Synthesis of existing legislation, guidelines, standards, organisations and projects related to drinking water safety and monitoring

ERNCIP Thematic Group Chemical and Biological Risks to Drinking Water Task 2, deliverable 2.3

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Abstract

In order to define the basic elements for harmonisation in the field of drinking water safety and security, existing European standards and directives are presented. A specific focus is made on biological risks. It clearly appears that little information is available for biological monitoring and only a few microorganisms are recommended for monitoring.

Outside Europe, guidelines and directives are available either at international (the World Health Organisation (WHO)) or at national (Canada, the United States, Australia) levels. Although the risks may be different from one country to another, these documents can be considered as models, as they include reference scientific information.

Various European partnerships also exist to tackle water quality, such as the water joint programming initiative (JPI-Water), the water European innovation partnership (EIP-Water), Eureau, the water information system for Europe (WISE), and mandate 487 (M/487). All these networks are of great importance because they group the major stakeholders in the water sector (institutions, private companies, operators, governmental agencies, regulators, etc.). They point out the needs, and are actively involved in driving strategy, policy, and scientific approaches.

In parallel, EU-funded projects ensure research and development (R & D) innovations and they define future monitoring technologies and efficient European networks.

Finally, recommendations are presented in order to avoid overlap with existing initiatives and to strengthen the mission of the water thematic group.

1. Introduction

A wide variety of chemical and biological contaminants can potentially be found in drinking water, resulting from either an attack or a natural contamination incident. Whatever the origin of the contamination, detection and identification are needed to ensure water quality and subsequent citizen safety.

A number of reports were previously produced by the ERNCIP thematic group on water (TG-Water) on the screening methods for rapid identification of chemical or biological contaminations in drinking water. The group concluded that while the water sector is specifically mentioned in the European programme for critical infrastructure protection, drinking water should be regarded as critical infrastructure. The need for vulnerability assessments of utilities as a prerequisite to targeting measures to reduce security risks was clearly identified.

In this context, it is necessary to establish how EU Member States (as well as countries outside of the European Union) deal with drinking water safety and security. Indeed, harmonisation of detection and identification of chemical and biological threats through event detection systems (EDS) may be needed.

This report is a synthesis of existing European, international and national initiatives (directives, standards and guidelines), European organisations and research programmes related to drinking water safety and monitoring. The choice has been made to mainly focus on the biological aspects, although information concerning chemicals is available in the same documents.

This work intends to represent the basic elements to prepare the ground for a harmonised/standardised water safety plan (WSP).

2. International and European standards

2.1. International standard on water quality, ISO/TC 147

ISO is the International Organisation for Standardisation which develops and publishes international standards. **ISO/TC 147** is the standard dedicated to water quality. It includes definition of terms, sampling of waters and measurement and reporting of water characteristics. It is divided into six parts.

- ISO/TC 147/SC 1: terminology.
- ISO/TC 147/SC 2: physical, chemical and biochemical methods (including ISO/TC 147/SC 02/WG 68 on 'Turbidity').
- ISO/TC 147/SC 3: radioactivity measurements.
- ISO/TC 147/SC 4: microbiological methods (dealing with Coliforms, *Legionella*, *Campylobacter* and *Pseudomonas aeruginosa, etc.* Information is available by contacting the secretariat.)
- ISO/TC 147/SC 5: biological methods (mainly focusing on toxicity).
- ISO/TC 147/SC 6: sampling (general methods).

To obtain details of such standards, standards shall be bought and specific secretariats contacted.

http://www.iso.org/iso/iso_technical_committee?commid=52834

2.2. European standard on water supply CEN/TC 164

The European Committee for Standardisation (CEN) developed CEN Technical Committee (CEN/TC) 164 to establish standards for 'the installation and performance requirements of systems, constructions of components used for the water supply from the production facility, including the treatment of the water, to the taps attached or unattached to a sanitary appliance with the view of maintaining the quality of water as stated in Directive 80/778'.

Eleven working groups (WGs) were set up including CEN/TC 164/WG 15 which is in charge of the security of the drinking water supply. Guidelines for crisis management (part 1) describes good practice principles of drinking water supply management in the event of a crisis, including preparatory and follow-up measures, and risk management (part 2) describes the principles of a risk management approach to improve the integrity of the drinking water supply system; it addresses all entities and stakeholders sharing responsibility in the provision of safe drinking water throughout the entire supply chain from the source to the point of use.

Standards must be bought to obtain further information.

http://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:6145&cs=1F7C7AA73990546C443B4206E2810EED6

3. European Directives

3.1. Drinking Water Directive 98/83/EC

The Drinking Water Directive (DWD) (Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption) aims 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.

http://ec.europa.eu/environment/water/water-drink/legislation_en.html

This directive indicates that Member States shall take all measures necessary to ensure that:

— regular monitoring of the quality of water is carried out, in order to check that the water available to consumers meets the requirements of this directive and in particular the parametric values set in accordance with Annex I (Table 1);

— where disinfection forms part of the preparation or distribution of water intended for human consumption, the efficiency of the disinfection treatment applied is verified, and that any contamination from disinfection by-products is kept as low as possible without compromising the disinfection.

To meet these obligations, appropriate monitoring programmes shall be established by the competent authorities. Those monitoring programmes shall meet the minimum requirements set out in Annex II (Fig. 1). Member States may add other parameters to this list if they deem it appropriate.

Regarding this directive and recommendations on biological contamination, only three categories of microorganisms have to be checked: *E. coli*, *Enterococci* and *Pseudomonas aeruginosa*. One can note that only a few pathogenic bacteria are addressed. Moreover, no viruses, no microalgae and no protozoa are mentioned. Counting is recommended (22 °C and 37 °C) which is time-consuming and doesn't enable an early warning of contamination.

3.2. Water Framework Directive

Water Framework Directive 2000/60/EC (WFD) of 23 October 2000 establishes a framework for Community action in the field of water policy for the protection of inland surface waters (rivers, lakes, transitional water and coastal waters) and groundwater. It relies on quality elements for the classification of ecological status (high, good, moderate) according to biological elements such as: (i) composition, abundance and biomass of phytoplankton, (ii) composition and abundance of aquatic flora, (iii) composition and abundance of benthic invertebrate fauna and (iv) composition, abundance and age structure of fish fauna.

However, neither nominative nor quantitative information related to pathogenic microorganisms is reported in this directive. Annex X, initially reporting the priority substances, has been removed. A new list is currently included in Environmental Quality Standards Directive 2008/105/EC (see below).

http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF

3.3. Other European water quality directives

- **Environmental Quality Standards Directive 2008/105/EC (EQS)** (24 December 2008) in the field of water policy, amending Directive 2000/60/EC, was published in the *Official Journal of the European Union*. In Annex I, limits on concentrations of 33 priority substances and eight other pollutants are reported. These substances or groups of substances include selected existing chemicals, plant protection products, biocides, metals and other groups like polyaromatic hydrocarbons and polybrominated biphenylethers.

No biological pathogens are listed.

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0105&from=EN

- **Bathing Water Directive 2006/7/EC (BWD)** (15 February 2006, repealing Directive 76/160/EEC) lays down provisions for: (i) the monitoring and classification of bathing water quality, (ii) the management of bathing water quality and

(iii) the provision of information to the public on bathing water quality. The purpose of this directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater and to protect human health by complementing Directive 2000/60/EC.

The quality of bathing waters is classified as poor, sufficient, good or excellent depending on the presence of either *E. coli* or intestinal *enterococci* (Table 2). Moreover, in case of a potential for cyanobacterial proliferation or a tendency for proliferation of macro-algae and/or marine phytoplankton, appropriate monitoring must be carried out to enable timely identification of health risks and to implement adequate management measures (see Annex III to the BWD).

However, the way to perform these assessments is not defined, although Annex IV mentions frequency of sampling.

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0007&from=EN

- **Groundwater Directive 2006/118/EC (GWD)** (12 December 2006) establishes specific measures in order to prevent and control groundwater pollution. These measures include criteria for the assessment of good groundwater chemical status. It essentially concerns nitrates and active substances in pesticides. Annex II (part B) gives a minimum list of pollutants and their indicators for which Member States have to consider establishing threshold values, such as arsenic, cadmium, lead, mercury, ammonium and chloride.

No biological pathogens are listed.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF

3.4. Inspire (Directive 2007/2/EC)

The infrastructure for spatial information in the European Community (Inspire) enables the sharing of environmental spatial information among public sector organisations and facilitates public access to spatial information across Europe. The Inspire directive came into force in May 2007 and will be fully implemented by 2019.

Although no specific cluster is dedicated to drinking water, this directive addresses various themes of interest. For example, the hydrography theme (data from which is being used in water supplies, assessment and monitoring in estimation of water resources, assessment of flow patterns of particles and pollutants and pollution monitoring) is a concern for TG-Water. The human health and safety theme describing, *inter alia*, the well-being of humans linked to the quality of the environment could also be of interest.

NB: the Directorate-General for the Environment acts as an overall legislative and policy coordinator, the Joint Research Centre acts as the overall technical coordinator and the European Environmental Agency increased its involvement by taking on tasks related to monitoring and reporting.

http://inspire.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf

http://inspire.ec.europa.eu

3.5. M/487

M/487 aims to analyse the existing security standardisation landscape, select priority sectors and develop standardisation roadmaps to support EU policy on security. The work on M/487 is led by CEN TC 391 Societal and Citizen Security. Following consultation

of the DGs and agencies involved, priorities were defined for the crisis management and the CBRN-E areas.

No priority is currently given to either chemical or biological threat detection and/or standardisation. However, the European Commission is aware of the French standard mentioned above (NF X52-120) and can rely on this regulatory text as a template for coming standardisation activities.

4. European organisations

4.1. Water information system for Europe (WISE)

WISE is a partnership between the European Commission (DG Environment, Joint Research Centre and Eurostat) and the European Environment Agency, known as 'the Group of Four (Go4)'. The main roles and responsibilities of the partners are:

- **DG Environment**, leads the policy and strategic aspect of WISE. It liases with Member States, especially on official reporting requirements of EU water legislation. http://ec.europa.eu/environment/water/index.html
- The **European Environment Agency** hosts the Water Data Centre and the thematic WISE http://www.eea.europa.eu/themes/water/dc; http://www.eea.europa.eu/themes/water
- The **Joint Research Centre** conducts environmental monitoring and water resources modelling including nowcasting and forecasting services. http://ies.jrc.ec.europa.eu/the-institute/units/rural-water-and-ecosystem-resources-unit.html; http://floods.jrc.ec.europa.eu; http://desert.jrc.ec.europa.eu; http://fate.jrc.ec.europa.eu
- **Eurostat** is collecting and disseminating water statistics, also as a part of WISE data and themes, and provides significant input in the development of the GIS part of WISE and in particular ensuring the link to Inspire.

http://epp.eurostat.ec.europa.eu/

Monitoring of pollutants campaigns are organised by the WISE: in addition to the reporting from countries, monitoring of pollutants released to surface waters or within the aquatic environment is conducted by JRC in cooperation with a network of laboratories. Environmental monitoring of pollutants means to measure the occurrence and the level of chemical substances released accidentally or deliberately in the environment as a consequence of human activities. Thus, biological contaminations in drinking water don't seem to be a concern handled by the WISE.

http://fate.jrc.ec.europa.eu/monitoring/monitoring-overview

4.2. Eureau

Eureau brings together national associations (from 25 EU countries, two EFTA countries and one observer member). Eureau promotes the common interests of our members within the EU institutions and keep the members informed of relevant developments. They provide forums for sharing and exchanging experiences and views on the implementation of existing directives as well as policies relating to new directives, framework and strategies. They also have several working groups within the commissions to look at certain topic more in depth. This work helps advise the major European institutions, Member State governments and regulators.

http://eureau.org

4.3. EIP — Water Innovation Network

The EIP Water facilitates the development of innovative solutions to address major European and global water challenges. At the same time, the EIP Water supports the creation of market opportunities for these innovations, both inside and outside of Europe via the establishment of Action Groups (http://www.eip-water.eu). Example of interesting groups:

- **RTWQM** — Real time water quality monitoring (AG100) addresses specifically developments that strengthen the interaction between 'sensor technologies' and 'data analyses and monitoring tools' to safeguard or improve water quality. The objectives are: (i) to identify the current State of the Art and best practices, (ii) to identify the water managers' and users' needs in terms of RTWQM, (iii) to foster RTWQM techniques in operational applications for improved water management, (iv) to initiate the use of advanced data processing and modelling tools to add value to real time data and provide useful information for decision-making, (v) to act as a bridge between promising R & D results towards reliable and robust industrial products, ready to market, and (vi) to identify market opportunities and address barriers. A document reporting the 'Innovative monitoring technologies and EU water legislation' was published in July 2015 and is available at:

http://www.eipwater.eu/sites/default/files/AG100 %20RTWQM %20water %20legislation_whitepaper_v2_150714_def.pdf

- **Augment** — Water monitoring for decision support (AG124), whose main activities deal with: (i) developing and testing cheaper and more accurate static and mobile sensor devices that monitor water quality and quantity to generate denser monitoring networks in space and time, (ii) developing methods to include dynamic and heterogeneous data from multi-sources into models, in order to support current water management and decision support systems, and (iii) preparing workshops and stakeholder consultations.

- **CTRL+SWAN** — Cloud Technologies and real time monitoring + Smart water network is devoted to the further development of innovative sensor systems' technologies to be integrated and implemented in the design of an innovative approach to the water distribution networks management, with the broaden goal to introduce our concept of Smart water network (SWAN). This group focuses on: (i) developing innovative sensor systems' technologies, (ii) defining water network partitioning techniques and (iii) implementing a cloud platform to manage big data control (Lead: Armando Di Nardo, Italy).

- **Waterreg** — Water services regulation and governance in Europe (AG102)

4.4. JPI-Water

The joint programming initiatives (JPIs) are intergovernmental initiatives that aim at tackling societal challenges that cannot be addressed by European countries in isolation.

The water JPI (http://www.waterjpi.eu) brings together 19 partner countries, the European Commission and 5 observer countries. It started with the publication of the Water JPI Vision Document in 2011. Then, a Water JPI Strategic Research and Innovation Agenda (SRIA) (version 1.0) was released in June 2014 and relies on (i) review of foresight documents, (ii) a consultative workshop and (iii) an online consultation (responses from various stakeholders including researchers, managers, citizens …). An Implementation Plan (Table 3) was set out to deliver the Water JPI SRIA in the period 2014-2016. Moreover, in June 2014, the Water JPI suggested ten topics for inclusion in Horizon 2020 Societal Challenge 5 new Work Programme 2016-2017. These topics complement the activities owned and performed by the Water JPI. Eight of the proposed topics would be implemented by European RDI actors, while two of them by

the Water JPI (and include Coordination and Support Action and an ERA-NET Cofund). More recently, the 2nd consultative workshop about the SRIA took place in October 2015. About 40 people, members of the Advisory Boards, the Water JPI, national experts and relevant stakeholders participated in this consultative workshop. The SRIA version 2.0 should be released by the end of 2015.

Cooperation with the European Commission also addresses linkages wit DG Environment. In 2012, the Water JPI published a Position Document on the EIP on Water 4, and got involved in the European Innovation Partnership (EIP) governance at the steering group and task force levels. In addition, the Water JPI is following up the implementation of the Water Framework Directive, contributing to the events of the CIS-SPI (Science-Policy Interface of the Common Implementation Strategy of the Water Framework Directive) and gathering the input of the working groups.

Table 1 presents the major groups of activities of the Water JPI Implementation plan. http://www.waterjpi.eu/images/WaterJPI/Implementation_2014_web.pdf

Concerning the first activity corresponding to first joint call on 'Emerging water contaminants — anthropogenic pollutants and pathogens', seven projects (representing a research investment of EUR 9 million) were recommended for funding. Briefly:

- **FRAME** (framework to assess and manage contaminants of emerging concern in indirect potable reuse): the aim is to develop an overall evaluation procedure enabling a comprehensive assessment of efficient and cost-effective indirect potable reuse (INPR) measures to minimise the risks associated with emerging chemicals and microbial contaminants, while closing local and regional water cycles (Project Coordinator: Thomas Ternes, BfG, Germany)

- **Metawater** (new metagenomics and molecular based tools for European scale identification and control of emergent microbial contaminants in irrigation water): this project will investigate what pathogenic microoganisms are contaminating irrigation water used in Europe, where are there they coming from, what treatments are more useful for removing microbial pathogens from reclaimed water and how to improve management of irrigation water and national and international regulations. It will also use most advanced technologies for developing standard protocols for the simultaneous detection of microorganisms in water used for irrigation and will identify existing, emerging and new pathogens and microbial communities in water from rivers, ground water, wastewater and reclaimed water, and distribution water (Project Coordinator: Rosina Girones, University of Barcelona, Spain).

- **Motrem** (integrated processes for monitoring and treatment of emerging contaminants for water reuse): this project focuses on the development of integrated processes for monitoring and treatment of emerging contaminants (ECs), improving the efficiency of the removal of these pollutants in urban wastewater treatment plants (WWTPs), especially for water reuse. The project aims to provide new technologies for water treatment and/or improving the existing ones through the development of integrated processes for monitoring and treatment of ECs in the current waterline of municipal wastewater treatment plants, especially focusing on the aspect of water reuse (Project Coordinator: Javier Marugán, Universidad Rey Juan Carlos (URJC), Spain).

- **Persist** (fate and persistence of emerging contaminants and MRB in a continuum of surface water groundwater from the laboratory scale to the regional scale): the PERSIST project aims to increase our knowledge on the behavior of a selection of targeted pharmaceutical products and multi resistant bacteria in both surface water and groundwater bodies (Project Coordinator: Corinne Le Gal La Salle, University of Nîmes, France).

- **Promote** (protecting water resources from mobile trace chemicals): promote will focus on persistent, persistent mobile organic contaminants (pmoc). Two strategies will be followed to identify and monitor PMOC: (a) developing and applying analytical methods for screening of water samples for PMOC and (b) selection and prioritisation of candidate substances based on REACH data and developing analytical

methods for their quantitative analysis (Project Coordinator: Thorsten Reemtsma, Helmholtz Centre for Environmental Research — UFZ, Germany).

- **Stare** (stopping antibiotic resistance evolution): the major aims of this project are (i) the establishment of standardised protocols, (ii) the elucidation of the relationship between antibiotic residues and resistance genes in wastewater, (iii) the comparison of antibiotic resistance prevalence in the effluents discharged by urban wastewater treatment in Northern and Southern European regions and (iv) the development of improved advanced wastewater treatment technologies and their effects on the microbiome and resistome (Project Coordinator: Célia M. Manaia — Universidade Católica Portuguesa, Portugal).

- **TRACE** (tracking and assessing the risk from antibiotic resistant genes using chip technology in surface water ecosystems): TRACE will develop detection technologies that allow for a simpler on-site detection of antibiotic resistance, thereby enabling a much higher throughput and faster result-to-user turnaround. This will allow for an increasing number of measuring points, as well as a higher frequency of measurements. Extending this instrumental development for water system characterisation, also fast and robust on-site tests will be developed in order to enable simple and timely testing (Project Coordinator: Wolfgang Fritzsche, Leibniz Institute of Photonic Technology Jena, Germany).

The second call for proposals for collaborative projects, which is supported by ERA-NET Water Works 2014 was launched in 2014 and is funded by the EC under Horizon 2020. Proposals are invited on the topic 'Research and innovation for developing technological solutions and services (i) for water treatment, reuse, recycling and desalination, (ii) for water resources management, and (iii) to mitigate impacts of extreme events (floods and droughts) at catchment scale'. The deadline for submission was September 2015. The evaluation is still under way.

5. Links with European programmes

5.1. FP6/FP7 projects

❖ **Techneau** was a FP6 project (completed in 2011) developing system and technology solutions for drinking water supply to cope with global threats (high potency pollutants and pathogens). Online monitors as early-warning systems (including automated biomonitoring systems, electronic tongues and noses, sensors such as effect-related DNA-arrays, and UV spectroscopy) were elaborated, optimised and tested during case studies. The TKI (Techneau knowledge integrator) was developed to enable users to match appropriate and available technologies, practices, methodologies, etc. Unfortunately, the link is no longer available. The S::can company was a partner of the project which also deals with a risk assessment work package.

https://www.techneau.org

❖ **Safewater, Aquavalens and Secureau** are FP7 projects which were presented in previous TG-Water meetings. They are all three of great interest for the drinking water concern and TG-Water is in contact with the corresponding coordinators/partners.

https://www.safewater-project.eu
http://aquavalens.org
http://www.secureau.eu

❖ **Icewater** (ICT solutions for efficient water) (FP7) aims at using wireless sensor networks for water flow monitoring and providing a decision support system for the water utilities so that supply and demand patterns can be matched in real-time. The general concept of this technology is based on a decision support system (i) comprising advanced simulation and optimisation algorithms and (ii) using cloud computing approaches and networking components. Pressure and flow sensors are used (there is

no chemical neither biological monitoring). However, available documents such as a 'State of the art' and 'Multiple spatial and temporal models for consumption patterns identification' may be relevant for our work.

http://icewater-project.eu

❖ **Resfood** (FP7) addresses food chain topic towards resource efficient and safe food production and processing to maximised resource productivity and recycling of valuable materials such as water. WP6 (led by Technion) is dedicated to developing methodologies for rapid monitoring and detection of bacterial pathogens in recycled water, which is of interest for TG-Water.

http://www.resfood.eu

❖ **Wateur** is a coordination and support action (CSA) of the Joint programming Initiative 'Water challenges for a changing world' funded by the European Commission in the frame of FP7. Wateur project prepares the successful development and implementation of the water JPI (see below). Its activities started on January 2013 and will end on December 2015. The project is composed of six *work packages* which aim to ease the collaboration among all the organisations involved in the water JPI and implement some joint calls and the mapping of the national and regional programmes and projects on water research and innovation. Ispra with its water department is involved in all the activities of this project and coordinates work package devoted to communication and dissemination.

5.2. H2020 projects

The search was performed on the Cordis website with the keyword: 'drinking water'.

http://cordis.europa.eu

❖ **Aqua Shield** — Protecting citizens against intentional drinking water contamination with a water quality firewall
Call: DRS-17-2014 — Critical infrastructure protection topic 7: SME instrument topic: 'Protection of Urban soft targets and urban critical infrastructures' (H2020-SMEINST-2-2014)
Start date: 2015-01-01, End date: 2017-01-01
Coordination: Optisense B.V.

❖ **Answer** — antibiotics and mobile resistance elements in wastewater reuse applications: risks and innovative solutions

Call: MSCA-ITN-2015-ETN — Marie Skłodowska-Curie Innovative Training Networks (ITN-ETN)
Start date: 2015-10-01, End date: 2019-10-01
Coordination: University of Cyprus

❖ **Beep-water** — Biosensor for effective environmental protection through the on-site, automated monitoring of a large set of chemical contaminants in water
Call: NMP-25-2014-1 — Accelerating the uptake of nanotechnologies, advanced materials or advanced manufacturing and processing technologies by SMEs (H2020-SMEINST-1-2014)
Start date: 2015-05-01, End date: 2015-09-01
Coordination: Biosensor S.R.L.

❖ **BIWAS** — Biological water alarm system for protection of urban drinking water infrastructure against CBRN threats

Call: DRS-17-2014-1 — Critical infrastructure protection topic 7: SME instrument topic: 'Protection of Urban soft targets and urban critical infrastructures' (H2020-SMEINST-1-2014)
Start date: 2015-02-01, End date: 2015-08-01
Coordination: Sensovann AS

❖ **Freewat** — free and open source software tools for water resource management
Call: WATER-4a-2014 — Dissemination and exploitation, ICT, knowledge, gaps, research needs, etc. (H2020-WATER-2014-one-stage), Coordination and Support Action
Start date: 2015-04-01, End date: 2017-10-01
Coordination: Scuola Superiore Di Studi Universitari e di Perfezionamento Sant'Anna

❖ **OX-SIHA** — Integral water sanitation system
Call: SC5-20-2014 — Boosting the potential of small businesses for eco-innovation and a sustainable supply of raw materials (H2020-SMEINST-2-2014)
Start date: 2015-07-01, End date: 2017-07-01
Coordination: Ox-Compañia de Tratamiento de Aguas sl.

6. Bilateral projects

6.1. Resiwater

Resiwater is a bilateral **Franco-German** funded project that aims at improving WDS (water distribution systems) security and resilience based on the development of sensors and secure sensor networks, self-learning monitoring tools, robust simulation models, vulnerability and resilience assessment tools. The new developments will be investigated and evaluated by means of real-world use cases (kick-off meeting, 9 July 2015).

German coordinator: Mrs Fereshte Sedehizade (fereshte.sedehizade@bwb.de)
French coordinator: Dr Olivier Piller (olivier.piller@irstea.fr)
NB: Fraunhofer Institute and CEA are partners

http://www.resiwater.eu

6.2. SWAN

SWAN (sustainable water action) is a four years international cooperation project granted by the European Commission (FP7-INCOLAB-2011). It focuses on the creation of a research centre on water to reinforce links between **EU and US** research in the field. The project promises to strengthen European research capacity in the US, promote competitiveness of European research and industry while also informing and involving policy-makers and the general public. A SWAN eNewsletter is available.

http://swanproject.arizona.edu

7. International regulations

7.1. Guidelines for drinking-water quality (WHO)

The guidelines for drinking-water quality are recommendations edited by WHO in order to protect public health. These guidelines are intended to support the development and implementation of risk management strategies that will ensure the safety of drinking-water supplies through the control of hazardous constituents of water. Chemical and radiological aspects are detailed in the guidelines but not reported in this review which mainly focuses on the microbiological aspects.

http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en

- **Biological contaminations**

Table 4 and Table 5 provide general information on pathogens that are of relevance for drinking-water supply management.

In general terms, the greatest microbial risks are associated with ingestion of water that is contaminated with human or animal (including bird) faeces. Faeces can be a source of pathogenic bacteria, viruses, protozoa and helminths. The indicator organism of choice for faecal pollution is *E. coli*. Methods of detection of faecal indicator bacteria are reported. It is also indicated that thermo-tolerant coliforms can be used as an alternative to the test for *E. coli* in many circumstances.

In addition to faecally-borne pathogens, it is reported that other microbial hazards (e.g. guinea worm, toxic cyanobacteria and Legionella) may be of public health importance under specific circumstances. Moreover, protozoa and some enteroviruses are more resistant to many disinfectants, including chlorine, and may remain viable (and pathogenic) in drinking-water following disinfection. Other organisms may be more appropriate indicators of persistent microbial hazards, and their selection as additional indicators should be evaluated in relation to local circumstances and scientific understanding. Therefore, verification may require analysis of a range of organisms, such as intestinal *enterococci*, (spores of) *Clostridium perfringens* and bacteriophages.

It is also mentioned that some microorganisms will grow as biofilms on surfaces in contact with water. With few exceptions, such as *Legionella*, most of these organisms do not cause illness in healthy persons, but they can cause nuisance through generation of tastes and odours or discoloration of drinking-water supplies.

In conclusion, the framework for safe drinking-water by WHO reports that microbial quality of drinking-water includes testing for *E. coli* as an indicator of faecal pollution. However, enteric viruses and protozoa being more resistant to disinfection, the absence of *E. coli* doesn't necessarily indicate freedom from these organisms. Thus, under certain circumstances, it is recommended to check for more resistant microorganisms, such as bacteriophages and/or bacterial spores. However, no quantitative information on detection limits is available.

- **Risk assessment approach**

A system assessment involves determining whether the drinking-water supply chain as a whole can deliver drinking-water quality that meets identified targets. Consequently, this requires an understanding of the quality of source water. Table 6 gives examples of concentrations of pathogens in deferent types of source waters, but no similar information is reported for drinking water.

In many circumstances, estimating the effects of improved drinking-water quality on health risks in the population is possible through constructing and applying risk assessment models. QMRA (quantitative microbial risk assessment) is a rapidly evolving field that systematically combines available information on exposure and dose–response to produce estimates of the disease burden associated with exposure to pathogens. Mathematical modelling may be used to estimate the effects of low doses of pathogens in drinking-water on populations and subpopulations. However, it is noticed that many problems still remain (Table 7).

- **Water safety plan (WSP)**

Preventive management is pointed out in the WHO Guidelines as the preferred approach to drinking-water safety. It is mentioned that, as many aspects of drinking-water quality management are often outside the direct responsibility of the water supplier, it is essential that a collaborative multiagency approach be adopted to ensure that agencies with responsibility for specific areas within the water cycle are involved in the management of water quality. However, drinking-water suppliers are responsible at all

times for the quality and safety of the water that they produce. A handbook for implementation of a 'rapid assessment of drinking-water quality' is in preparation.

Meanwhile, it is stated that (i) the management of microbial drinking-water safety requires a system-wide assessment to determine potential hazards that can affect the system, (ii) identification of the control measures needed to reduce or eliminate the hazards, and operational monitoring to ensure that barriers within the system are functioning efficiently, and (iii) the development of management plans to describe actions taken under both normal and incident conditions.

http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en

7.2. The US Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act (SDWA) is the main federal law that ensures the quality of the United States drinking water. Under SDWA, EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. Information is available on the EPA website (http://water.epa.gov/drink) and briefly presented below.

- **Drinking water standards**

The EPA sets standards that, when combined with protecting ground water and surface water, are critical to ensuring safe drinking water. EPA works with its regional offices, states, tribes and many partners to protect public health through implementing the 'Safe Drinking Water Act'. These standards form a legal basis for controlling pollution entering the waters of the United States from a variety of sources (e.g. industrial facilities, wastewater treatment plants, and storm sewers). States may either adopt the EPA recommended criteria or use other scientifically-defensible methods to develop their own criteria. Proposed water quality standards must be approved by EPA before they can be used as the basis for actions such as establishing total maximum daily loads (TMDLs).

http://water.epa.gov/drink/standardsriskmanagement.cfm

- **List of contaminants and their maximum contaminant levels**

National primary drinking water regulations (NPDWRs or primary standards) are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in drinking water (http://water.epa.gov/drink/contaminants). An alphabetical list, listing concerns, has been defined concerning microorganisms, disinfectants, disinfection by-products, inorganic chemicals, organic chemicals, and radionuclides. The list of microorganisms is reported on Table 8.

http://water.epa.gov/drink/contaminants/index.cfm#Microorganisms

- **Analytical methods**

Analytical methods are approved procedures used to measure the amount of particular contaminants in water samples to ensure compliance with regulations. Analytical methods generally describe how to (i) collect, preserve, and store the sample, (ii) gather, separate, identify, and measure contaminants in the sample, (iii) meet quality control criteria, and (iv) report the results of the analysis.

http://www2.epa.gov/dwanalyticalmethods/learn-about-drinking-water-analytical-methods

- **Science and technology**

Contaminants of emerging concern: chemicals are being discovered in water that previously had not been detected or are being detected at levels that may be significantly different than expected. These are often generally referred to as 'contaminants of emerging concern' (CECs) because the risk to human health and the environment associated with their presence, frequency of occurrence, or source may not be known. EPA is working to improve its understanding of a number of CECs, particularly pharmaceuticals and personal care products and perfluorinated compounds among others.

No emergent pathogen is mentioned.

http://water.epa.gov/scitech/cec

Monitoring and assessing water quality: waters are monitored by state, federal, and local agencies, universities, dischargers, and volunteers. Water quality data are stored and used to characterise waters, identify trends over time, identify emerging problems, determine whether pollution control programs are working, help direct pollution control efforts to where they are most needed, and respond to emergencies such as floods and spills.

http://water.epa.gov/type/watersheds/monitoring/index.cfm

Research: The national water quality research strategy was developed to comprehensively define the research needed by the national water program to address EPA's strategic goals and sub-objectives for clean and safe water, and communicate them to potential research partners. The newsletter, called 'Water research updates' is an online publication that reports on relevant water research activities on a semi-annual basis.

http://www2.epa.gov/water-research/recent-water-research-rwr-newsletter

Microbial (and chemical) risk research: EPA research increases our understanding of water contaminants in order to promote safe recreational waters, maintain healthy water resources and ecosystems, and prepare for potential terrorist threats to the Nation's water sources. Research is under way to better understand individual water contaminants as well as groups of contaminants in order to minimise human health risk and to identify effective treatment approaches.

http://www2.epa.gov/water-research/chemical-and-microbial-risk-research

Example of research projects on microbial risk: (i) microbiological and chemical exposure assessment, (ii) using mussels to detect microbial contamination of ambient water, (iii) sample preparation techniques for concentrating microbes from water or (iv) saliva-based measurement method for detecting exposure to waterborne pathogens.

http://www2.epa.gov/water-research/microbiological-and-chemical-exposure-assessment-water

Moreover, EPA has compiled information on freshwater cyanohabs including causes, detection, treatment, health and ecological effects, current research activities in the US; and policies and regulations for cyanotoxins at the state and international levels.

http://www2.epa.gov/water-research/harmful-algal-blooms-drinking-water-treatment

- **Risk assessment**

EPA developed this software tool to assist drinking water and wastewater utility owners and operators in understanding potential climate change threats and in assessing the related risks at their individual utilities (see CREAT**,** climate resilience evaluation and awareness tool).

http://www2.epa.gov/crwu/assess-water-utility-climate-risks-climate-resilience-evaluation-and-awareness-tool

- **Water security home**

Significant actions are underway to help drinking water and wastewater utilities in order to assess and reduce consequences, threats, and vulnerabilities to potential terrorist attacks, to plan for and practice response to natural disasters, emergencies, and incidents and to develop new security technologies to detect and monitor contaminants and prevent security breaches.

http://water.epa.gov/infrastructure/watersecurity/basicinformation.cfm

7.3. Canadian guidelines for drinking quality

The 'Guidelines for Canadian drinking water quality' and the 'Guidelines technical documents' (formerly known as 'Guideline supporting documents') are developed by the Federal-Provincial-Territorial Committee on Drinking Water and have been published by Health Canada since 1968.

http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php

Briefly, the highest-priority guidelines are those dealing with microbiological contaminants, such as bacteria, protozoa and viruses. These guidelines focus on indicators (*E.coli*, total coliforms) and treatment goals in order to reduce microorganisms to levels that have not been associated with illness. Table 9 reports such microbiological parameters (a similar table is available for chemicals)

http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php#t1

Technical documents are available and give accurate information about microbiological parameters and bacteriological quality. For example, health effect, sample concentration or detections methods are defined, relying on scientific literature. However, only *E. coli*, enteroviruses and two enteric protozoa (*Giardia* and *Cryptosporidium*) are listed.

http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php#tech_doc

7.4. Australian Drinking Water Guidelines (ADWG)

The 2011 ADWG have been endorsed by the National Health and Medical Research Council (NHMRC) and have been updated in March 2015. These are very complete guidelines (more than 1 300 pages) developed after consideration of the best available scientific evidence and providing a framework for good management of drinking water supplies to ensure safety at point of use.

https://www.nhmrc.gov.au/guidelines-publications/eh52

The Australian management of drinking water quality is based on 12 elements (such as operational procedures and process control, management of incidents and emergencies, research and development …) and information concerning monitoring (including monitoring priorities, critical limits and critical control points, sample integrity, methods, detection limits …), risk assessment and preventive measures are reported, although not related in this review.

Microbial, physical and chemical, and radiological quality of drinking water is detailed. More precisely, it is clearly mentioned that he most common and widespread health risk associated with drinking water is contamination, either directly or indirectly, by microorganisms contained in faeces. The classic waterborne diseases are caused by

organisms originating in the gut of humans or other animals. However, many organisms of environmental origin that are not normally associated with the gastrointestinal system are found in water, and some of them may, under certain circumstances, cause disease in humans.

Examples of waterborne pathogens are reported below:

- Bacteria: excreted pathogens (*Salmonella spp, Shigella spp*, enterovirulent *E. coli*, *Vibrio cholera*, *Yersinia enterocolitica*, *Campylobacter jejuni* and *E. coli.*); pathogens growing in water supplies (*Pseudomonas aeruginosa*, species of *Klebsiella* and *Aeromonas*, and certain slow-growing mycobacteria). *Legionellosis*, commonly caused by the free-living bacterium *Legionella pneumophila*, is a serious illness resulting from inhalation of water.

- Protozoa: enteric protozoa (*Cryptosporidium* and *Giardia* species are likely to be the most important in water in Australia, although infection by *Entamoeba histolytica* is also endemic in some communities); free-living protozoa (*amoebae*, *Naegleria* and *Acanthamoeba*).

- Viruses: epidemiological proof of waterborne transmission of viral diseases is very difficult to establish and adequately sensitive methods for detecting the infectious agent in water are often not available. However, Adenovirus, Enterovirus, Hepatitis virus, Norovirus, and Rotavirus are mentioned.

- Cyanobacteria and toxins: cyanobacteria are of concern in drinking water because of the toxins they produce. No human deaths have been recorded from ingesting the toxins of cyanobacteria but gastroenteritis may result from drinking water containing toxic species and extended exposure may lead to more serious impacts. For example: *Anabaena circinalis* (*Dolichospermum circinalis*), *Nodularia spumigena, Microcystis* genus.

- Helminths (worm): the major helminth parasites of humans listed by the WHO as being transmitted by water do not occur in Australia.

- Nuisance organisms causing taste and odour or colour problems, deposits due to iron and manganese bacteria, and corrosion problems due to iron and sulfur bacteria are also listed.

Very detailed fact sheets are available (one per microorganism) relating: an accurate description, the source and occurrence, the method(s) of detection and identification, health considerations and scientific references. NB: some pages have been intentionally left blank (probably for confidential raisons).

However, only the monitoring for *Escherichia coli* within the distribution system is indicated, as *no E. coli* should not be detected in a minimum 100 mL sample of drinking water (if detected, immediate corrective action must be taken). For water systems where drinking water temperatures in service tanks/reservoirs and the distribution system can consistently reach temperatures greater than 25ºC, the monitoring should also include a similar review of *Naegleria*. No other specific microorganism monitoring is actually recommended even if real-time turbidity monitoring is necessary to ensure that filtration (for example) is optimised and that the required pathogen removal is achieved at all times.

In conclusion, Australian guidelines on drinking water quality are of great interest and need to be read carefully as they gather essential information for the basis of European harmonisation.

8. Conclusion

8.1. Current situation for standards and directives

International (ISO/TC 147) and European (CEN/TC 164) standards cover water quality and water supply, respectively. However, although water supply security is a concern for working groups at the European level, no specific guidelines dealing with biological and chemical monitoring have been established up to now. Nevertheless, European directives such as DWD and WFD recommend regular monitoring to ensure the quality of water intended for human consumption. Obviously, monitoring for chemicals is much more taken into account than monitoring for contaminations due to biological pathogens: although biological issues are not neglected, it is more complicated to deal with for technical and economic reasons. National initiatives (for both chemical and biological pollutants) may exist but are not easily accessible, except one French standard developed in the CBRNE context and well-suited for water monitoring.

Outside Europe, Guidelines and directives are available either at the international (WHO) or national (Canada, US, Australia) levels. Although the risks may be different from one country to another, these documents can be considered as models, including their reference scientific information.

8.2. The key European organisations

Various European partnerships already exist to tackle water quality (including water safety and security):

- JPI-Water: defines a strategic research agenda, points out priorities and recommends projects for funding;
- EIP-Water: supports innovative solutions and market opportunities via Action Groups;
- Eureau: brings together national associations;
- WISE: gathers the key EU agencies (and organises pollutant monitoring campaigns);
- M/487: focuses on standardisation in the field of civil security

All these networks are of great importance because they group the major stakeholders in the water sector (institutions, private companies, operators, governmental agencies, regulators …). They point out the needs, and are actively involved in driving strategy, policy, and scientific approaches.

8.3. Scientific sources

Technological innovation, as well as its validation and implementation, is a long and cost-effective process. European projects and initiatives enable such developments. For this reason, particular attention has to be paid to all new projects as they define future monitoring technologies and efficient European networks.

8.4. Suggestions

It may be relevant for the group to contact and/or to invite people involved in the key organisations mentioned above, in order to obtain a clear picture of 'who is doing what". Moreover, their expertise and global insight over standardisation/harmonisation in the water sector is necessary (at least from my point of view) in order to avoid overlaps and to strengthen our mission. Thus, the next step for the group could be (with assistance from the ERNCIP/JRC) (i) to set up a list of who to contact and (ii) to write out a (brief) questionnaire to send in order to fix a framework for the discussions. Ideally, a workshop would give the opportunity to share information and to 'actively' involve officials/delegates in highlighting the needs (not covered by others) to work on.

Potential contacts (to be discussed):

- ✓ People involved in: JPI-Water, EIP-Water, Eureau, WISE

- ✓ People involved in European standardisation M/487
- ✓ Coordinators of EU networks (Wateur, Resiwater, SWAN) and H2020 projects (see chapter V)
- ✓ European validation platforms (see Benten Water Solutions)
- ✓ Local bodies — national/regional clusters (to be discussed depending on the countries)
- ✓ End-users such as citizen/consumer associations

Potential points to investigate:

- — The interest to enlarge the list of pathogens in order to take into account CBRNE biological threats
- — The possibility to define complementary reference technologies (EDS) (different from counting which is time-consuming)
- — Procedures homogenisation
- — The way to include such points in a Water Security Plan.

List of abbreviations and definitions

ADWG: Australian Drinking Water Guidelines
BWD: Bathing Water Directive
CEC: Contaminants of Emerging Concern
CEN: European Committee for Standardisation (Comité européen de normalisation)
CSA: Coordination and Support Action
DG: Directorate-General
DWD: Drinking Water Directive
EC: European Commission
E. coli: Escherichia coli
EDS: event detection system
EFTA: European Free Trade Association
EIP: European Innovation Partnerships
EPA: Environmental Protection Agency
EQS: Environmental Quality Standard Directive
ERA-NET: European Research Area Network
ERNCIP: European Reference Network for Critical Infrastructure Protection
EU: European Union
FP 6/7: Framework Programme 6/7
GWD: Ground Water Directive
Inspire: infrastructure for spatial information in the European Community
ISO: International Organisation for Standardisation
JPI: joint programming initiative
JRC: Joint Research Centre
NF: Norme Française (French Standard)
PMOC: Persistent Mobile Organic Contaminants
QMRA: Quantitative Microbial Risk Assessment
R & D: research and development
SDWA: Safe Drinking Water Act
SRIA: Strategic research and Innovation Agenda
TG: thematic group
US: United States
WFD: Water Framework Directive
WHO: World Health Organisation
WISE: Water Information System for Europe
WG Working Group
WSP: Water Safety Plan

List of standards

http://www.iso.org/iso/iso_technical_committee?commid=52834

http://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:6145&cs=1F7C7AA73990546C443B4206E2810EED6

http://ec.europa.eu/environment/water/water-drink/legislation_en.html

http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0105&from=EN

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF

http://inspire.ec.europa.eu

List of figures

Figure 1. Drinking Water Directive 98/83/EC, Annex II (Table A). Parameters to be analysed. The purpose of check monitoring is regularly to provide information on the organoleptic and microbiological quality of the water supplied for human consumption as well as information on the effectiveness of drinking-water treatment (particularly of disinfection) where it is used, in order to determine whether or not water intended for human consumption complies with the relevant parametric values laid down in this Directive. The following parameters must be subject to check monitoring. Member States may add other parameters to this list if they deem it appropriate.

Aluminium (Note 1)
Ammonium
Colour
Conductivity
Clostridium perfringens (including spores) (Note 2)
Escherichia coli (E. coli)
Hydrogen ion concentration
Iron (Note 1)
Nitrite (Note 3)
Odour
Pseudomonas aeruginosa (Note 4)
Taste
Colony count 22 °C and 37 °C (Note 4)
Coliform bacteria
Turbidity

Note 1: Necessary only when used as flocculant (*).

Note 2: Necessary only if the water originates from or is influenced by surface water (*).

Note 3: Necessary only when chloramination is used as a disinfectant (*).

Note 4: Necessary only in the case of water offered for sale in bottles or containers.

(*) In all other cases, the parameters are in the list for audit monitoring.

List of tables

Table 1. Drinking Water Directive 98/83/EC, Annex I. Parameters and parametric values, Part A, Microbiological parameters.

Parameter	Parametric value (number/100 ml)
Escherichia coli (E. coli)	0
Enterococci	0

The following applies to water offered for sale in bottles or containers:

Parameter	Parametric value
Escherichia coli (E. coli)	0/250 ml
Enterococci	0/250 ml
Pseudomonas aeruginosa	0/250 ml
Colony count 22 °C	100/ml
Colony count 37 °C	20/ml

Table 2. Bathing Water Directive 2006/7/EC, Annex I. Criteria set out in order to classify bathing water status.

For inland waters

	A	B	C	D	E
	Parameter	Excellent quality	Good quality	Sufficient	Reference methods of analysis
1	Intestinal enterococci (cfu/100 ml)	200 (*)	400 (*)	330 (**)	ISO 7899-1 or ISO 7899-2
2	Escherichia coli (cfu/100 ml)	500 (*)	1 000 (*)	900 (**)	ISO 9308-3 or ISO 9308-1

(*) Based upon a 95-percentile evaluation. See Annex II.
(**) Based upon a 90-percentile evaluation. See Annex II.

For coastal waters and transitional waters

	A	B	C	D	E
	Parameter	Excellent quality	Good quality	Sufficient	Reference methods of analysis
1	Intestinal enterococci (cfu/100 ml)	100 (*)	200 (*)	185 (**)	ISO 7899-1 or ISO 7899-2
2	Escherichia coli (cfu/100 ml)	250 (*)	500 (*)	500 (**)	ISO 9308-3 or ISO 9308-1

(*) Based upon a 95-percentile evaluation. See Annex II.
(**) Based upon a 90-percentile evaluation. See Annex II.

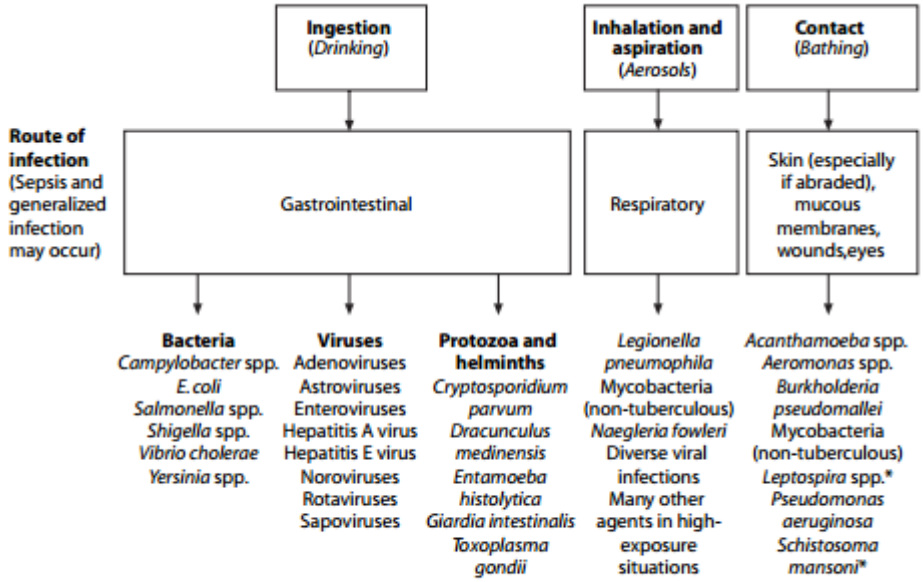
Table 3. Major groups of activities composing the Water JPI Implementation Plan.

Owns	Performs	Ref.	Group of Activities and its description	
Water JPI		1	Pilot Call for Proposals	Topic: "Emerging water contaminants – anthropogenic pollutants and pathogens" (published in Nov. 2013)
		2	Second Call for Proposals	Topic: "Developing technological solutions and services for water distribution and measurement, waste water treatment and reuse, desalination, floods and droughts, etc." (to be published in first quarter 2015)
		3	Third Call for Proposals	Topic: "Improving water use efficiency and reducing soil and water pollution for a sustainable agriculture" (to be published in first quarter 2016)
		4	Programme Alignment	A set of continued activities throughout the planning period
		5	SRIA Development	From SRIA 1.0 to 2.0 and beyond
		6	Outreach	Dedicated activities to link up with key stakeholders and society at large
DG Research and Innovation	Horizon 2020	A	Approaches for Assessing and Optimizing Ecosystem Services and the Ecological Functioning of Ecosystems, *Collaborative projects*	
		B	Hydromorphology: Restoring Continuity, Sediment Transport and Fish Migration Within River Systems, *Collaborative projects*	
		C	Understanding the Implications of Ecological Flows, *Collaborative projects*	
		D	Assessing the Impacts of Unconventional Gas Exploration and Extraction on Water resources, *Collaborative projects*	
		E	Systemic Reuse and Recycling Technologies in the Water Sector, *Collaborative projects*	
		F	Towards Urban Flood Proof Cities, *Collaborative projects*	
		G	Measures to Achieve Water Framework Directive Objectives in Heavily Modified Water Bodies, *Collaborative projects*	
		H	Infrastructure for Water Research and Innovation, *Collaborative projects*	
DG Research and Innovation	Water JPI	I	Support to Water JPI Development in Specific Target Areas (topic for 2016), *Coordination and Support Action*	
		J	Closing the Water Cycle Gap (topic for 2017), *ERA-NET Cofund*	
DG Environment		K	EIP on Water: *Participation in Governance meetings*	
		L	Common Implementation Strategy of the Water Framework Directive: *follow-up and integration in SRIA*	

Table 4. Guidelines for drinking-water quality edited by WHO. Waterborne pathogens and their significance in water supplies.

Pathogen	Health significance[b]	Persistence in water supplies[c]	Resistance to chlorine[d]	Relative infectivity[e]	Important animal source
Bacteria					
Burkholderia pseudomallei	High	May multiply	Low	Low	No
Campylobacter jejuni, C. coli	High	Moderate	Low	Moderate	Yes
Escherichia coli – Pathogenic[f]	High	Moderate	Low	Low	Yes
E. coli – Enterohaemorrhagic	High	Moderate	Low	High	Yes
Legionella spp.	High	May multiply	Low	Moderate	No
Non-tuberculous mycobacteria	Low	May multiply	High	Low	No
Pseudomonas aeruginosa[g]	Moderate	May multiply	Moderate	Low	No
Salmonella typhi	High	Moderate	Low	Low	No
Other salmonellae	High	May multiply	Low	Low	Yes
Shigella spp.	High	Short	Low	High	No
Vibrio cholerae	High	Short to long[h]	Low	Low	No
Yersinia enterocolitica	Moderate	Long	Low	Low	Yes
Viruses					
Adenoviruses	Moderate	Long	Moderate	High	No
Enteroviruses	High	Long	Moderate	High	No
Astroviruses	Moderate	Long	Moderate	High	No
Hepatitis A virus	High	Long	Moderate	High	No
Hepatitis E virus	High	Long	Moderate	High	Potentially
Noroviruses	High	Long	Moderate	High	Potentially
Sapoviruses	High	Long	Moderate	High	Potentially
Rotavirus	High	Long	Moderate	High	No
Protozoa					
Acanthamoeba spp.	High	May multiply	Low	High	No
Cryptosporidium parvum	High	Long	High	High	Yes
Cyclospora cayetanensis	High	Long	High	High	No
Entamoeba histolytica	High	Moderate	High	High	No
Giardia intestinalis	High	Moderate	High	High	Yes
Naegleria fowleri	High	May multiply[i]	Low	Moderate	No
Toxoplasma gondii	High	Long	High	High	Yes
Helminths					
Dracunculus medinensis	High	Moderate	Moderate	High	No
Schistosoma spp.	High	Short	Moderate	High	Yes

Table 5. Guidelines for drinking-water quality edited by WHO. Transmission pathways and examples of water-related pathogens.



* Primarily from contact with highly contaminated surface waters.

Table 6. Guidelines for drinking-water quality edited by WHO. Examples of high concentrations (per litre) of enteric pathogens and faecal indicators in different types of sources from the scientific literature.

Pathogen or indicator group	Lakes and reservoirs	Impacted rivers and streams	Wilderness rivers and streams	Groundwater
Campylobacter	20–500	90–2500	0–1100	0–10
Salmonella	—	3–58000 (3–1000)[a]	1–4	—
E. coli (generic)	10000–1000000	30000–1000000	6000–30000	0–1000
Viruses	1–10	30–60	0–3	0–2
Cryptosporidium	4–290	2–480	2–240	0–1
Giardia	2–30	1–470	1–2	0–1

[a] Lower range is a more recent measurement.

Table 7. Guidelines for drinking-water quality edited by WHO. Risk assessment paradigm for pathogen health risks.

Step	Aim
1. Problem formulation and hazard identification	To identify all possible hazards associated with drinking-water that would have an adverse public health consequence, as well as their pathways from source(s) to consumer(s)
2. Exposure assessment	To determine the size and nature of the population exposed and the route, amount and duration of the exposure
3. Dose–response assessment	To characterize the relationship between exposure and the incidence of the health effect
4. Risk characterization	To integrate the information from exposure, dose–response and health interventions in order to estimate the magnitude of the public health problem and to evaluate variability and uncertainty

Table 8. Safe Drinking Water Act (SDWA) ensuring the quality of the United States drinking water. List of Contaminants and their Maximum Contaminant Levels (MCLs), edited by the EPA.

Microorganisms				
Contaminant	**MCLG[1] (mg/L)[2]**	**MCL or TT[1] (mg/L)[2]**	**Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term)**	**Sources of Contaminant in Drinking Water**
Cryptosporidium	zero	TT[3]	Gastrointestinal illness (such as diarrhea, vomiting, and cramps)	Human and animal fecal waste
Giardia lamblia	zero	TT[3]	Gastrointestinal illness (such as diarrhea, vomiting, and cramps)	Human and animal fecal waste
Heterotrophic plate count (HPC)	n/a	TT[3]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment
Legionella	zero	TT[3]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems
Total Coliforms (including fecal coliform and *E. Coli*)	zero	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5]	Coliforms are naturally present in the environment; as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.
Turbidity	n/a	TT[3]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (such as whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff
Viruses (enteric)	zero	TT[3]	Gastrointestinal illness (such as diarrhea, vomiting, and cramps)	Human and animal fecal waste

Table 9. Canadian Drinking Waters Guidelines. Microbiological parameters.

Parameter (approval)	Guideline	Common sources	Health considerations	Applying the guideline
Enteric protozoa: *Giardia* and *Cryptosporidium*(2012)	Treatment goal: Minimum 3 log removal and/or inactivation of cysts and oocysts	Human and animal faeces	*Giardia* and *Cryptosporidium* are commonly associated with gastrointestinal upset (nausea, vomiting, diarrhoea). Less common health effects vary. *Giardia* infections may include prolonged gastrointestinal upset, malaise and malabsorption. *Cryptosporidium* infections, in immunocompromised individuals, can occur outside the gastrointestinal tract including in the lungs, middle ear, and pancreas.	Monitoring for *Cryptosporidium* and *Giardia* in source waters will provide valuable information for a risk-based assessment of treatment requirements. Depending on the source water quality, a greater log removal and/or inactivation may be required.
Enteric viruses (2011)	Treatment goal: Minimum 4 log reduction (removal and/or inactivation) of enteric viruses	Human faeces	Commonly associated with gastrointestinal upset (nausea, vomiting, diarrhoea); less common health effects can include respiratory symptoms, central nervous system infections, liver infections and muscular syndromes.	Routine monitoring for viruses is not practical; characterise source water to determine if greater than a 4 log removal or inactivation is necessary.
Escherichia coli(*E. coli*) (2012)	MAC: None detectable per 100 mL	Human and animal faeces	The presence of *E. coli* indicates recent faecal contamination and the potential presence of microorganisms capable of causing gastrointestinal illnesses; pathogens in human and animal faeces pose the most immediate danger to public health.	*E. coli* is used as an indicator of the microbiological safety of drinking water; if detected, enteric pathogens may also be present. *E. coli* monitoring should be used, in conjunction with other indicators, as part of a multi-barrier approach to producing drinking water of an acceptable quality.
Total coliforms (2012)	MAC of none detectable/100 mL in water leaving a treatment plant and in non-disinfected groundwater leaving the well	Human and animal faeces; naturally occurring in water, soil and vegetation	Total coliforms are not used as indicators of potential health effects from pathogenic microorganisms; they are used as a tool to determine how well the drinking water treatment system is operating and to indicate water quality changes in the distribution system. Detection of total coliforms from consecutive samples from the same site or from more than 10 % of the samples collected in a given sampling period should be investigated.	Total coliforms should be monitored in the distribution system because they are used to indicate changes in water quality. In **water leaving a treatment plant**, total coliforms should be measured in conjunction with other indicators to assess water quality; the presence of total coliforms indicates a serious breach in treatment. In **a distribution and storage system**, detection of total coliforms can indicate regrowth of the bacteria in biofilms or intrusion of untreated water.

Parameter (approval)	Guideline	Common sources	Health considerations	Applying the guideline
				In **non-disinfected groundwater**, the presence of total coliforms may indicate that the system is vulnerable to contamination, or it may be a sign of bacterial regrowth.
Turbidity (2012)	Treatment limits for individual filters or units: Conventional and direct filtration: ≤ 0.3 NTU[Table 1 footnote1] slow sand and diatomaceous earth filtration: ≤ 1.0 NTU[Table 1 footnote2] membrane filtration: ≤ 0.1 NTU[Table 1 footnote3]	Naturally occurring particles: *Inorganic*: clays, silts, metal precipitates *Organic*: decomposed plant & animal debris, microorganisms	Filtration systems should be designed and operated to reduce turbidity levels as low as reasonably achievable and strive to achieve a treated water turbidity target from individual filters of less than 0.1 NTU. Particles can harbour microorganisms, protecting them from disinfection, and can entrap heavy metals and biocides; elevated or fluctuating turbidity in filtered water can indicate a problem with the water treatment process and a potential increased risk of pathogens in treated water.	Guidelines apply to individual filter turbidity for systems using surface water or groundwater under the direct influence of surface water. The decision to exempt a waterworks from filtration should be made by the appropriate authority based on site-specific considerations, including historical and ongoing monitoring data. To ensure effectiveness of disinfection and for good operation of the distribution system, it is recommended that water entering the distribution system have turbidity levels of 1.0 NTU or less. For systems that use groundwater, turbidity should generally be below 1.0 NTU.

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