

Monitoring and control of drinking water quality

Selection of key-parameters

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Title

Monitoring and control of drinking water quality – Selection of key-parameters

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Summary

Monitoring and control technologies are indispensable for the production of safe drinking water. They allow for the surveillance of source water quality and the detection of biological and chemical threats, thus defining the boundary conditions for the subsequent treatment and providing early-warning in case of unexpected contaminations. They are mandatory for the permanent control of the treatment process and the efficacy of each single treatment step, and they safeguard the high quality of finished water. Furthermore, appropriate analytical techniques are indispensable for the detection of changes in water quality during distribution and for monitoring drinking water quality at consumers' tap. Reliable monitoring technologies contribute to a large extent to the consumers' trust in a high drinking water quality.

This report handles about different locations and purposes in which monitoring and control technologies need to be applied and the respective biological and chemical water quality parameters that provide essential information for water suppliers.

The following purposes for water quality monitoring are considered:

- Catchment characterisation
- Source water characterisation
- Performance of treatment technologies
- Overall treatment effect/water quality status (before entering distribution network)
- Detection of quality changes during distribution
- Monitoring of water quality at consumers' tap

For each purpose tables with selected microbiological and chemical key-parameters are presented, together with the criteria for selection. Criteria for selection were:

- A. Health-related parameter
- B. Parameter listed in EU Drinking Water Directive 98/83/EC (DWD).
- C. Parameter for process control
- D. Aesthetic parameter
- E. Early-warning parameter
- F. Emerging water quality parameter (usually not new parameters, but recently emerged as being of interest).

At the end of the report all tables have been combined into one major monitoring table for all purposes.

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1 Introduction

Monitoring and control technologies are indispensable for the production of safe drinking water. They allow for the surveillance of source water quality and the detection of biological and chemical threats, thus defining the boundary conditions for the subsequent treatment and providing early-warning in case of unexpected contaminations. They are mandatory for the permanent control of the treatment process and the efficacy of each single treatment step, and they safeguard the high quality of finished water. Furthermore, appropriate analytical techniques are indispensable for the detection of changes in water quality during distribution and for monitoring drinking water quality at consumers' tap. Reliable monitoring technologies contribute to a large extent to the consumers' trust in a high drinking water quality.

Following the overall objective of the TECHNEAU project, the major objective of WA 3 is to provide a set of analytical techniques and methods that ensure the provision of safe high quality drinking water that has the trust of the consumers. Existing monitoring technologies will be evaluated according to their suitability for application in controlling water quality in the whole drinking water production process. Evaluation criteria will not only be analytical parameters like sensitivity or reproducibility but will include criteria like ease-of-use, robustness, maintenance, and costs. Latest results from ongoing research projects in this field will be followed and will also be included in the evaluation process. In addition to this, new and innovative monitoring technologies like effect-related DNA-arrays or electronic nose technology will be developed, optimized and tested.

The current report was produced within WP 3.1 of the TECHNEAU project and describes 'fields of application' and 'key-parameters for water quality control'. It will handle about different locations and purposes in which monitoring and control technologies need to be applied and the respective biological and chemical water quality parameters that provide essential information for water suppliers.

2 Method

2.1 Purpose for monitoring

The parameters that are a priority for monitoring and the analytical tools that can be applied for this purpose are highly dependent on the nature of the supply system that is considered. What kind of water is used as source: surface water from a densely populated area, or well protected deep groundwater? What treatment steps are applied and in what condition is the distribution system? These aspects will influence the requirements and possibilities for monitoring and control.

To select key-parameters for water quality monitoring, the first question is about the purpose for monitoring. The purpose will then determine what key-parameters need to be monitored. Of course the prime purpose of monitoring is to safeguard water quality and to prevent actual and perceived health risks. However, depending on point in the treatment process different parameters are relevant to measure. Removal efficiencies of treatment steps for certain compounds need also to be taken into consideration in determining the need to monitor. As can be seen below, the purpose of monitoring is closely related to the location of monitoring.

Within this report, the following purposes for water quality monitoring are considered:

- Catchment characterisation
- Source water characterisation
- Performance of treatment technologies
- Overall treatment effect/water quality status (before entering distribution network)
- Detection of quality changes during distribution
- Monitoring of water quality at consumers' tap

In chapter 3, tables with selected key-parameters will be presented for each purpose. Both microbiological and chemical parameters are included therein. It should be noted that these tables have been developed with the focus on what *should* at least be routinely monitored and not on what *could* be monitored. For instance, if certain pollutants are found to be present in the source water, the performance of the treatment technologies applied in that specific situation needs to be monitored as well. However as the level of contamination will vary within supplies and between supplies, no general statements can be made at this moment.

In addition it should be emphasized that in this report no choice is made regarding the way of analysis that should or could be used.

If, for instance, organic micropollutants need to be monitored this can be done with several techniques (HPLC, MS, effect tests etc.). The choice for the analytical technique to be used will be made in WP 3.1.3 and 3.1.4 and reported separately in a later stage of the TECHNEAU project.

The selection of microbiological parameters is based on a table in the WHO book "Assessing microbial safety of drinking water: Improving approaches and methods" and a table in the WEKNOW report (3rd Expert Working Group Microbial Quality: Indicators, 17-18/03/2005), but the tables have been adapted according to the special focus of this report. The parameters included in the tables are general by nature. Depending on the special situation of a water supplier and the results of previous monitoring programmes, additional parameters could be of relevance and should be included in the monitoring. Monitoring frequencies will not be discussed in this report as this is not the main objective of WP 3.1.

At the end of the TECHNEAU project, when the relevant monitoring technologies have been identified, some examples for defined scenarios will be given on how to work with these tables (for example for small groundwater supplies, or for systems comprising different treatment steps).

2.2 Criteria for selection of parameters

The key-parameters in the following tables have been selected according to several criteria. For each parameter the relevant criteria for selection are indicated in the tables. A group of parameters was classified according to a given criterion if at least one member of the group fulfils this criterion (e.g. pesticides are classified as "health-related parameter" as some pesticides fulfil this criterion). The criteria for selection of parameters were:

- A. Health-related parameter
- B. Parameter listed in EU Drinking Water Directive 98/83/EC (DWD). The EU DWD is the only legislation that was taken into account. National DWDs and the Water Framework Directive (WFD) were left out.
- C. Parameter for process control
- D. Aesthetic parameter
- E. Early-warning parameter
- F. Emerging water quality parameter. Usually these are not new parameters, but they have recently emerged as being of interest. Emerging parameters are not regulated in the DWD.

3 Selection of key-parameters

3.1 Catchment characterisation

Many countries are densely populated by both man and livestock, resulting in contamination of sources for drinking water. Monitoring needs to be designed in such a way that both, peak contamination events and chronic contamination can be detected. This purpose is only elaborated for surface water; for groundwater, catchment characterisation is assumed equal to source water characterisation (see 3.2). The key-parameters selected for the purpose of catchment characterisation are presented in table 1.

Table 1. Key-parameters selected for catchment characterisation

Parameter	Selection criteria	Comments
<i>Microbiology</i>		
E. coli	A, B	
Enterococci	B	
Clostridium perfringens	B	
Total coliforms	B	
Enteric viruses	A	
Giardia/Cryptosporidium	A	
Campylobacter	A	
<i>Chemistry</i>		
EDCs	A, F	includes monitoring of both effects and individual substances
Genotoxic substances	A	
Algae toxins	A, E, F	includes monitoring of both effects and individual substances
Pharmaceuticals	F	
Boron	A, B	used as indicator for domestic wastewater*
Industrial chemicals	A, F	
Pesticides	A, B, F	
Acute toxicity	A, E	

*others may be used as well such as complexing agents or caffeine

3.2 Source water characterisation

The difference between catchment characterisation and source water characterisation is that the latter defines the water quality just before entering the drinking water treatment plant (raw water quality).

In this report, a maximum scenario for surface water and a minimum scenario for well-protected deep groundwater will be regarded. Monitoring of other types of source water, e.g. spring water, shallow groundwater, or bank filtrated water, will be in between. The key-parameters selected for surface water characterisation are presented in table 2, for groundwater characterisation in table 3.

Table 2. Key-parameters selected for source water characterisation of surface waters

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B	
Enterococci	B	
Clostridium perfringens	B	
Total coliforms	B	
Enteric viruses	A	
Giardia/Cryptosporidium	A	
Campylobacter	A	
<i>Chemistry</i>		
EDCs	A, F	includes monitoring of both effects and individual substances
Genotoxic substances	A	
Algae toxins	A, E, F	includes monitoring of both effects and individual substances
Pharmaceuticals	F	
Boron	A, B	used as indicator for domestic wastewater*
Industrial chemicals	A, F	
Pesticides	A, B, F	
Acute toxicity	A, E	
DOC/TOC	B, E	
UV absorption	E	
Turbidity	B, E	
Cyanides	A, B	
Ammonium	B	

*others may be used as well such as complexing agents or caffeine

Table 3. Key-parameters selected for source water characterisation of groundwaters

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B	
Total coliforms	B	
<i>Chemistry</i>		
TOC	B	
Pesticides	A, B	
Arsenic	A, B	
Fluoride	A, B	
Selenium	A, B	
Iron	B, D	
Manganese	B, D	
Radioactivity	A, B	
Nitrate	A, B	
Ammonium	B	

3.3 Monitoring of performance of treatment technologies

Among the steps in safe water production from catchment to consumer, treatment technologies play an important role. Each treatment step poses its own demands on the key-parameters to be monitored in order to guarantee

an accurate and sustainable operation of the treatment process. Therefore, separate key-parameters have been defined for each technique.

Treatment techniques that have been considered are:

- Flocculation/coagulation
- Rapid sand filtration
- Slow sand filtration/bank filtration/dune infiltration/artificial recharge
- Activated carbon filtration
- Membrane filtration
- Ozonation (single ozone, or ozone based advanced oxidation processes, with or without biological oxidation)
- Chlorination/chlorine dioxide dosage/chloramination
- UV based treatment (single UV and UV based AOP)
- Softening/conditioning/others

The key-parameters selected for the monitoring of the efficiency of the considered treatment steps are presented in tables 4-12. In principle, all source water parameters can of course be followed during the individual treatment steps, in order to get information on their behaviour during treatment. If pollutants are detected in source water, there will be a need to analyse these later on during the process and in the final drinking water as well. In the following tables only general parameters for the specific treatment steps are included.

Table 4. Key-parameters for the monitoring of the efficiency of coagulation /flocculation

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli Enterococci F specific RNA-phages Total coliforms	A, B, C B, C C B, C	as long as no regrowth is expected due to elevated temperatures in raw water
<i>Chemistry</i>		
Turbidity DOC/TOC UV absorption Particle counts Colour	B, C B, C C C B, C, D	
<i>Process parameters</i>		
Dose and residual of iron/aluminium/polymer pH Turbidity Particle count	(A), B, C	depending on coagulant/flocculant used

Table 5. Key-parameters for the monitoring of the efficiency of rapid sand filtration

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B, C	as long as no regrowth is expected due to elevated temperatures in raw water
Enterococci	B, C	
Total coliforms	B, C	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
DOC/TOC	B, C	for treatment of anaerobic groundwaters for treatment of anaerobic groundwaters
Turbidity	B, C	
Particle counts	C	
UV absorption	C	
Iron	C, D	
Manganese	C, D	
<i>Process parameters</i>		
Head loss	C	
Filter velocity (Flow rate)	C	
Turbidity		
Particle counts		
Back wash rate		
Back wash frequency		

Table 6. Key-parameters for the monitoring of the efficiency of slow sand filtration/bank filtration/dune infiltration/artificial recharge

Parameter	Classification	Comments	
<i>Microbiology</i>			
E. coli	A, B, C	as long as no regrowth is expected due to elevated temperatures in raw water	
Enterococci	B, C		
Total coliforms	B, C		
F specific RNA phages	C		
Giardia/Cryptosporidium	A, C		
Clostridium perfringens	B, C		
Total cell counts	C		
Cultivation-free viability analysis	C		
<i>Chemistry</i>			
DOC/TOC	B, C		depending on source water quality
AOC/BDOC	C		
Turbidity	B, C		
Particle counts	C		
UV absorption	C		
Oxygen	C		
Ammonium	B, C		
Nitrite	A, B, C		
Organic micropollutants*	A, (B), C, F		
<i>Process parameters</i>			
Head loss	C		
Residence time (Flow rate)	C		
Turbidity			
Particle count			
Oxygen			

* = general group, consisting of e.g. pharmaceuticals, industrial pollutants etc

Table 7. Key-parameters for the monitoring of the efficiency of activated carbon filtration

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B, C	as long as no regrowth is expected due to elevated temperatures in raw water
Enterococci	B, C	
Total coliforms	B, C	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
DOC/TOC	B, C	depending on source water quality if AC filter is used as biofilter if AC filter is used as biofilter if AC filter is used as biofilter
AOC/BDOC	C	
UV absorption	C	
Taste	B, C, D	
Odour	B, C, D	
Colour	B, C, D	
Organic micropollutants*	A, B, C, F	
Nitrite	A, B, C	
Ammonium	B, C	
Oxygen	C	
<i>Process parameters</i>		
Head loss	C	
Filter velocity(flow rate)	C	
Break through of target compound(s)		

* = general group, consisting of e.g. pharmaceuticals, industrial pollutants etc

Table 8. Key-parameters for the monitoring of the efficiency of membrane filtration

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B, C	
Enterococci	B, C	
Total coliforms	B, C	
Giardia/Cryptosporidium	A, C	
F specific RNA phages	C	
Total cell concentrations	C	
<i>Chemistry</i>		
DOC/TOC	B, C	NF, RO
Turbidity	B, C	MF, UF, NF, RO
Particle counts	C	MF, UF, NF, RO
Conductivity	B, C	RO
AOC/BDOC	C	NF, RO
UV absorption	C	NF, RO
Taste	B, C, D	NF, RO
Odour	B, C, D	NF, RO
Colour	B, C, D	NF, RO
Organic micropollutants	A, B, C, F	NF, RO; depending on source water quality
<i>Process parameters</i>		
Permeability (flow rate, transmembrane pressure)	C	
Membrane integrity test (pressure drop, turbidity/ particle size distribution)	C, E	
Membrane (bio)fouling	C	

* = general group, consisting of e.g. pharmaceuticals, industrial pollutants etc.

Note: There are differences between different types of membrane filtration. This table covers microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO). For specifications, see comments. If RO is used for softening, parameters in table 12 have to be monitored as well.

Table 9. Key-parameters for the monitoring of the efficiency of ozonation

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B, C	
Enterococci	B, C	
Total coliforms	B, C	
Colony counts/ HPC	B, C	
Aerobic spore-forming bacteria	C	
Clostridium perfringens	B, C	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
DOC/TOC	B, C	
AOC/BDOC	C	
Turbidity	B, C	
UV absorption	C	
Taste	B, C, D	
Odour	B, C, D	
Colour	B, C, D	
Organic micropollutants*	A, B, C, F	depending on source water quality
Ozonation by-products	A, B, C, F	possible by-products: bromate, ketones, organic acids
Iron	B, C	for groundwater
Manganese	B, C	for groundwater
<i>Process parameters</i>		
Ozone dose, contact time (c x t)	C	
Ozone concentration	C	
Residual ozone	C	
pH	C	

* = general group, consisting of e.g. pharmaceuticals, industrial pollutants etc.

Table 10. Key-parameters for the monitoring of the efficiency of chlorination

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B, C	as indicator for Giardia/Cryptosporidium
Enterococci	B, C	
Total coliforms	B, C	
Colony counts/ HPC	B, C	
Aerobic spore-forming bacteria	C	
Clostridium perfringens	B, C	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
AOC/BDOC	C	possible by-products: THM, chlorite, chlorate, haloacetic acids, MX, NDMA (chloramination)
Chlorination by- products	A, B, C, F	
Genotoxicity	A, F	
<i>Process parameters</i>		
Disinfectant dose	C	
Contact time	C	
Residual disinfectant	C	
pH	C	

Table 11. Key-parameters for the monitoring of the efficiency of UV-based processes

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B, C	
Enterococci	B, C	
Total coliforms	B, C	
Colony count/ HPC	B, C	
Aerobic spore-forming bacteria	C	
Clostridium perfringens	B, C	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
DOC/TOC	B, C	
Organic micropollutants	A, B, C, F	especially when UV is applied in combination with oxidants
By-products	A, C, F	especially when UV applied in combination with oxidants; possible by-products: nitrite, organic acids
<i>Process parameters</i>		
Turbidity	C	
UV absorption	C	
UV dose	C	
Oxidant dose	C	if AOP
Residual oxidant	C	if AOP
Alkalinity	C	

Table 12. Key-parameters for the monitoring of the efficiency of softening/conditioning/others

Parameter	Classification	Comments
<i>Microbiology</i>		
None		
<i>Chemistry</i>		
Saturation index	C	
Alkalinity	C	
Conductivity	B, C	
Sodium	B, C	
Calcium	C, D	
Magnesium	C, D	
Sulphate	B, C	
Chloride	B, C	
<i>Process parameters</i>		
Inhibitors	C	if dosed
Fluoride	A, B, C	if dosed

3.4 Overall treatment effect/water quality status before entering distribution network

To monitor the overall effect of all treatment steps and to know the drinking water quality before entering the distribution system, monitoring needs to be conducted at the finished water. The definition of finished water used here is: water at the exit of the treatment plant after all treatment steps, disinfection and fluoridation included (if applicable). The key-parameters selected for the monitoring of finished drinking water are presented in table 13.

Table 13. Key-parameters for the monitoring of the quality of finished drinking water

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B	
Enterococci	B	
Clostridium perfringens	B	
Colony counts/HPC	B	
Total coliforms	B	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
AOC/BDOC	C	
Acute toxicity	A	
Benzene	A, B	
Boron	A, B	
Bromate	A, B	
Chromium	A, B	
Cyanides	A, B	
1,2-Dichloroethane	A, B	
Fluoride	A, B	
Nitrate	A, B	
Pesticides	A, B	
Mercury	A, B	
Selenium	A, B	
Tri- and tetrachloroethene	A, B	
EDCs	F	only if already present in source water
Pharmaceuticals	A	only if already present in source water
Genotoxicity	A	only if already present in source water
Algae toxins	A, F	only if already present in source water
Industrial chemicals		only if already present in source water
<i>Process parameters</i>		
Taste	B, D	
Odour	B, D	
pH	B, C	
Chloride	C	
Alkalinity	C	
Disinfectant	A	
Turbidity	B, C	
Particle count	C	
UV absorption	C	

3.5 Detection of quality changes during distribution

Water that has been properly treated and is safe when leaving the treatment works should maintain its high quality during its way through the distribution network. Changes in water quality can be caused by either:

- Ingress of pollutants
- Time-related changes in water quality (due to residence time and pipe material applied in the distribution network)

For both situations key-parameters have been selected. These are presented in tables 14-15.

Table 14. Key-parameters for the monitoring of ingress of pollutants

Parameter	Classification	Comments
<i>Microbiology</i>		
E. coli	A, B	indicator
Enterococci	B	indicator
Total coliforms	B	indicator
Colony counts/HPC	B	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
Residual disinfectant	A	if applicable
Toxicity	A	no list of substances included because of risk of missing important toxic compounds
Turbidity	B, D	
UV absorption	C	

Table 15. Key-parameters for the monitoring of time related changes in water quality due to residence time in the distribution network

Parameter	Classification	Comments
<i>Microbiology</i>		
Colony counts/HPC	B, C	
Total coliforms	B, C	
Pseudomonas aeruginosa	A, C	
Aeromonas	C	
Biofilm formation	C	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
Residual disinfectant	C	if applicable, see treatment
Sediments	C	e.g. iron oxides
Turbidity	C	
Aluminium	C	If alumina mortar lining is used
pH	C	Initial period with new mortar linings for soft surface water distribution

3.6 Safeguarding water quality at consumers' tap

Monitoring of water quality at consumers' tap is recommended to ensure that no changes during distribution or in the domestic installations occur. Next to this some aesthetic parameters need to be monitored at consumers' tap as well.

Table 16. Key-parameters for the monitoring of water quality at consumers' tap

Parameter	Classification	Comments
<i>Microbiology</i>		
Legionella	A	
Pseudomonas aeruginosa	A	
E. coli	A, B	
Enterococci	B	
Clostridium perfringens	B	
Colony counts/HPC	B	
Total coliforms	B	
Total cell counts	C	
Cultivation-free viability analysis	C	
<i>Chemistry</i>		
Antimony	A, B	
Arsenic	A, B	
Benzo(a)pyrene	A, B	
Cadmium	A, B	
Chromium	A, B	
Copper	A, B	
Lead	A, B	
Nickel	A, B	
Nitrite	A, B	
PAHs	A, B	
Disinfection by-products	A, B	if applicable
Acute toxicity	A	
Residual disinfectant	D	if applicable
Taste	B, D	
Odour	B, D	
Colour	B, D	
Turbidity	B, D	

3.7 Overall results

A compilation of the information given in tables 1-16 is presented in table 17. The table shows all key-parameters and the purpose they can be used for. If the monitoring of a parameter is recommended for a purpose, this is shown in black. For reasons of clearness, all treatment processes have been combined (even disinfection and removal processes are not distinguished anymore).

Table 17. Total list of parameters and where they are/can be used

Parameter	Catchment	Source water SW	Source water GW	Treatment	Finished water	Distribution ingress	Distribution time related	Customer's tap
<i>Microbiological parameters</i>								
E. coli	■	■	■	■	■	■	■	■
Enterococci	■	■	■	■	■	■	■	■
Clostridium perfringens	■	■	■	■	■	■	■	■
Total coliforms	■	■	■	■	■	■	■	■
Colony count/HPC	■	■	■	■	■	■	■	■
Enteric viruses	■	■	■	■	■	■	■	■
Giardia/Cryptosporidium	■	■	■	■	■	■	■	■
Campylobacter	■	■	■	■	■	■	■	■
Legionella	■	■	■	■	■	■	■	■
Pseudomonas aeruginosa	■	■	■	■	■	■	■	■
Aeromonas	■	■	■	■	■	■	■	■
F-specific RNA phages	■	■	■	■	■	■	■	■
Aerobic spore-forming bacteria	■	■	■	■	■	■	■	■
Biofilm formation	■	■	■	■	■	■	■	■
Total cell counts	■	■	■	■	■	■	■	■
Cultivation-free viability analysis	■	■	■	■	■	■	■	■
<i>Chemical parameters</i>								
antimony	■	■	■	■	■	■	■	■
arsenic	■	■	■	■	■	■	■	■
benzene	■	■	■	■	■	■	■	■
benzo(a)pyrene	■	■	■	■	■	■	■	■
boron	■	■	■	■	■	■	■	■
bromate	■	■	■	■	■	■	■	■
cadmium	■	■	■	■	■	■	■	■
copper	■	■	■	■	■	■	■	■
chromium	■	■	■	■	■	■	■	■
cyanides	■	■	■	■	■	■	■	■
1,2-dichloroethane	■	■	■	■	■	■	■	■
fluoride	■	■	■	■	■	■	■	■
lead	■	■	■	■	■	■	■	■
mercury	■	■	■	■	■	■	■	■
nickel	■	■	■	■	■	■	■	■
nitrite	■	■	■	■	■	■	■	■
nitrate	■	■	■	■	■	■	■	■
PAHs	■	■	■	■	■	■	■	■
pesticides	■	■	■	■	■	■	■	■
selenium	■	■	■	■	■	■	■	■
tetra- & trichloroethene	■	■	■	■	■	■	■	■
disinfection byproducts*	■	■	■	■	■	■	■	■
radioactivity	■	■	■	■	■	■	■	■
EDCs	■	■	■	■	■	■	■	■
genotoxicity	■	■	■	■	■	■	■	■
acute toxicity	■	■	■	■	■	■	■	■
algae toxins	■	■	■	■	■	■	■	■

Parameter	Catchment	Source water SW	Source water GW	Treatment	Finished water	Distribution ingress	Distribution time related	Customer's tap
pharmaceuticals	■							
industrial chemicals	■							
organic micropollutants**				■	■			■
pH				■				
chloride					■			
alkalinity					■			
saturation index					■			
sodium					■			
conductivity				■				
calcium					■			
magnesium					■			
sulphate					■			
aluminum				■				
ammonium		■	■					
iron		■						
manganese			■					
taste					■			■
odour					■			■
colour					■			■
turbidity		■			■	■		■
AOC/BDOC		■			■			
DOC/TOC		■			■			
UV absorption		■				■		
particle counts				■				
oxygen				■				
inhibitors					■			
<i>Process parameters</i>								
head loss				■				
filter velocity				■				
residence time				■				
ozone dose, contact time (Ct)				■				
ozone concentration				■				
residual ozone				■				
UV dose				■				
oxidant dose				■				
residual oxidant conc.				■				
disinfectant dose				■				
residual disinfectant conc.					■		■	■
inhibitors					■			
sediments (e.g. iron oxides)							■	
flow rate				■				
transmembrane pressure				■				
pressure drop				■				
particle size distribution				■				
membrane (bio)fouling				■				

* disinfection by-products: chlorination by-products, ozonation by-products, UV/ AOP by-products

** general group, consisting of e.g. pharmaceuticals, industrial pollutants etc