004 reducing to 417 in 2013). The quality of remaining schemes has also improved dramatically (only 78% of samples analysed in 2004 complied with the E. coli standard improving to 97.6% in 2013).

Figure A.E.7 Percentage of public water supplies fully compliant with the E.coli standard (DWD) Ireland source D. Page (2015)

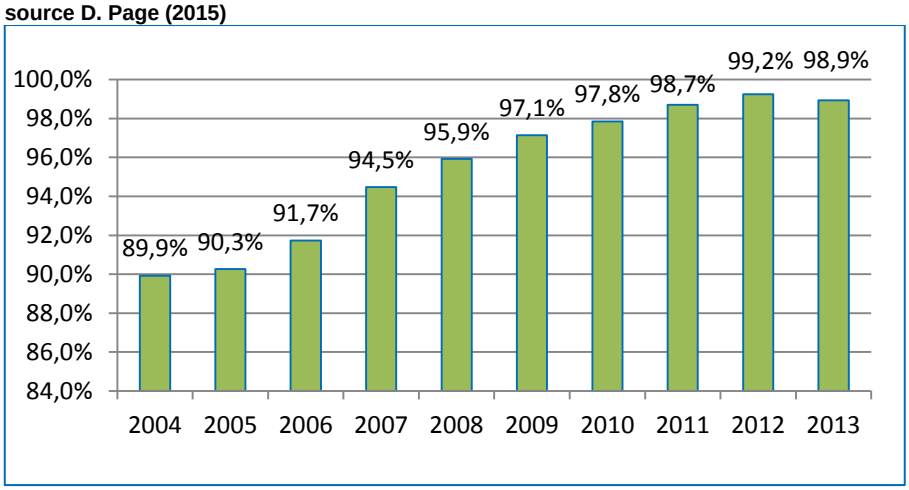


Figure A.E.8 Number of public water supplies with detected E.coli Ireland source D. Page (2015)

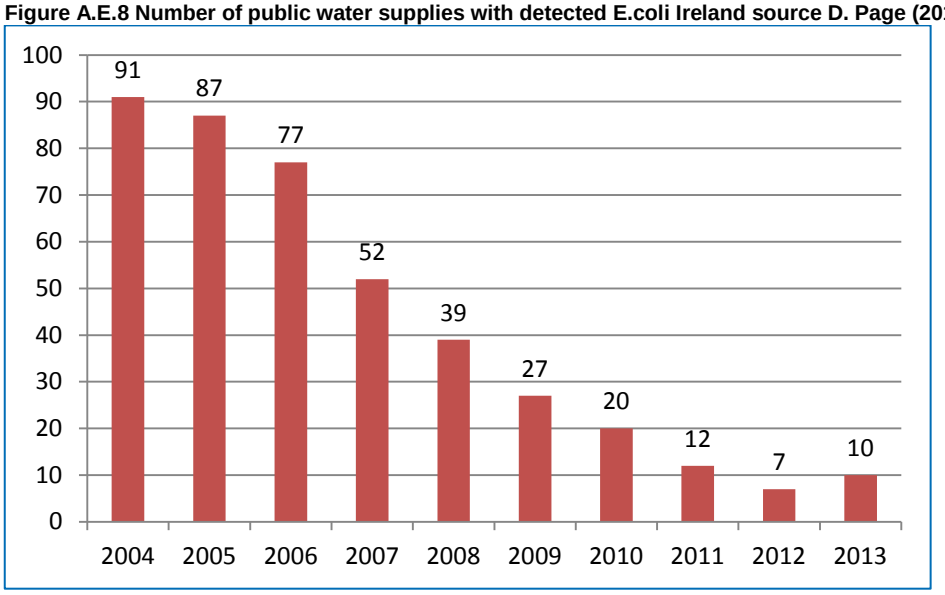
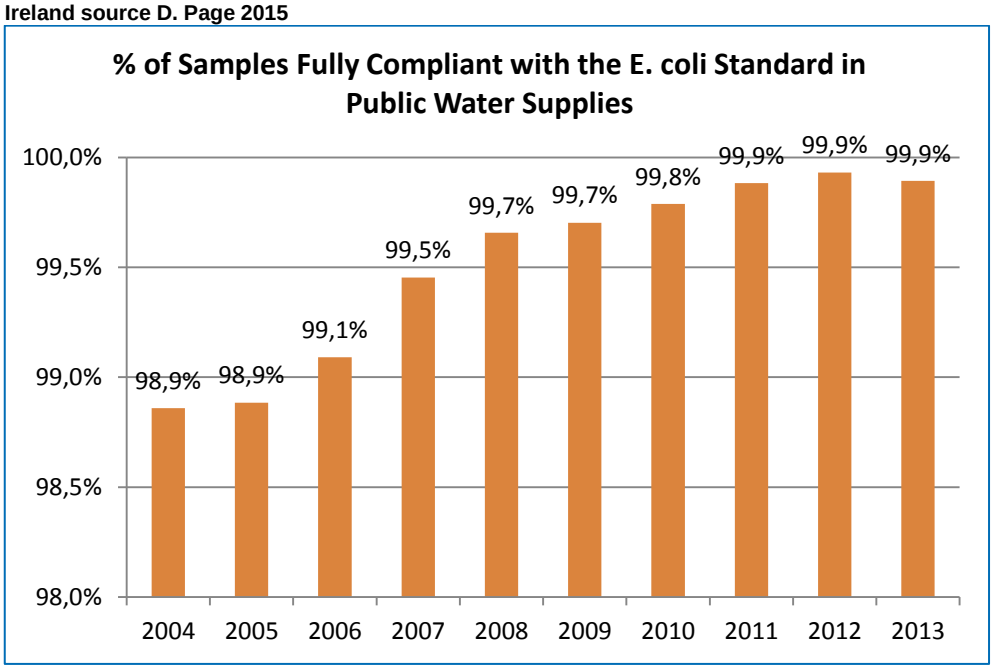


Figure A.E. 9 Percentage of samples fully compliant with the E.coli standard in public water supplies in Ireland source D. Page 2015



C.3.8 Impact of DWD and other related legislation on microbial outbreaks

With respect to epidemiological data on the potential microbiological parameters that are discussed a number of conclusions can be drawn.

- The micro-organisms that can cause outbreaks through water are not directly included in the DWD as the Directive only includes two indicator parameters;
- In most cases outbreaks can be caused by a number of sources besides drinking water and it is often not possible to relate outbreaks to (drinking) water;
- The epidemiological data on these micro-organism indicate an increased number of outbreaks for pathogenic E. coli STEC/VTEC between 2008 and 2012, no significant changes in the outbreaks related to Shigella and Giardia. Cases related to Campylobacter increased in the period 2007-2011 but showed a slight decrease in 2012. Cryptosporidium related cases showed an increase in 2012;

- The only micro-organism that most certainly related to (drinking) water Legionella showed significant increase from the start of monitoring the cases of Legionnaires' disease in 1987 till 2012. The significant increase in travel related cases within Europe almost certainly reflects increased ascertainment of cases through improved national surveillance schemes and can also be attributed to improved collaboration and reporting by participating countries;
- The epidemiological data are, however, presumably only the tip of the iceberg as water related disease surveillance systems are not necessarily capable to detect waterborne outbreaks due to methodological problems. Comparisons over time are this not very meaningful in terms of assessing an impact of the DWD unless there is convincing evidence that the disease was water borne and reduced due to remedial actions taken because of the DWD.

Annex D Comparison between EU legislation and legislation in other countries

Introduction

This Annex forms part of the Study reporting the revision of the EU DWD. Its objective is determine the similarities and differences between the DWD and drinking water legislation in other regions and countries with the aim to identify good practices that can be introduced at European level.

The Annex is based primarily on literature review of relevant legislative documents, guidelines, reports and technical standards related to drinking water of the following countries: United States of America (USA), Canada, Australia and New Zealand. The desk research have been complemented by an interview with representative of World Health Organization (WHO) on effectiveness of the drinking water legislation in other countries.

D.1 Drinking water legislation in the USA

D.1.1 General information

The Safe Drinking Water Act (SDWA) is the main federal law regulating the quality of the drinking water in the USA. SDWA sets standards for drinking water quality and requirements as well as provisions for control on the implementation of the SDWA by the United States Environmental Protection Agency (US EPA), states, localities, and water suppliers who implement the standards.

SDWA was originally passed by the Congress in 1974 to protect public health by regulating public drinking water supply. The law was amended in 1986 and in 1996. Until 1996 the SDWA focused primarily on treatment as the means of providing safe drinking water at the tap. With the amendments in 1996 provisions were introduced recognizing source water protection, operator training, funding for water system improvements, and public information as important components of safe drinking water. Sound science and risk-based standard setting, small water supply system flexibility and technical assistance, community-empowered source water assessment and protection, and water system infrastructure assistance through a multi-billion-dollar state revolving loan fund were introduced.

SDWA applies to every public water system in the United States. Public water systems are defined as systems that have at least 15 service connections or serve at least 25 people per day for 60 days of the year. The public water systems may be publicly or privately owned. There are currently more than 170,000 public water systems. SDWA does not regulate private wells (these serve less than 25 individuals). Drinking water standards apply to water systems differently based on their type and size. The following water supply systems are distinguished:

- Community Water System (approximately 54,000) - A public water system that serves the same people year -round. Most residences including homes, apartments, and condominiums in cities, small towns, and mobile home parks are served by Community Water Systems;
- Non-Transient Non-Community Water System (approximately 20,000) - serves the same people more than six months per year, but not year -round, for example, a school with its own water supply is considered a non-transient system;

- Transient non-community water system (there are approximately 89,000) - serves the public but not the same individuals for more than six months, for example, a rest area or campground may be considered a transient water system.

In addition to the SWDA, National Primary Drinking Water Regulations set maximum contaminant levels for particular contaminants in drinking water and treatment technologies to remove contaminants. National Primary Drinking Water Regulations are legally enforceable standards that apply to public water systems. Each standard also includes requirements to test for contaminants in the water to make sure standards are achieved.

National Secondary Drinking Water Regulations are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or colour) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

The responsibility for application of the SDWA is divided among US EPA, states, tribes, water systems, and the public. SDWA provides a framework in which these parties work together. US EPA provides guidance, assistance, and public information about drinking water, collects drinking water data, and oversees state drinking water programs.

States can apply to US EPA for "primacy," the authority to implement SDWA within their jurisdictions, if they can show that they will adopt standards at least as stringent as US EPA's and make sure water systems meet these standards. All states and territories, except Wyoming and the District of Columbia, have received primacy. While no Indian tribe has yet applied for and received primacy.

Both US EPA and states can take enforcement actions against water systems not meeting safety standards. US EPA and states may issue administrative orders, take legal actions, or fine utilities.

D.1.2 Main provisions of the legislation

Drinking water standards: US EPA sets primary drinking water standards trough the National Primary Drinking Water Regulations. Two type of contaminants levels are defined:

- Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals;
- Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

When it is not economically or technically feasible to set a maximum level, or when there is no reliable or economic method to detect contaminants in the water, US EPA instead sets a required Treatment Technique which specifies a way to treat the water to remove contaminants. US EPA performs a cost-benefit analysis and obtains input from interested parties when setting standards.

The primary drinking water standards are determined by EPA through a three-step process:

- US EPA identifies contaminants that may adversely affect public health and occur in drinking water with a frequency and at levels that pose a threat to public health. US EPA identifies these contaminants for further study, and determines contaminants to potentially regulate;
- US EPA determines a maximum contaminant level goal for contaminants it decides to regulate;

- US EPA specifies a maximum contaminant level which is enforceable standard or required Treatment Technique.

The List of Contaminants and their Maximum Contaminant Level Goal and Maximum Contaminant Level are available at: http://water.epa.gov/drink/contaminants/#Primary.

There are activities undertaken to strengthen protection for microbial contaminants, including Cryptosporidium, while strengthening control over the by-products of chemical disinfection. The Stage 1 Disinfectants and Disinfection By-products Rule and the Interim Enhanced Surface Water Treatment Rule together address these risks. Defined are the following criteria:

- Maximum Residual Disinfectant Level Goal - The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.);
- Maximum Residual Disinfectant Level - The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

Contaminant candidate list (CCL): Contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, but are known or anticipated to occur in public water systems are also monitored and listed in CCL. Contaminants listed on the CCL may become part of future regulation under the SDWA. Water systems must monitor certain contaminants from the CCL. These monitoring data are used to help determine which contaminants should be regulated by new standards, and the levels of those standards. SDWA requires EPA to publish the CCL every five years. EPA also solicit public nominations for the CCL.

US EPA must conduct a thorough cost-benefit analysis for every new standard to determine whether the benefits of a drinking water standard justify the costs.

EPA's surface water treatment rules require systems using surface water or groundwater under the direct influence of surface water to:

- disinfect their water; and
- filter their water; or
- meet criteria for avoiding filtration so that the selected contaminants (Cryptosporidium, Giardia lamblia, Viruses, Legionella, Turbidity, Heterotrophic Plate Count,) are controlled at certain levels.

The following rules specifically apply for surface water treatment:

- Long Term 1 Enhanced Surface Water Treatment: Surface water systems or groundwater under the direct influence systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (such as turbidity standards, individual filter monitoring, Cryptosporidium removal requirements, updated watershed control requirements for unfiltered systems);
- Long Term 2 Enhanced Surface Water Treatment Rule: This rule applies to all surface water systems or groundwater systems under the direct influence of surface water. The rule targets additional Cryptosporidium treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storage facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts;
- The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

The groundwater treatment is regulated through the Ground Water Rule. The purpose of the rule is to provide for increased protection against microbial pathogens (through fecal contamination) in public water systems that use groundwater sources. The rule also applies to any system that mixes surface and groundwater if the groundwater is added directly to the distribution system and provided to consumers without treatment. SDWA also sets a framework for the Underground Injection Control program to control the injection of wastes into groundwater. The SDWA also provides for designation of aquifers which are the sole or principal drinking water source for an area, and which, if contaminated, would create a significant hazard to public health. After a Sole Source Aquifer is designated, no commitment for federal financial assistance may be provided for any project which the EPA determines may contaminate the aquifer through its recharge area so as to create a significant hazard to public health.

Source Water Assessment: Every state must conduct an assessment of its sources of drinking water (rivers, lakes, reservoirs, springs, and groundwater wells) to identify significant potential sources of contamination and to determine how susceptible the sources are to these threats. Protecting drinking water sources is implemented through combined efforts of many partners such as public water systems, communities, resource managers and the public. The 1996 amendments to the SDWA established EPA's Source Water Assessment and Protection Programs.

Monitoring water quality: Water systems are responsible for conducting monitoring of drinking water to ensure that it is meets all drinking water standards. To do this, water systems and States use analytical methods developed by government agencies, universities, and other organizations. EPA is responsible for evaluating analytical methods developed for drinking water and approves those methods that it determines meet Agency requirements for monitoring organic, inorganic, radionuclide and microbiological contaminants. States or US EPA certify the laboratories that conduct the analyses. Individual water systems submit samples for laboratory testing (monitoring) to verify that the water they provide to the public meets all federal and state standards. How often and where samples are taken varies from system to system and contaminant to contaminant. Requirements vary depending on the contaminant group, whether the water system uses groundwater or surface water, and the number of people served. Water systems serving large populations generally require more monitoring because of the greater potential impact of violations. Small water systems can receive variances or exemptions from monitoring in limited circumstances.

Risk assessment and management: The use of science in decision making is made-the best available, peer-reviewed science and supporting studies conducted in accordance with sound and objective scientific practices. The effect of the water on human health is studied and Drinking Water Standards and Health Advisories Tables are developed. Health Advisories provide information on contaminants that can cause human health effects and are guidance values based on non-cancer health effects for different durations of exposure (e.g., one-day, ten-day, and lifetime).

Operator Certification: Water system operators must be certified to ensure that systems are operated safely. US EPA issued guidelines in February 1999 specifying minimum standards for the certification and recertification of the operators of community and non-transient, noncommunity water systems. These guidelines apply to state Operator Certification Programs. All states are currently implementing EPA-approved operator certification programs.

Funding programmes and grants: US EPA provides grants to implement state drinking water programs, and to help each state set up a special fund to assist public water systems in financing the costs of improvements. The following financial mechanisms have been created:

- Drinking Water State Revolving Fund: States can use this fund to help water systems make infrastructure or management improvements or to help systems assess and protect their source water;
- Clean Water State Revolving Fund: available to a range of borrowers including municipalities, communities of all sizes, farmers, homeowners, small businesses, and nonprofit organizations; the interest rates are low (the interest rates average 1.7 percent, compared to market rates that average 3.7 percent); The fund partners with banks, nonprofits, local governments, and other federal and state agencies.

Small Water Systems: The small water systems are given special consideration. US EPA and states provide them with extra assistance (including training and funding) as well as allowing, on a case-by- case basis, alternate water treatments that are less expensive, but still protective of public health. EPA funds eight Technical Assistance Centers through earmark grants to provide on-site technical assistance, training, financial planning support and other services for small water systems. The TACs offer specialized technical assistance based on the needs of small systems in your area and provide management training that can improve system performance and efficiency.

Consumer information and consultation: It is required that the information is provided to the public about public health effects which is comprehensive, informative, and understandable. US EPA operates Safe Drinking Water Hotline. All community water systems must prepare and distribute annual reports about the water they provide, including information on detected contaminants, possible health effects, and the water's source. If a water system is not meeting the standards, it is the water supplier's responsibility to notify its customers. States and US EPA must prepare annual summary reports of water system compliance with drinking water safety standards and make these reports available to the public. In addition data on the numbers and types of public water supplies, populations served, source water, violations, enforcement actions are publicly available through EPA's public web sites, although the statistics are a bit outdated (2011 statistics available in August 2015). The public can be involved in developing source water assessment programs, state plans to use drinking water state revolving loan funds, state capacity development plans, and state operator certification programs.

Sources of information for the USA

- Safe Drinking Water Act
- Understanding the Safe Drinking Water Act (PDF)
- National Primary Drinking Water Regulations
- Secondary Drinking Water Regulations
- List of Contaminants and their Maximum Contaminant Level Goal and Maximum Contaminant Level
- Contaminant candidate list
- Drinking Water Standards and Health Advisories Tables
- Microbiological Risk Assessment (MRA) Tools, Methods, and Approaches for Water Media
- Variances and Exemptions in water monitoring
- Long Term 1 Enhanced Surface Water Treatment
- Long Term 2 Enhanced Surface Water Treatment Rule
- Ground Water Rule
- The Filter Backwash Recycling Rule
- Underground Injection Control
- Standards & Risk Management
- Ground Water Rule (GWR)
- Source Water Assessment and Protection Programs
- Underground Injection Control Program

- Sole Source Aquifer
- Drinking Water State Revolving Fund
- Clean Water State Revolving Fund
- Technical Assistance Centers
- Safe Drinking Water Hotline
- National Public Water Systems Report
- Drinking Water Monitoring, Compliance, and Enforcement

D.2 Drinking water legislation in Canada

D.2.1 General information

The main document regulating drinking water at national level in Canada is Guidelines for Canadian Drinking Water Quality (GCDWQ). GCDWQ are established by the Federal-Provincial-Territorial Committee on Drinking Water (CDW) and published by Health Canada. The GCDWQ set out the basic parameters that every water system should achieve in order to provide clean and safe drinking water. They are used by every jurisdiction in Canada as the basis for establishing their own requirements for drinking water. In some cases, a department or responsible authority may choose to meet more stringent objectives than those detailed in the GCDWQ. This decision is left to the discretion of each department or authority.

The drinking water systems in Canada are divided into the following categories:

- Large systems serve more than 5,000 people;
- Small systems serve between 501 and 5,000 people;
- Very small systems serve between 26 and 500 people;
- Micro-systems serve up to and including 25 people.

In addition to these categories unique facilities are recognised as those in remote locations. For the unique facilities, very small systems and micro-systems specific approaches are developed as it is recognised that they face proportionally higher costs, and have less access to sophisticated technologies and adequately trained staff.

Throughout much of Canada the water supply systems are operated by municipalities, however, an increasing number are being operated and in some cases owned by private companies. A few municipalities have delegated service provision to public companies owned by provinces.

The governing of drinking water in Canada falls under provincial/territorial jurisdiction. The provinces and territories are responsible for developing and enforcing all legislation pertaining to municipal and public water supplies including their construction and operation. Although drinking water quality is generally an area of provincial jurisdiction, the federal government has some responsibilities for drinking water quality, including on federal lands and in First Nations communities located south of 60° N latitude. North of 60° N, the territorial governments are responsible for ensuring safe drinking water in all communities in their territories, including First Nations and Inuit communities. In some instances (e.g., for federal employees), there are legislative obligations to ensure the safety of drinking water supplies. Federal departments have an obligation under the Canada Labour Code and its Occupational Health and Safety Regulations to provide potable water to their employees.

Interdepartmental Working Group on Drinking Water (IWGDW) was created in August 2002 to develop a federal drinking water program that would incorporate an intake-to-tap approach to drinking water quality in all areas of federal jurisdiction. The Mandate of the IWGDW is two-fold: (1)

to maintain the GCDWQ and update it as necessary; and (2) to be the principal interdepartmental forum for discussing and providing input to issues related to drinking water quality and the GCDWQ. The IWGDW consists of representatives of federal departments who have responsibilities for producing and/or providing clean, safe and reliable drinking water in areas of federal jurisdiction, as well as the Treasury Board of Canada Secretariat. Interdepartmental Water Quality Training Board is a sub-group of the IWGDW. The Training Board is developing and disseminating a range of training tools for very small systems in the federal domain. Its focus is systems serving only up to 25 people, as no tools are available to this vulnerable sub-set of drinking water systems. Health Canada provides the technical and scientific expertise to the IWGDW, through its role as technical secretariat.

The Canadian Council of Ministers of the Environment also has some role in drinking water management as far as it concerns water sources protective and pollution prevention measures.

D.2.2 Main provisions of the legislation

The Guidelines for Canadian Drinking Water Quality regulate:

- Microbiological parameters;
- Chemical and physical parameters;
- Radiological parameters.

Each guideline was established based on current, published scientific research related to health effects, aesthetic effects, and operational considerations. For each parameter the guidelines establish treatment goal, maximum acceptable concentration or operational guidance values. Health-based guidelines are established on the basis of comprehensive review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical technologies. Aesthetic effects (e.g., taste, odour) are taken into account when these play a role in determining whether consumers will consider the water drinkable. Operational considerations are factored in when the presence of a substance may interfere with or impair a treatment process or technology (e.g., turbidity interfering with chlorination or UV disinfection) or adversely affect drinking water infrastructure (e.g., corrosion of pipes). Technical documents for each parameter are developed.

The guidelines are reviewed in order to assess the need to update them. In the tables, guidelines that have been reaffirmed include both the original approval and reaffirmation year indicated after the name of the parameter.

Science-based documents published as part of the Guidelines for Canadian Drinking Water Quality are developed through literature review, internal and external peer-reviews, public consultations and Federal-Provincial-Territorial approval processes.

Multi-barrier approach to safe drinking water is set as fundamental approach for managing Canadian drinking water in line with the integrated water management approach. The approach comprises an integrated system of procedures, processes and tools that collectively prevent or reduce the contamination of drinking water, from source to tap. It also includes stakeholder commitments to develop legislative and/or policy frameworks; guidelines, standards and objectives; research, science and technology solutions; and consumer awareness and involvement. The application of the multi-barrier approach at the federal level varies from department to department and from site to site. As part of the multi-barrier approach a sanitary survey is undertaken. The survey is on-site review, from intake to tap, of the specific raw water quality, facilities, equipment, operations, and maintenance records for the purpose of evaluating the system's ability to

adequately treat source water in order to produce and deliver safe drinking water. The sanitary survey varies depending upon the type and complexity of the system.

Due diligence: In addition to meeting regulatory requirements, federal departments, drinking water system operators, and other responsible authorities are expected to be able to demonstrate due diligence in carrying out their duties (whether these duties are regulated or not). Demonstrating due diligence means taking every precaution reasonable in the given circumstances to avoid harm and having mechanisms in place to deal with non-compliance and for holding employees accountable for their decisions and actions.

Operator Certification: In 1974, the Canadian group adopted a set of guidelines for operator certification programs. Today Certified Operators are required in 5 of the 10 provinces. The 3 territories have no requirements for operator Certification.

Water quality monitoring: The monitoring program for all federal drinking water systems should be developed based on a sanitary survey in combination with a vulnerabilities assessment and a baseline chemical analysis. At minimum, an initial sanitary survey, vulnerabilities assessment, and baseline chemical analysis should be conducted within five years for an existing system and before a new system is put into service. They should continue to be conducted every five years, or when there are significant changes to the treatment system, land use, or other conditions which may adversely affect water quality.

For departments and other responsible authorities who produce/treat their own drinking water, the recommended monitoring frequency for microbiological parameters depends on a number of factors, including the size of the population served, the monitoring history, type and quality of the source water, and the presence and type of treatment used. For all systems serving up to and including 5,000 people, bacteriological samples should be collected at a minimum four times per month at regular intervals. It is recommended that monitoring programs for identified chemical contaminants include, at minimum, annual monitoring for surface water sources, and monitoring every two years for groundwater sources, unless otherwise specified in the GCDWQ.

There is case-specific guidance for monitoring of groundwater supplies and municipally supplied systems. Monitoring at the tap is still required for some contaminants originating in plumbing systems (e.g., lead).

The water monitoring is divided into operational monitoring and compliance monitoring.

Operational monitoring practices focus on critical control points in the drinking water system to ensure the system is being operated as required. This type of monitoring allows the operator to detect changes in water quality and adjust the treatment process accordingly. In addition, increased monitoring is provided during extreme conditions to collect information on the ability of the system to cope with the pressures. Where feasible, continuous monitoring at plants is recommended for some parameters (e.g., chlorine residual, turbidity). Tests for operational monitoring do not need to go to an accredited laboratory. Operational monitoring strategies are system-specific and foster due diligence.

Compliance monitoring ensures drinking water reaching consumers meets established requirements. Every facility will need to develop its monitoring program based on the results of the vulnerabilities assessment, sanitary survey and baseline chemical analysis. In addition, many federal departments and First Nations communities have their own documents and/or directives that provide guidance on monitoring frequency and related monitoring issues.

It is provided that the results of water testing within the building should be compared with the results of testing at the treatment plant or in the distribution system (municipal or federal), conducted during the same time period, in order to identify any discrepancies. All discrepancies should be investigated and remedial actions taken as appropriate.

Disinfection by-products: Disinfection by products are monitored from point of view of ensuring the minimum concentration of choline in order to control bacterial regrowth and not from point of view of reducing the unnecessary levels of residual chlorine in the system. In the provinces and territories, specific requirements for chlorine residual concentrations are set by the regulatory authority and may vary between jurisdictions. Any chemicals (additives) used in drinking water treatment processes and/or the distribution system must meet the NSF/ANSI Standard 60 (NSF, 2012).

Materials that come into contact with drinking water are divided into the following three categories:

- treatment devices (such as filters and reverse osmosis systems and their components);
- treatment additives (such as alum and chlorine); and
- system components (such as pipes and faucets).

There are no recommended specific brands of drinking water treatment devices, but it is recommended that consumers look for a mark or label indicating that the device has been certified by an accredited certification body as meeting the appropriate NSF International (NSF)/American National Standards Institute (ANSI) health-based performance standards. Plumbing systems (internal building distribution systems) within federal buildings and in First Nations communities must be designed and constructed to meet the National Plumbing Code of Canada.

Incident and emergency response plans are developed by the federal suppliers of drinking water and Chief and Council in the Nations communities. To address cases of a suspected/confirmed event of contamination, the plan should include the possibility that water advisory are issued (boil water advisory, drinking water avoidance advisory). Drinking water advisories are public announcements to advise the public of an identified or expected risk to their water supply. Incident response protocols are established. Web-based alert and reporting system for drinking water advisories is available for use by agencies across Canada.

Consumer information: The consumer information provided by the national authorities is scares. There are no national-wide requirements for provision of information and reporting. This is regulated at provinces based on their legislation. For example all municipalities in Ontario are required to produce an annual report on drinking water systems.

Sources of information for Canada

- Guidelines for Canadian Drinking Water Quality;
- Health Canada;
- Canadian Council of Ministers of the Environment;
- From Source to Tap: Guidance on the Multi-Barrier Approach to Safe Drinking Water;
- Canadian Water and Waste Water Association;
- Guidance for Providing Safe Drinking Water in Areas of Federal Jurisdiction;
- Technical documents;
- Drinking Water System Annual and Summary Reports in Ontario.

D.3 Drinking water legislation in Australia

D.3.1 General information

Australian Drinking Water Guidelines (ADWG) is the main national-wide document that sets requirement related to drinking water. The Guidelines provide a framework for good management of drinking water supplies and contain information about management of drinking water systems, monitoring and the contaminants that may be present in drinking water. The ADWG are not mandatory standards. The Australian states are given the right to determine requirements to the drinking water quality considering the regional or local factors, and taking into account economic, political and cultural issues, including customer expectations and willingness and ability to pay.

The development and enforcement of the drinking water legislation is under the jurisdiction of the Australian states. A comprehensive list of the responsible institutions and legislation is available at the site of the Australian Water Association. The institutional arrangements for service provision vary among States and Territories. For example in Western Australia, drinking water quality management is a shared responsibility between the Water and Rivers Commission and the Water Corporation of Western Australia. The Water and Rivers Commission is responsible for administration of catchment and source protection legislation and the Water Corporation of Western Australia is the major licensed drinking water supplier responsible for the collection, treatment and distribution of drinking water to consumers. Other key agencies in the supply of drinking water are the regulators, including the health authority (National Health and Medical Regulation Council), which provides interpretation and guidance on potential health impacts of drinking water quality.

The Australian Government Department on the Environment is responsible for water policies at the federal level.

D.3.2 Main provisions of the legislation

The ADWG provide guidance on the following categories of contaminants in drinking water:

- Physical;
- Microbial;
- Chemical, including:
  - inorganic chemicals;
  - organic compounds;
  - pesticides.
- Radiological.

The ADWG include two different types of guideline value:

- a health-related guideline value, which is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption;
- an aesthetic guideline value, which is the concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer; for example, appearance, taste and odour.

Preventive management approach that encompasses all steps in water production from catchment to consumer is applied. Preventive risk management approach includes elements of HACCP, ISO 9001 and AS/NZS 4360:2004, but applies them in a drinking water supply context to support consistent and comprehensive implementation by suppliers. Multiple barriers approach and critical points approach are also applied.

Hazard identification and risk assessment requires to:

- Define the approach and methodology to be used for hazard identification and risk assessment;
- Identify and document hazards, sources and hazardous events for each component of the water supply system;
- Estimate the level of risk for each identified hazard or hazardous event;
- Evaluate the major sources of uncertainty associated with each hazard and hazardous event and consider actions to reduce uncertainty;
- Determine significant risks and document priorities for risk management;
- Periodically review and update the hazard identification and risk assessment to incorporate any changes.

Continuous review of the reports and monitoring data is required and as a result development of Water quality management improvement plans.

Materials and chemicals in contact with water

Chemicals added to water include disinfectants, oxidants, coagulants, flocculants, algicides, antioxidants and chemicals for softening, pH adjustment, fluoridation and scale prevention. It is provided that all chemicals used should be evaluated for potential contamination. General considerations include data on impurities, chemical and physical properties, maximum dosages, behaviour in water, migration and concentration build-up. In addition, the potential impact of water treatment chemicals on materials used in treatment plants is considered. Materials used should comply with Australian Standard AS/NZS 4020 Products for use in contact with drinking water. The products used in water systems should be subjected to an audited system of quality control.

Water quality monitoring is divided into

- operational monitoring in the source/catchment, through the treatment process, and in the distribution system, to ensure that processes and activities are functioning optimally to achieve safe drinking water;
- verification of drinking water quality, which consists of:
  - drinking water quality monitoring in the distribution system to verify the quality of treated water as supplied to the consumer; and
  - consumer satisfaction monitoring to assess consumer comments and complaints;
- investigative studies and research monitoring (including baseline monitoring where new water sources are going to be used to supply drinking water) to identify and characterise hazards, and increase understanding of a water supply system;
- validation monitoring of new operational processes and barriers, to assure effective operation and control; and
- incident and emergency response monitoring, undertaken in response to incidents or emergencies.

It is envisaged that the monitoring is planned and directed at significant characteristics among which characteristics that might have potential impact on human health and aesthetic characteristics. Critical control points approach is used in operational monitoring.

Sampling locations depend on the water quality characteristic being examined. Sampling at the treatment plant or at the head of the distribution system may be sufficient for characteristics where concentrations do not change during delivery; however, for those that can change during distribution, it is provided that the sampling is undertaken throughout the distribution system, including the point of supply to the consumer.

Frequency of testing for individual characteristics depend on variability, and whether the characteristics are of aesthetic or health significance. Sampling and analysis are required most frequently for microbial constituents, and less often for organic and inorganic compounds. Once parameters and sampling locations have been identified, these are documented in a consolidated monitoring plan. Procedures for sampling and testing are also documented.

Disinfection by-products

To be acceptable, the chemical must have a practical application (e.g. clarify dirty water, destroy or inactivate harmful microorganisms). The chemical must achieve its purpose and must not be toxic when ingested at concentrations present in treated water. Only the chemical approved by national Health and Medical Research Council to the Government of Australia can be used for water treatment. There are minimum standards established by the relevant state or territory regulatory agency for the concentrations of the residuals of the chemicals used for treatment of drinking water.

The determination of contaminants in drinking water treatment chemicals is carried out by an independent laboratory accredited to undertake the necessary assays.

Consumer information and public consultations

Development of a comprehensive strategy for community consultation is recommended in the ADWG. The Guidelines also provide advice on how consumers to be involved in considering options for effective and acceptable monitoring and reporting on performance of their water supply, and on the frequency of such reporting. A consumer complaint and response program operated by appropriately trained personnel is recommended to be established. Complaints and responses should be recorded and, in the longer term, the types, patterns and changes in numbers of complaints received should be evaluated. Appropriate documentation and reporting of the incident or emergency id also required.

The water supplies produce reports to inform consumers about the water quality and the water supply systems they manage as for example the report of Sydney water.

Funding programmes: The National Water Security Plan for Cities and Towns is providing funding to cities and towns with fewer than 50,000 people to upgrade older water systems, install new infrastructure and support practical projects that save water or reduce water losses.

Sources of information for Australia

- Australian Drinking Water Guidelines;
- Australian Water Association;
- Australian Government Department on the Environment;
- Sydney water;
- National Water Security Plan for Cities and Towns.

D.4 Drinking water legislation in New Zealand

D.4.1 General information

The amended Health (Drinking Water) Act of 2007 is the New Zealand's main legislative document which deals with the protection of public health by improving the quality of drinking water provided to communities.

The Act only applies to drinking water supplies above a certain size as listed below:

- 25 or more people for 60 or more days per year; or

- if there are fewer than 25 people, but 6000 or more 'person/days' (that is the number of people multiplied by the number of days they receive water from the supply).

The main responsibilities which apply to the above listed suppliers include the obligations to:
- take all practicable steps to comply with the (previously voluntary) drinking water Standards;
- introduce and implement water safety plans for the water supply (if serving more than 500 people);

As of 1 July 2008 all drinking water suppliers will be required to apply to the Ministry of Health for registration on the drinking water register. Supplies that serve fewer people also need to apply to be included on the Register of Community Drinking water Supplies, however, this is free and involves no other obligations.

The Director-General of Health maintains the register of drinking water assessors. No agencies have been appointed as drinking water assessors so far, but a number of individuals have been appointed.

The Associate Minister of Health issues Drinking water Standards for New Zealand 2005 (Revised 2008). The Standards are applicable to water intended for drinking by the public irrespective of the water's source, treatment or distribution system, whether it is from a public or private supply, or where it is used. The exception is bottled water, which is subject to standards set under the Food Act 1981.

The Standards have been made after consultation with all interested persons who made submissions to the Ministry of Health. According to the Health Act of 2007 drinking water suppliers should comply with the Drinking water Standards for New Zealand until 31 December 2014. The Standards have been published since 1984, however until the amendment of the Health act in 2007 the Standards were applied on voluntary basis. It is provided that the Standards are used together with a Water safety plan.

The Guidelines for Drinking water Quality Management in New Zealand provide additional information about the:
- Contaminants listed in the Standards;
- Management of drinking water quality;
- Publications on which the Standards are based.

Organisations at three levels are responsible for the provision of safe and wholesome drinking water to any particular community in New Zealand - one at the local level, one regional and one at national level. The Ministry of Health, through the provision of Drinking water standards, guidelines and other tools, ensures at national level that an appropriate infrastructure is present in New Zealand to support the provision of clean and safe drinking water.

At the local level, usually the water supply is provided by a territorial local authority such as a district or city council. They extract the source water, run the treatment plant to remove risks or contaminants, and pipe the water to the consumer houses. Under the Drinking water Standards for New Zealand 2005, they are expected to test the water regularly to demonstrate that it is safe.

The Ministry of Health does not supervise the local authorities directly, but instead works at the regional level through the District Health Boards (DHBs). Each DHB is expected to oversee the territorial local authorities in its area and ensure (audit) that they maintain appropriate water quality. In a serious health risk situation, the DHB can, through the health district's Medical Officer of

Health, order a water supply to close. DHBs also report to the Ministry so that a national picture can be maintained of the state of all community drinking water supplies. Drinking water responsibilities of the DHBS are undertaken by the Drinking Water Assessors.

D.4.2 Main provisions of the legislation

The Drinking water Standards for New Zealand provide requirements for drinking water safety by specifying the:

- Maximum amounts of substances or organisms or contaminants or residues that may be present in drinking water. The maximum concentrations of chemicals of health significance (MAVs) in water are defined based on current knowledge. Wherever possible, the MAVs have been based on the latest WHO guideline values. The MAVs constitute no significant risk to the health of a person who consumes 2L of water a day over their lifetime (usually taken as 70 years). The Standards provide MAV of microbial, chemical and radiological substances in drinking water that are acceptable for public health;
- Criteria for demonstrating compliance with the Standards;
- Remedial action to be taken in the event of non-compliance with the different aspects of the Standards.

The Standards apply only to health significant contaminants. Guideline values for aesthetic characteristics are also provided, however they are not part of the water quality standards.

There are separate compliance requirements for small drinking water supplies (serving fewer than 500 people, tankered drinking water, and rural agricultural drinking water supplies.

Multiple barriers approach in drinking water management is applied. The barriers include:

- minimising the extent of contaminants in the source water that must be dealt with by the treatment process;
- removing undesirable soluble and particulate matter;
- disinfecting to inactivate any pathogenic organisms present;
- protecting the treated water from subsequent contamination.

Monitoring

To demonstrate compliance with the MAVs, water suppliers need to follow the relevant sampling and testing programmes detailed in the Standards. The contaminants of public health significance have been divided into four priority classes to minimise monitoring costs without compromising public health. To demonstrate compliance, only those relatively few contaminants that fall into the classes with highest potential risk, Priorities 1 and 2, must be monitored. Monitoring of contaminants in the lower potential risk categories, Priorities 3 and 4, is at the supplier's discretion, unless a Drinking Water Assessor requires it for public health reasons.

The sampling frequencies are chosen to give 95 percent confidence that the medium to large drinking water supplies comply with the Standards for at least 95 percent of the time. The larger supplies are required to monitor more frequently.

The Ministry of Health requires all testing of drinking water made as part of the monitoring process is to be performed by accredited laboratories The Register of recognised laboratories provides information about the laboratories that have been assessed by the New Zealand's main accreditation body (IANZ) and found to comply with either NZS/ISO/IEC 17025:1999 or the Ministry of Health Level 2 Criteria analytical laboratories. The Director General of Health maintains a register of Recognised Laboratories.

Water safety plans and risk management

Water safety plans for drinking water supplies were introduced in 2001. They are intended to ensure management procedures that reduce the likelihood of contaminants entering supplies in the first place. Water safety plans encourage the use of risk-management principles during treatment and distribution. To assist drinking water suppliers to develop water safety plans for their drinking water the Ministry of Health produced 39 water safety plan guides covering the system elements (filtration, disinfection, water storage, distribution etc.) that are most frequently found in drinking water supplies. All but the smallest community water supplies are required to prepare and implement a Water safety plan.

Contingency planning

The drinking water suppliers should develop contingency plans to be invoked in the eventuality that an emergency arises. These plans should consider:

- potential natural disasters (such as earthquakes, volcanic eruptions, algal blooms, droughts and floods);
- accidents (spills in the catchment or recharge area);
- areas with potential backflow problems (including ones with fluctuating or low pressures);
- damage to the electrical supply;
- damage to intakes, treatment plant and distribution systems;
- human actions (strikes, vandalism, and sabotage).

The contingency plan should include a communications plan to alert and inform users of the supply and plans for providing and distributing emergency supplies of water. The plans should be developed in liaison with civil defence personnel and should be updated.

Funding programmes

In 2005 the Government announced $150 million programme to assist small drinking water supplies in providing safe water to their communities. The programme will run for 10 years. The programme has two major components:

Technical Assistance Programme, trains and assists communities to improve their own supplies.

Capital Assistance Programme, will help fund improvements where TAP participation has shown that local resourcing is inadequate for a good solution.

Consumer information

The Drinking Water for New Zealand web portal is an information source for the consumers and those managing drinking water quality.

Annual Reports on Quality of Drinking Water in New Zealand and other publications as guidelines are publicly available at http://www.health.govt.nz/our-work/environmental-health/drinking water/drinking water-publications.

Sources of information for New Zealand

- Health (Drinking Water) Act;
- Drinking water register;
- Drinking water Standards;
- Guidelines for Drinking water Quality Management in New Zealand;
- The Register of recognised laboratories;
- Safety plan guides;
- Technical Assistance Programme;

- Capital Assistance Programme;
- Drinking Water for New Zealand;
- Annual Reports on Quality of Drinking Water.

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Annex F Interview list

Group	Country	Sector	Institute
EU28	n.a.	Academics	Eureau
		Industry	CEIR
		Industry	CEFIC
		Industry	ECPA
		NGO	ANEC
		Utility	Aquapublica
Central	Germany	Industry	Hach
		Utility	Rheinisch-Westfalische Wasserwerksgesellschaft
		Utility	Berlin Wasser Betriebe
		Utility	AoW
		Utiltiy	Figawa
	Hungary	Regulator	Ministry of Health
	Poland	Regulator	Inspektorat Sanit
		Regulator	Water Health Security Comission
		Utility	Water&Sewer Blonie
	Slovakia	Regulator	Public Health Authority
		Regulator	Min. of Health
North	Finland	Regulator	Min. of Health
South	Italy	Utility	Matropolitana Milanese
		Utility	CapHolding
		Utility	Abbanoa
		Utility	Viveracqua
	Portugal	Regulator	Ersar
	Spain	Utility	Agbar
South - East	Bulgaria	Utility	Sofia Vodia
	Croatia	Regulator	Min. of Health
		Utility	City of Zagreb
West	Belgium	Other	Aquaflanders, dewatergroep, pidpa
		Regulator	VMM
		Utility	Pidpa
		Utility	VIVAQUA
	Fr / Be	Utility	Aquawal
	France	Utility	Veolia
		Utility	FNCCR
		Utility	Compagnie Intercommunale Liégeoise des eaux
	Ireland	Regulator	EPA

Group	Country	Sector	Institute
	NL	Regulator	RIVM
		Utility	VEWIN
		Utility (Advisor)	VEWIN
	UK	Academics	University of Exeter
		Academics	WHO

Annex G Linking the DWD to national drinking water related costs and benefits

G.1 Methodological approach (as taken up in main text):

The costs –and benefits of the DWD have a link to the DWD, but in most cases can not completely be attributed purely to the existence of the DWD. This means that from the total cost and/or benefit only a specific share can be contributed to the Directive. In short this is because the identified actions/improvements of the drinking water system would also occurred/occurred to a lesser extend through national legislation and/or other EU Directives.

The determination of attributability is extremely difficult, since it depends on many interlinkages (for some countries there is even a chicken-egg story, because they had already certain parametric values in legislation prior to the '98 DWD). Attributability is thus a difficult to determine, but nevertheless crucial when determining the impact of the DWD (or any legislation for that matter). To obtain reliable estimates the evaluators developed, based on available literature and interviews, estimated shares of attributability for reporting-, monitoring –and (lead) pipe replacement costs. Due to the importance of these values and the possible differences between MS stakeholders were contacted to respond on these estimation. The stakeholders provided feedback on MS for which they indicated themselves knowledgeable (often their home country) based on the below definition of attributability and in some cases additional discussions with the evaluators.

Attributability over 17 years DWD

An activity is 100% attributable if this activity would not have taken place without the implementation of the DWD. An activity is 0% attributable if this activity is already implemented by the MS (please take the 'awaremess raised by the DWD' into account). An intermediate impact of the DWD (so a share between 0% and 100%) on an activity could be because (i) the MS implemented already some sort of similar (perhaps less strict) activity and/or (ii) the MS would, in your opinion, implement at a point in time (later then 1998) autonomously a similar activity. The table below assumes that neither 100% or 0% are likely outcomes (chicken – egg problem) and that MS who joined the EU (and adopted the DWD in legislation) at a later stage than 1998 are, in general, more impacted by the DWD compared to the 15 early EU members.

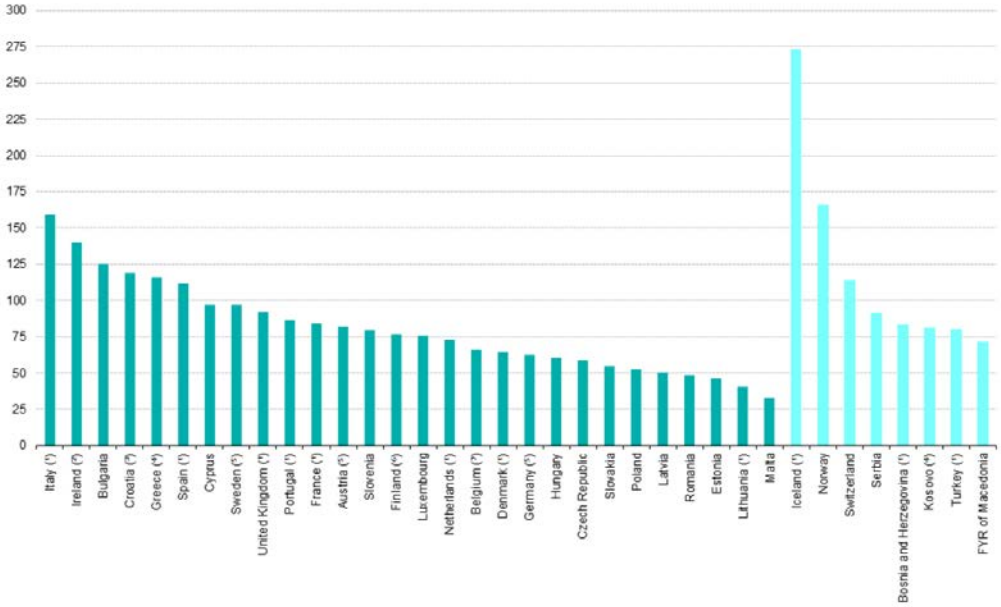
In the case that stakeholders informed us that we over-/underestimated certain shares (and solid information was given as of why we over-/underestimated) we have adjusted the estimations of the attributability of the DWD regarding reporting, monitoring and (lead) pipe replacement. For X out of the 28 MS we received one or more responses. In Annex G we provide the outcome of this activity, where the various colors indicate through what method the share has come to be.

G.2 Attributability of costs to the DWD[139] and overview of average water consumption per MS

Country	Average liter per capita per day consumption[140]	Share of reporting costs	Share of monitoring costs	Share of lead replacement
Austria	80	25%	25%	10%
Belgium	70	25%	25%	90%
Bulgaria	125	50%	50%	65%
Croatia	120	50%	75%	75%
Cyprus	165	50%	50%	0%
Czech Republic	63	50%	75%	75%
Denmark	70	25%	25%	0%
Estonia	45	75%	75%	0%
Finland	76	50%	50%	0%
France	83	35%	35%	70%
Germany	50	25%	25%	10%
Greece	119	25%	50%	3%
Hungary	65	50%	10%	50%
Ireland	140	0%	50%	95%
Italy	159	15%	15%	20%
Latvia	50	75%	75%	75%
Lithuania	35	75%	75%	75%
Luxembourg	75	25%	25%	90%
Malta	33	75%	75%	0%
Netherlands	74	10%	10%	10%
Poland	53	35%	35%	35%
Portugal	85	33%	75%	15%
Romania	48	75%	75%	75%
Slovakia	58	50%	25%	10%
Slovenia	77	50%	25%	10%
Spain	130	70%	50%	10%
Sweden	71	45%	50%	0%
United Kingdom	90	25%	25%	5%

[139] Green: Stakeholders confirm estimates
Red: Stakeholders provide a 'better' estimate
Purple: Stakeholders do not agree with estimate but find it difficult to provide an 'exact' estimation; and Ecorys made a new estimation based on the comments from stakeholders

[140] Information based on Eurostat 2002-2011 for most MS (http://ec.europa.eu/eurostat/statistics-explained/images/thumb/8/8a/Total_freshwater_abstraction_by_public_water_supply%2C_2013_%28m%C2%B3_per_inhabitant%29_YB16.png/786px-Total_freshwater_abstraction_by_public_water_supply%2C_2013_%28m%C2%B3_per_inhabitant%29_YB16.png.



Source: Eurostat, 2007-2012, code: env_wat_abs

Annex H Background of the parametric values in the DWD.

H.1 Three groups of parameters

The DWD distinguishes three groups of parameters: the microbiological parameters, the chemical and the indicator parameters. All three groups have a different background and different weighting. Standards for drinking water in the DWD are based on health aspects (this holds for both microbiological and chemical parameters) and on other aspects such as organoleptic or consumer perception aspects (odour, taste, colour), or operational aspects (pH and hardness of the water) or as indicator for possible pollutants(this holds for indicator parameters) .

The *microbiological parameters E.coli* and Enterococci for tap water (there are additional parameters for water in bottles), have been included in the DWD, not because they are dangerous for human health, but since they are an indication for the potential contamination of the water with faecal matter and thus the potential presence of pathogenic organisms. The values in the DWD are set based on the principle that these should be absent from drinking water. In the case either *E.coli* or Enterococci are detected this is an indication that something is wrong with the water supplied and urgent and immediate action is needed to find the source and take remedial action.

The *Indicator parameters* have not be included in the DWD for their adverse effects on human health. These parameters are monitored to ascertain the proper functioning of the water production and the water supply. In the case of non-compliance or abnormal changes the water supplier needs to investigate the reason behind these changes and take action as and when required. Even though the parameters and their parametric values (if any) do not have a health-based background, they often are the first change noticed by consumers. Wholesomeness and cleanliness of the water (organoleptic issues) are key to the consumer's perception and confidence in the water supplied at the tap. Parametric values are often based on perception and are best judged by the local operators. Any changes as noticed by indicator parameters should be a signal for water suppliers to make sure the water supply is still safe.

The *chemical parameters* do have a health-related basis. In principle health-based quality standards for chemical substances in drinking water are based on toxicity for humans through oral exposure. Considering the low concentrations of such substances in drinking water and sources of drinking water, the risk of acute effects during normal operational circumstances is negligible. Health-based limit values are generally based on effects that might occur after life-long exposure such as chronic toxicity, hormone disruption and geno-toxic and carcinogenic effects. As data on long-lasting exposure of human beings is hardly ever available toxic effects of substances are determined through animal testing.

A distinction is made between substances with and without a threshold doses below which no adverse health effects are to be expected. The existence of a threshold depends on the mode of action of a substance. Threshold substances will only cause toxic effects above a certain doses - the No Observed Adverse Effect Level, NOAEL. The NOAEL, based on long lasting animal testing (or when available on the basis of effects on humans), is used to determine a doses judged to be safe for human beings – the Tolerable Daily Intake (TDI, usually expressed as mg/kg body weight/day). A safety factor or 'uncertainty factor' (UF) is applied. Uncertainty factors are used in the development of drinking water guidelines to account for uncertainties in the database, including extrapolations of toxicity from animal studies (intra species) and variability within humans (inter

species), which result in some uncertainty about risk. The individual UFs are multiplied, to derive the overall UF. The application of uncertainty factors is entrenched in toxicological risk assessment worldwide, but is not applied consistently. The Tolerable Daily Intake is calculated as follows:

$$TDI = \frac{NOAEL}{UF}$$

The intake standards are health-based limit values, defined as the maximum amount of a substance that can be ingested on a daily basis during a life time without any adverse effects on human health. When effects of a substance only occur after life-long exposure and are based on the most sensitive effects after chronic exposure, short term and relatively slight exceedances of the intake standard will not immediately result in adverse health effects. Furthermore a safety margin has been applied in setting the intake standard through the use of a 'worst case' approach. In case a substance will already cause adverse health impacts during a single or short term exposure, exceedance of the limit value will result in a risk to human health. In such cases each event will have to be judged individually to assess impacts on human health.

In general drinking water is not the only route of exposure. To ensure the total exposure to a substance does not exceed the TDI, a percentage of the total exposure (ingestion, inhalation and skin contact) is allocated to drinking water in setting health-based standards. The exposure through drinking water is generally relatively small compared to other exposure routes.
In case the contribution of drinking water is unknown, the WHO applies a standard allocation of 20% since 2010, and 10% before 2010. Since most of the current health-based standards, were set before 2010, they used the 10% allocation. Furthermore its assumed that the average drinking water consumption is 2 litres per person per day and the body weight of an adult is 60 kg or 70 kg.
Health-based standard for drinking water = (TDI x body weight x drinking water allocation) / 2 litres
For non-threshold substances, mostly geno-toxic and or carcinogenic substances a different approach is used. For these substances it is not possible to decide on a no-effect doses as theoretically one molecule could result in uninhibited cell growth. In these case the effect of a substance is expressed as the risk of death caused by cancer. A mathematical model is used to calculate the concentration in drinking water that at life-long exposure results in one additional cancer case per 1.000.000 people. This is considered to be a negligible risk level. WHO uses one additional case in 100.000 people. As this specific risk calculation only concerns exposure through drinking water no allocation factor is applied. However it is sometimes not evident whether or not a substance has a threshold for exposure, below which no adverse effects occur. Also a substance can have two modes of action one with a threshold and a non-threshold action. In those case the non-threshold mode of action is often used for the setting of standards as the level is mostly lower than the threshold.

H.2 Pesticides a special case

In the DWD a non-scientific limit value of 0,1 µg/l for individual pesticides has been agreed. This value also applies to toxicologically relevant metabolites. This value conforms with the TTC-concept. For non-toxicologically relevant metabolites a precautionary value of 1 µg/l is used. These TTC values are not based on health considerations. (TTC Threshold of Toxicological Concern).
For each of the chemical parameters in the DWD we have studied the background (used by EC/WHO or the CSTE (Scientific Committee) used in setting the value in the DWD. We have also tried to assess if the substances are threshold or non-threshold substances. This is important for the assessment of the potential impact on human health of exceedances reported by MS.
In the case of threshold parameters we will add the uncertainty factor, also called safety factor, that was used. In the case of non-threshold parameters we will add the additional level of risk through drinking water accepted by the EC. Currently the assessments we have made are being checked by KWR toxicologists.

H.3 Assess the adverse effects of non-compliance on human health

For the *microbiological parameters* the assessment of the impact on human health is not a straightforward exercise as we are only dealing with the monitoring data on indicator organisms and not on pathogenic organisms. Based on our knowledge the level of *E.coli* and Enterococci in water polluted with faecal matter a rough estimate of the potential presence of pathogenic organisms is possible. This can be used to try and estimate a potential adverse effect on human health through drinking water as described in the inception report.

For the chemical parameters the level of non-compliance is assessed for their potential impact on human health using the uncertainty/safety factors used for the setting of threshold chemicals and the change in the level of risk used to set the non-threshold chemicals.

DRAFT FINAL

DRAFT FINAL

P.O. Box 4175
3006 AD Rotterdam
The Netherlands

Watermanweg 44
3067 GG Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E netherlands@ecorys.com

W www.ecorys.nl

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