WATER-M

Unified Intelligent WATER

Deliverable 1.4

Analysis of Current Water Policies

Project Identifier	Water-M
Project Title	**Unified Intelligent Water**
Document Version	2.0
Planned Delivery Date	
Actual Delivery Date	
Document Title	**Analysis of Current Water Policies**
Work Package	WP1 (Task 1.3)
Document Type	Word

Abstract Drinking water legislation in Finland and in EU. The revision aspects of DWD in European Union.

Keywords Drinking water, legislation

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List of abbreviations

EC	**European Council**
EU	**European Union**
DW	**drinking water**
DWD	**drinking water directive**
SET-Plan	**European Strategic Energy Technology plan**
UN	**United Nations**
WHO	**World Health Organization**
WSP	**Water Safety Planning**

The goals of task 1.3: In this task, current water policies, standards and leading technological solutions for water management in Finland and EU will be analyzed. In the Water-M project this task considers the analysis of European directives and policies established in the SET-Plan for water management and other directives and agreements at national and international level. Investigation will address how to formulate water management objectives at the municipality level aligned with utilities and municipalities' business models. Technological, regulatory and business oriented aspects will be considered within this task. As a result, a document with the analysis of European directives and policies established in the SET-Plan for water management and other directives and agreements will be written.

1 Background

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There is long worldwide history of legislation concerning water services. Globally the guidelines for drinking water quality originate from the World Health Organization (since 50´s). Thus, WHO provides the foundation for drinking water quality requirements ensuring safety of water. European nations and European Union has also a long period of legislation related to drinking water production and distribution. As on example, drinking water directive (DWD) states the detailed quality requirements for water intended for human consumption (EU 1998). DWD is a result of scientific and political process agreed with the EU Member States. Still, the scientific bases of water quality requirements of DWD originate from the guidelines of WHO. In national level Member state need to lay down the legislation which follow the EU directives. As concerning DWD Member States may set values for other additional parameters not included in DWD where that is deemed necessary in their own legislation concerning water intended for human consumption.

EU Water Framework Directive, established in 2000, is primarily a water protection instrument. The directive has a number of objectives, such as preventing and reducing pollution, promoting sustainable water usage, environmental protection, improving aquatic ecosystems and mitigating the effects of floods and droughts. The EU and its Member States engage in international water cooperation within the UN and other contexts. One important task is research and development in the sector. Member States must identify and analyze European waters, on the basis of individual river basin and district. They shall then adopt management plans and programs of measures adapted to each body of water (EU 2000).

2 WHO Guidelines for drinking-water quality

The first World Health Organization (WHO) publication dealing specifically with drinking-water quality was published in 1958 as International Standards for Drinking-water. WHO produces international norms on water quality and human health in the form of guidelines that are used as the basis for regulation and standard setting, in developing and developed countries world-wide (WHO 2015). One of the guidelines focus on general drinking water quality, WHO Guidelines for drinking-water quality (WHO 2010).

WHO Guidelines for drinking-water quality provide guidance on good practice in surveillance, monitoring and assessment of drinking-water quality in community supplies. The Guidelines are addressed primarily to water and health regulators, policymakers and their advisors, to assist in the development of national standards. The Guidelines and associated documents are also used by many others as a source of information on water quality and health and on effective management approaches (WHO 2010).

The fourth edition of Guidelines further develops concepts, approaches and information introduced in previous editions, including the comprehensive preventive risk management approach for ensuring drinking-water quality that was introduced in the third edition. It considers:

- drinking-water safety, including minimum procedures and specific guideline values
- approaches used in deriving the guidelines, including guideline values
- microbial hazards
- climate change
- chemical contaminants in drinking-water
- the important roles of many different stakeholders in ensuring drinking-water safety
- guidance in situations other than traditional community supplies or managed utilities, such as rainwater harvesting and other non-piped supplies or dual piped systems (WHO 2010).

3 UNECE-WHO/Europe Protocol on Water and Health

The UNECE-WHO/Europe Protocol on Water and Health aims to protect human health and well-being by better water management and by preventing, controlling and reducing water-related diseases. The Protocol provides a sound framework for the translation into practice of the human right to water and sanitation. To meet these goals, its Parties are required to establish national and local targets e.g. for the quality of drinking water and the quality of discharges, as well as for the performance of water supply and waste-water treatment. They are also requirement to reduce outbreaks and the incidence of water-related diseases (UNECE/WHO 1992).

The Protocol introduces a social component into cooperation on water management. Water resources management should link social and economic development to the protection of natural ecosystems. Moreover, improving the water supply and sanitation is fundamental in breaking the vicious cycle of poverty (UNECE/WHO 1992).

The implementation of the Protocol on Water and Health: The process of target-setting entails analyzing the national situation, streamlining and harmonizing responsibilities and commitments in water and health. A realistic plan for improvement, with prioritized time-bound targets adapted to the national situation, must be elaborated. When complying with Protocol's provisions, Parties are encouraged to tailor their targets accordingly to the country-specific problems.

The progress in setting targets and implementing the Protocol is assessed on the basis of summary reports provided by Parties. According to the article 7 of the Protocol, Parties shall collect and evaluate data on their progress towards the achievement of the targets and on indicators designed to show how that progress has contributed towards preventing, controlling or reducing water-related disease (UNECE/WHO 1992).

According to the Protocol on Water and Health, each Party has the obligation to establish and publish its national targets and the respective target dates for each target area within 2 years of becoming a Party. The targets shall cover the areas stipulated, except where national circumstances make them irrelevant for preventing, controlling and reducing water-related disease (UNECE/WHO 1992).

4 EU legislation

The European Union has a history of over 30 years of drinking water policy. This policy ensures that water intended for human consumption can be consumed safely on a life-long basis, and this represents a high level of health protection. The main pillars of the policy are to:

- Ensure that drinking water quality is controlled through standards based on the latest scientific evidence;
- Secure an efficient and effective monitoring, assessment and enforcement of drinking water quality;
- Provide the consumers with adequate, timely and appropriately information;
- Contribute to the broader EU water and health policy (EU 2015 a)

4.1 The EU Water Framework Directive (2000/60/EC)

The aim of the Water Framework Directive (2000/60/EC) of the European Parliament and of the Council is to achieve good status of surface water and groundwater by the year 2015. Set targets may be waived under certain conditions and deadlines continue until the year 2027. In addition to the Water Framework Directive there are also a number of other water protection key directives, such as the Groundwater Directive (2006/112/EC), Directive on Environmental Quality Standards (2008/105/EC), the Urban Waste Water Directive (91/271/EEC), the Nitrates Directive (91/676/EEC), the Bathing Water Directive (2006/7/EC) and the Drinking Water Directive (98/83/EC). Water Framework Directive aims to create a framework in accordance with the name of the European Union's water policy and unify the earlier number based different directives to water protection. The aim is to promote the sustainable use of water resources, prevent pollution of groundwater and to correct already resulted pollution.

The directive (WFD) commits European Union member states to achieve good qualitative and quantitative status of all water bodies by 2015. It is a framework in the sense that it prescribes steps to reach the common goal rather than adopting the more traditional limit value approach (EU 2000).

4.2 Council Directive (98/83/EC) on the quality of water intended for human consumption

Council Directive (98/83/EC) on the quality of water intended for human consumption is the most important directive for drinking water (EU 1998, 2015 b). The EU drinking water directive defines the minimum requirements of the quality of drinking water within the EU. It lays down, for example, requirements of the monitoring and the quality of water intended for human consumption, requirements for public information and management actions in the case of non-compliance, and also specifications for the analysis of parameters.

The Drinking Water Directive applies to:

all water supplies serving more than 50 people or supplying more than 10 cubic meter per day, but also supplies serving less than 50 people or less than 10 cubic meter per day if the water is supplied as part of a commercial or public activity.

In the directive, water intended for human consumption shall mean:

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 in containers;

all water used in any food-processing industry, unless the competent national authorities are satisfied that the quality of the water cannot affect the wholesomeness of the foodstuff in its finished form.

The Drinking Water Directive doesn't apply to natural mineral waters or waters which are medicinal products.

The purpose of the directive is to protect consumers of drinking water within the European Union and to make sure that water is aesthetically clean and without unpleasant taste, odor or color. A total of 48 microbiological, chemical and indicator parameters (Annex I) must be monitored and tested regularly. In general, World Health Organization'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 drinking water.

The basic idea of the monitoring is to confirm the adequate quality of drinking water throughout the year and in different parts of the network. The quality of water has to comply with the quality standards which have been set for the protection of consumers' health. Monitoring of water, based on drinking water samples, is normally carried out at the consumers tap in order to get information on the quality of water distributed for consumption.

The purpose of monitoring is to provide regular information on the organoleptic and microbiological quality of the water, and information of the effectiveness of drinking water treatment and to provide the information necessary to determine whether or not all of the Directive's parametric values are being complied with. Member States may set values for other additional parameters not included in DWD where that is deemed necessary for the purpose of ensuring the quality of the production, distribution and inspection of water intended for human consumption (EU 1998).

The annexes II and III of the Directive have been revised in 2015 (EU 2015 c). The revision concerned the minimum requirement of monitoring for water intended for human consumption and the specifications for the method of analysis of different parameters. The revision of the Directive has been described in the chapter 8 of this document.

4.3 Strategic Energy Technology Plan (SET Plan)

The Commission presents a strategic plan to accelerate the development and deployment of cost-effective low carbon technologies. This plan comprises measures relating to planning, implementation, resources and international cooperation in the field of energy technology. This Communication sets out the strategic energy technology plan (SET-Plan), the main aim of which is to develop low carbon technologies and to make them competitive. In order to meet that objective, the Plan proposes various European Industrial Initiatives and a risk sharing approach (EU 2007).

The strategic energy technology plan (SET plan) presented by the Commission aims to help achieve European objectives and face up to the challenges of this sector:

• in the short term by increasing research to reduce costs and improve performance of existing technologies, and by encouraging the commercial implementation of these technologies. Activities at this level should in particular involve second-generation biofuels, capture, transport and storage of carbon, integration of renewable energy sources into the electricity network and energy efficiency in construction, transport and industry;

• in the longer term by supporting development of a new generation of low carbon technologies. The activities to be carried out should focus, among other things, on the competitiveness of new technologies relating to renewable energies, energy storage, sustainability of fission energy, fusion energy, and the development of Trans-European Energy networks.

Implementation of this SET plan will involve collective effort and activities in the private sector, the Member States and the EU, as well as internationally (EU 2007).

One aim in SET-Plan concerns energy efficiency: the Smart Cities Initiative aims at promoting the creation of market opportunities for energy efficiency technologies. Through an investment of EUR 11 billion, this initiative should

make it possible, by 2020, to establish cities as nuclei from which energy efficiency technologies will spread. Smart networks, a new generation of buildings and low carbon transport solutions will be developed. The aim of these Smart Cities is to transform the energy system (EU 2007).

5 Water Safety Planning (WSP)

The most cost-effective and protective means of consistently assuring a supply of acceptable drinking-water is the application of some form of risk management based on sound science and supported by appropriate monitoring. Risk management needs to be inclusive and to cover the whole system from catchment to consumer. The primary risk management approach for drinking water is based upon HACCP (Hazard Analysis and Critical Control Point) principle. The HACCP is based on developing an understanding of the process system, prioritising risks and ensuring that appropriate control measures are in place to reduce risks to an acceptable level (WHO 2005).

The main principles of Water Safety Planning (WSP) modified from HACCP and adopted by WHO are aiming at 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 (WHO 2005).

The latest WHO´s WSP manual (2009) gives overview the philosophy of the WSP approach. The aim of the WSP manual is to provide that practical guidance to facilitate WSP development focusing particularly on organized water supplies managed by a water utility or similar entity (WHO 2009). The WSP manual outlines the key activities that should be carried out, lists typical challenges that may be encountered, and summarizes the essential outputs to be produced. The manual presents examples and tools (i.e. check lists) which could be adapted to support the development and implementation of WSPs. There are also case studies presenting lessons-learned from real-life experiences (WHO 2009).

6 Legislation related to water services in Finland

The main legislation related to the surveillance of drinking water quality in Finland is included in the Health Protection Act (763/1994) and its Degree (1280/1994) (Parliament of Finland 1994 a, b). More detailed requirements on monitoring and quality requirements of drinking water are included in the Decree of the Ministry of Social Affairs and Health (1352/2015) (Parliament of Finland 2015). Degree of the Ministry of Social Affairs and Health 1351/2006 lays down the minimum technical and hygiene knowledge requirements for the personnel working in the water works. All staff in water works should have basic knowledge about the raw water sources, water chemistry and microbiology, water treatment, hygiene of distributed water and legislation. Water Services Act (119/2001) defines the role and obligations of water supply plants in Finland (Parliament of Finland 2001). The roles and responsibilities concerning central and local authorities are described in the Water-M project´s Deliverable 1.1.

In Finland, comprehensive approach for WSP (i.e. water cycle safety plan principle) has been put into operation. This means that technical guidelines and tools for preparing WSP for drinking water production and distribution (WSP), waste water treatment (Sanitation Safety Plan, SSP) and building water systems (Building Water Safety Planning, BWSP) have been prepared. The adoption of WSP principles starts as voluntary basis, but in the future it will be regulated as a compulsory obligation.

6.1 Health Protection Act (763/1994)

According to the Finnish legislation on health protection, drinking water means “1) all water that is meant for drinking, food preparation, or other domestic purposes regardless of whether the water is transmitted through the distribution network, tanks, bottles, or containers; and 2) all water that is used in the food industry for production, processing, storage, and entry on the market” (Parliament of Finland 1994 a).

It is stipulated in the Health Protection Act that all drinking water should be safe and aesthetically suitable for potable usage. The waterworks has to be designed, located, built and maintained in such manner which secures the safety of drinking water. Health protection authorities have to regularly monitor the quality of drinking water, and if necessary, give orders e.g. for disinfection to ensure the safety of drinking water and to protect consumers’ health. The personnel of waterworks need to notify the health authorities in case of suspected water contamination or a waterborne outbreak (Parliament of Finland 1994 a).

6.2 Decree of the Social Affairs and Health on the Quality and Monitoring of Water Intended for Human Consumption (1352/2015)

In Finland, the requirements and recommendations for the quality of drinking water are defined in the Decree (1352/2015) of the Ministry of Social Affairs and Health (Parliament of Finland 2015). The decree is based on the EU´s drinking water directive and concerns all water that is 1) provided at least 10 m^3 per day or at least for 50 people, 2) supplied in the bottles or containers or from a tanker, 3) used for food production intended for human consumption, or 4) distributed to be used as drinking water as a part of public and commercial operation.

The water quality requirements concern the water taken from the consumers' faucets (tap water), or water taken from tanks or in inlet point when water is bottled. The quality of drinking water in Finland is monitored by municipal health protection authorities. The supervising authority and the plant providing drinking water must together prepare a plant specific monitoring programme for regular monitoring. Regular monitoring includes check monitoring and audit monitoring. Check monitoring is used to collect data on quality of drinking water, and to monitor the efficiency of water treatment, and to ensure the fulfilment of quality demands. Audit monitoring is used to establish whether the demands and recommendations of the Finnish decree on drinking water have been fulfilled (Parliament of Finland 2015).

In check monitoring, the minimum parameters to be determined are: odour, taste, turbidity, colour, pH, electric conductivity, iron, manganese, nitrite (if chloramine is used for disinfection), aluminium (if aluminium compounds are used in water treatment or if these compounds in present in raw water), ammonium, *Clostridium perfringens* (if surface water is used as raw water), *Escherichia coli*, coliformic bacteria, and the possible additional analyses defined in the monitoring research program. Monitoring and quality requirements of radioactive substances, radon, tritium, and indicative dose are also based on the Decree (Parliament of Finland 2015).

According to the Decree, municipal health protection authorities have to establish a plan for exceptional situations. The plan shall include e.g. a list of occasions that may compromise the safety of drinking water. The assessment has to be based on the risk analysis. The plan shall also include management actions to be taken in an exceptional situation, information during an event and contact details of authorities and other relevant bodies.

6.3 Water Services Act (119/2001)

The objective of Water Services Act is to ensure water services which provide a sufficient amount of impeccable household water with respect to health and otherwise as well as appropriate sewerage in terms of the protection of health and the environment. The Act states that a water supply plant manages the water services in its area of operation in accordance with the needs of community development as set out in the decision on the approval of the area of operation (Parliament of Finland 2001).

Within the territory of a municipality, the areas of operation of water supply plants must cover areas where connecting the properties to the water pipes or sewers is necessary due to the quantity or type of settlement or business and leisure activities comparable with settlement in terms of water services.

An area of operation must be such that the water supply plant can be considered capable of managing the water supply services under its responsibility in an economical and appropriate manner.

When approving an area of operation, a municipality must determine areas to be included in the water main network of the plant as well as areas to be included in the sewage networks of the plant, taking into account the needs of the different parts of the area. A timetable for including the different parts of the area of operation into the networks must be set in connection with the decision on approval. The alteration made in Water Services Act in 2014 includes also guidelines concerning preparation of emergency situations (including non-compliance and other exceptional situations) in water services. Each water works need to have plans aiming to manage and maintain the water services in case of any emergency situation (Parliament of Finland 2001).

7 Legislation related to water services in France

Numerous directives of the European Commission inspire much of the French national regulations on Water. In particular:

- The Directive of 16 June 1975 laying down quality standards for surface water which is intended for the production of drinking water
- Directive of 17 December 1979 on the protection of groundwater against pollution by certain dangerous substances
- Directive of 15 July 1980 on the quality of water intended for human consumption
- Directive of 3 November 1998, which addresses the quality of water, intended for human consumption.

These guidelines are not binding on any Member State directly, but they must be converted into national rights under the conditions and must respect the deadlines, as specified in the text.

Several conventions and guidelines (including the Aarhus Convention of 25 June 1998 and the Framework Directive on good ecological and chemical status of the 2000 Water Resources) make information and public participation a major issue.

States must justify the compliance with these guidelines Thus, in France, The State regulates the relationship between water stakeholders (while respecting the principle of cooperation between these actors). If the state is not involved in the utilization of water (which are the result of Commons), it is the state that ultimately has the authority over the disposition of water resources.

The State provides the water policy. For example, it defines the conditions under which it is possible to take raw water from the natural environment. It establishes the main policy orientations of water by keeping in compliance with EU rules in this area.

For example, in order to be qualified as drinking and be distributed to the population, the water should meet the specified requirements by the State (in accordance with European directives, but potentially stricter), which is a long list

of parameters. This includes the sanitary checks of the quality of water supply by the state.

In France, one ministry out of two is concerned directly or indirectly by water. It is the water management department of the Ministry of Ecology and Sustainable Development, which coordinates the program and state interventions in the field of water, in conjunction with other relevant ministries (Health, Agriculture, Industry, Interior...)

The various agencies or municipalities in charge of water services are required to report their activities by providing all requested information (both in terms of infrastructure as well as the quality of water delivered).

France is divided into six geographical areas called "river basins" irrigated by a given river system Since 1964, the watershed is the cornerstone of French water policy. Each basin corresponds to two instances

- The basin committee: the parliament of water which is developing a water management policy respecting the national policy orientations and regulations.
- Water agency: the executive agency to implement the policy decided by the basin committees.

In France, the distribution of drinking water is allotted to the French municipalities or their groups. Whatever be the mode of management of the water service, the municipal (or inter-municipal) remains the organizing entity of the service and as such is responsible for the quality of service.

8 Revision of Drinking Water Directive (98/83/EC)

8.1 Revision of the Annexes II and III of the Directive

The Directive was accepted in 1998 (EU 1998). The European Commission together with Member States has now accepted the revision of the Annexes II and III of the Directive (98/83/EC) (EU 2015 c). In the revised text, the Annex II grants a certain degree of flexibility in performing audit and check monitoring. The number of samples can be reduced under certain circumstances. The conditions of monitoring and monitoring techniques have been assessed in the light of scientific progress.

The approach of Water Safety Plan (WSP) which has been developed by the WHO since 2004 has now been included in the Annex II. WSP comprises risk assessment and risk management procedures throughout the water supply chain to prevent or reduce the risks threatening the production and delivery of safe drinking water. The main aim is to take actions as early stage as possible, and to observe effects of actions taken. One of the aims is to bridge the gap between water abstraction and supply. WSP approach and monitoring of drinking water has now been stuck together. If WSP approach is applied in a proper way including comprehensive documentation, it grants certain flexibility in monitoring. The number of samples can, for example, be decreased.

According to the revised Annex II, competent authorities shall establish monitoring programmes complying with the parameters and frequencies, and which may consist of:

a) collection and laboratory analysis of discrete water samples;

b) measurements recorded by a continuous monitoring process;

c) inspections of records of the functionality and maintenance status of equipment;

d) inspections of catchment area, water abstraction, treatment, storage and distribution infrastructure.

Monitoring programmes may be based on a risk assessment. Member states shall ensure that risk assessments are approved by their relevant competent authority and information on the performance of the risk assessment and a summary of its results is available.

According to the revised Annex III, the Member States shall ensure that the methods of analysis used are validated and documented according to the specified standard mentioned in the Annex. For chemical parameters and indicators, the Annex III includes a table containing minimum performance characteristic, uncertainty of measurement. The uncertainty of measurement is presented as percentage of parametric value.

The revision of the Annexes was accepted in the Committee Meeting held on 20th April 2015. The new Directive has been given on the 6th October 2015. National legislation shall be brought into force within 24 months after the entry into force of the new Directive (EU 2015 c).

9 Leading technological solutions

At the moment biological and chemical analysis are analyzed mainly in the laboratory with standardized/certificated methods. Currently, in the field there are number of other methods to be used in a description of drinking water quality. Methods such as on-line monitoring and early warning systems, flow cytometry and different kind of PCR methods are highly used in the research area.

General water quality parameters include pH, chlorine, temperature, flow and turbidity. These parameters can now be monitored also with on-line monitoring instrumentations. These new techniques will give additional information of drinking water quality and they can give it fast if data transmission is arranged. Also, continuous monitoring systems are mentioned in the monitoring programmes in the revision of drinking water directive (98/83/EC) (EU 2015 c).

The flow cytometry (FCM) for assessment and monitoring of total and intact bacterial cell concentrations during drinking water treatment and distribution is easy and rapid. Flow cytometry is quantitative and cultivation-independent method for routine monitoring of drinking water. Flow cytometry was first used in medical applications were it has been found as a tool in drinking water research and monitoring. In Switzerland flow cytometry has been accepted in standardized method for determining the total cell count and ratios of high and low nucleic acid (333.1).

A molecular technology based polymerase chain reaction (PCR) is a technology in use to amplify a single copy or a few copies of a piece of DNA a cross several orders of magnitude, generating thousands to millions of copies of particular DNA sequence. With found sequences wanted species in water may be found from the amount of sample that is not detectable with plate cultivation.

9 Standardization of methods

Standardization is the establishment of joint agreements to facilitate the business community, public authorities and citizens' activities. ISO (International Organization for Standardization) is an independent, non-governmental membership organization and the world's largest developer of voluntary International Standards. ISO made up of 163 member countries who are the national standards bodies around the world, with a Central Secretariat located in Geneva, Switzerland (ISO 2015).

ISO does not decide when to develop a new standard. Instead, ISO responds to a request from industry or other stakeholders such as consumer groups. Typically, an industry sector or group communicates the need for a standard to its national member who then contacts ISO. ISO standards are developed by groups of experts from all over the world that are part of larger groups called technical committees. These experts negotiate all aspects of the standard, including its scope, key definitions and content. The technical committees are made up of experts from the relevant industry, but also from consumer associations, academia, NGOs and government. Developing ISO standards is a consensus-based approach and comments from stakeholders are taken into account (ISO 2015).

ISO has published more than 19 500 International Standards covering almost every industry, from technology, to food safety, to agriculture and healthcare. ISO International Standards impact everyone, everywhere. An ISO standard is developed by a panel of experts, within a technical committee. Once the need for a standard has been established, these experts meet to discuss and negotiate a draft standard. As soon as a draft has been developed it is shared with ISO’s members who are asked to comment and vote on it. If a consensus is reached the draft becomes an ISO standard, if not it goes back to the technical committee for further edits (ISO 2015).

10 Implements

There still are ongoing work under EU legislations e.g. under the EU water framework directive (2000/60/EC) were good status of surface water and groundwater was settled in 2015, but was possible to be continued under certain conditions till the year 2027 (EU 2000). In EU member states for example In Finland this framework is enforced in different laws and directives. With a revision of the drinking water directive (98/83/EC) the monitoring of drinking water quality and methods will be more flexible and based on the risk assessment (EU 2015 c).

Despite recent advances in biological and chemical monitoring methods and technologies, there is no universal practice for water quality monitoring and contaminant detection. Emerging technologies: such as on-line monitoring or other early-warning systems, flow cytometry and PCR, have provided advantages and added more options in drinking water quality assays. Still technology needs to co-evolve and become less expensive to be used in everyday life in water plants.

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