Appendix 2: Quantify microbial hazards

Drinking Water - Safe Drinking Water Regulations 2015 – Regulation 8(2)

Purpose

This document is an addendum to *Guidance – Risk Management Plans* and should be read in conjunction with Regulation 8.

This guidance provides information to assist with documenting the methodology for quantifying microbial hazards in risk management plans. It also outlines the risk assessment approaches that can be undertaken in order to demonstrate safe drinking water.

Introduction

From 1 January 2016, Regulation 8(2) will apply to water agencies that operate and maintain drinking water treatment processes. It is applicable to primary treatment of untreated water and is not intended to cover secondary disinfection processes.

This regulation requires that the risk management plan contain details of the methodology that is used to quantify microbial hazards. This includes detailing the extent to which pathogenic micro-organisms are present in the source water for the drinking water supply and the extent to which treatment processes remove or reduce those pathogens.

There are a range of approaches that can be used to quantify pathogen risks. This guidance note describes a method which is based on the *Manual for the Application of Health Based Treatment Targets* (WSAA 2015). This method incorporates a health based target for microbial hazards which are adopted by the World Health Organization. It is increasingly being used by the water industry and relies on a range of national and international reference materials. While it provides a generic framework to follow, local verification of each system is required.

The use of health-based targets includes semi-quantitative characterisation of catchments and quantitative assessment of treatment process capabilities. This ensures that drinking water supplies will not increase rates of illness in the community to unacceptable levels. Implementing a health based targets framework provides a method to demonstrate that water is being treated to a safe level. Regulation 8(2) is consistent with the move towards a microbial health-based target. It is anticipated that future releases of the Australian Drinking Water Guidelines (ADWG) will incorporate a health based target and may also provide additional assessment methodologies.

Guidance

What is required?

The risk management plan must include a description of the approach taken to estimate the level of pathogenic micro-organisms that could be present in source waters and the extent to which the treatment process is effective in their removal or inactivation.

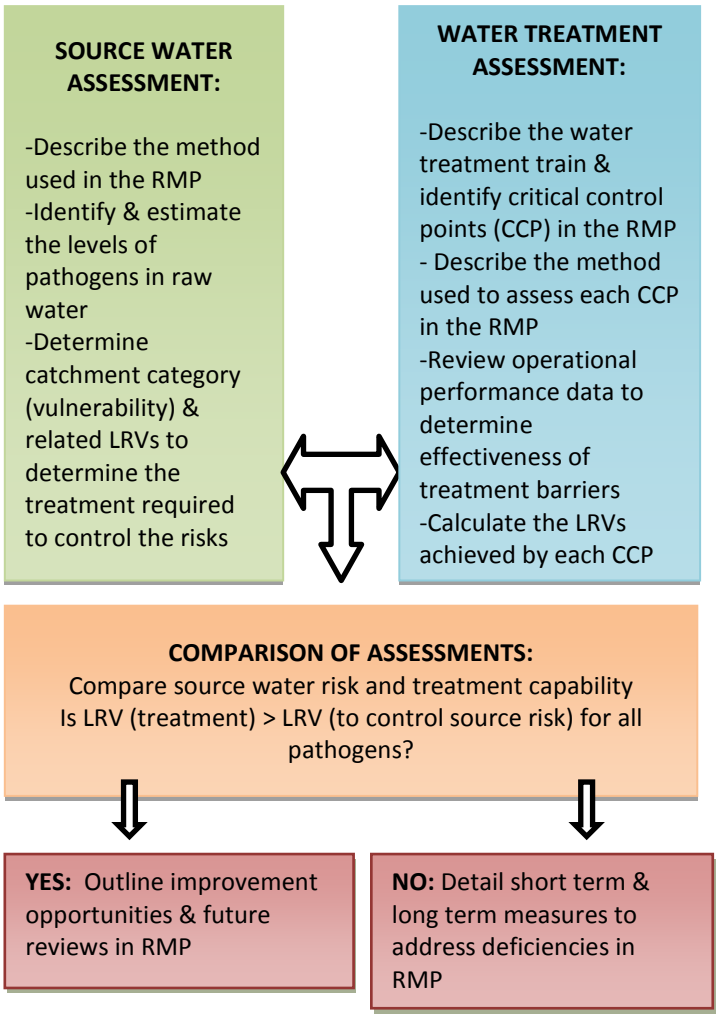
The risk assessment approach, outlined in Figure 1, requires separate assessments of the source water and the water treatment system. The source water assessment will identify the pathogen risk in the source water. This will be expressed as a log removal value (LRV) that any water treatment process must provide in order to reduce the source water pathogens to an acceptable level. The water treatment assessment is also expressed in terms of the LRV that each treatment process is actually capable of providing.

Log Reduction Value (LRV)

1 LRV = 90% removal of a target pathogen,
2 LRV = 99% removal
3 LRV = 99.9% removal
LRVs are applied to each collective group of pathogens namely LRV (virus), LRV (bacteria), LRV (protozoa)

The two LRV values are compared to determine if treatment sufficiently reduces the source water risk. Any gaps or shortfalls identified between the water treatment applied and the pathogen risk in the source water must be described in the risk management plan. This must include short term and long term measures to mitigate any impacts from identified deficiencies.

Figure 1: Process to quantify microbial hazards



Components of the assessment

The components of quantifying microbial hazards focus on source water assessment, water treatment assessment and comparison of this information which must be documented in risk management plans.

Source water assessment

In the method described, the source water is initially characterised through a sanitary survey. The results from the sanitary survey are verified using catchment monitoring data and the pathogen risk expressed as a LRV.

Sanitary Survey

A sanitary survey is a systematic qualitative assessment of a water catchment that considers the impacts to water quality from human activities and is used to understand each catchment system. It assesses the features and activities within the catchment to identify potential pathogen sources and the circumstances around their presence.

A sanitary survey is applicable to surface and ground water systems and considers human habitation impacts; the types and intensity of agricultural activities; and features related to closed /open catchments. Other characteristics to be considered that can influence water quality include storage size, buffer zones, run of the river, shared systems and recreational uses.

All potential hazards, hazardous events and contamination sources should be included in the assessment, regardless of whether or not they are under the direct control of the drinking water supplier. Continuous, intermittent or seasonal pollution patterns should also be considered as well as extreme and infrequent events such as droughts or floods.

This assessment should provide sufficient information to conclude with a catchment category based on level of risk from pathogens.

> The Manual for the Application of Health Based Treatment Targets (WSAA 2015) provides guidance on undertaking a sanitary survey. It also identifies four catchment categories that depict levels of vulnerability to contamination with pathogens.

Sanitary surveys are a valuable tool because they contribute information to determine levels of vulnerability that may not be obvious by data analysis alone. The department recommends sanitary surveys should be conducted regularly (3 – 5 years) to recognise impacts from population growth. It should also be revisited when significant changes occur.

Verification through catchment monitoring

To quantify the microbial contamination and verify the outcome of the sanitary survey, microbial data can be used. Source water *E.coli* data is the most commonly collected microbial measure for faecal contamination and is a useful indicator to confirm catchment assessments.

> WSAA's Manual for the Application of Health Based Treatment Targets (2015) provides information on using microbial data to verify sanitary survey results.

A sufficient data set is required to capture the natural variations of pathogens. Seasons, holiday periods, rainfall and temperature patterns can affect this distribution. The data should be analysed to determine reliability and statistical relevance. Data anomalies and identification of outliers should be detailed in the risk management plan.

If there is no raw water data to verify catchment categories a reasonable worst case category should be adopted. In such instances this should be used as an interim measure until data can determine otherwise. The basis for selecting a catchment category (vulnerability to contamination) needs to be documented and should be supported by literature or published sources where available.

Source water characterisation

Using both the sanitary survey results and catchment monitoring data, the catchment's susceptibility to contamination from pathogens can be quantified. This can be expressed as a LRV which describes the LRV required to control bacteria, virus and protozoa risks.

> WSAA's Manual for the Application of Health Based Treatment Targets and other tools (USEPA, NZ MoH and Health Canada) provide default source water LRVs which contain an 'in-built" health based target.

Alternative assessment methods

An alternative and more definitive approach to quantifying risk is Quantitative Microbial Risk Assessment (QMRA). This is a method that can be used where there is a high degree of uncertainty with the sanitary survey and microbial data results. This method can be complex, costly and typically requires a large amount of *Cryptosporidium* data. In the absence of relevant data and resources to undertake a QMRA, a simplified approach may be more suitable.

Water treatment assessment

The following explains the key steps for assessing water treatment effectiveness.

Treatment description

In line with the regulatory requirement to identify Critical Control Points (CCPs) and critical limits the treatment train must be described with a focus on each process essential for pathogen reduction. When describing the treatment at the plant, characterisation of large raw water storages should also be discussed in terms of how they may contribute to controlling identified risks. Treatment related impacts such as backwash and recycle water streams should also be noted as these may return pathogens to the source water.

Treatment assessment

An empirical approach to determining water treatment plant effectiveness involves a review of the operational performance of each treatment process. Literature studies of treatment plant components can be used to determine the range of microbial removal performance of various elements, such as:

- Coagulation, flocculation and sedimentation
- Media filtration
- Floatation processes
- Disinfection processes

An assessment of each treatment process must be undertaken to determine the effectiveness of the treatment applied. This is a consideration of how well each water treatment process has been performing in accordance with the set critical limits and target criteria.

The assessment of process performance should focus on the ability and frequency of achieving optimal performance. Performance should be assessed at a reasonable frequency to reflect real time operational changes. Annual averages do not provide sufficient detail to characterise performance. Where historic performance data is available in 15 minute readings, this may be suitable for determining performance. One (1) second interval data is not necessary; however, specific processes such as filter backwashing may be important in characterising performance and may need to be considered.

Physical Treatment

All physical water treatment processes should be characterised by operational performance monitoring analysis. Examples of monitoring include on-line instrumentation to measure turbidity, pH, and chemical dose rates. Analysis of monitoring records should provide an indication of treatment performance and identify where operational improvements can be made. Operational monitoring is a key feature of water treatment assessment especially if claiming default LRVs from published literature.

Other treatment processes such as membrane filtration can claim LRVs from manufacturer specifications and performance is controlled by a number of process parameters.

Disinfection Treatment

Disinfection processes such as UV irradiation and chlorine disinfection, should be characterised in terms of the key monitoring variables with reference to the best available guidance on disinfection effectiveness such as the USEPA's, *Ultraviolet Disinfection Guidance Manual* (2006), and *Disinfection Profiling and Benchmarking Guidance Manual for UV and chlorine (*1999). Operational monitoring of disinfection systems may include flowrates, UV transmissivity, UV intensity, UV dose, chlorine concentration, pH, temperature and chlorine CT.

Treatment LRV

Analysis of physical treatment and disinfection related data will enable an overall water treatment LRV for bacteria, virus and protozoa to be determined. This provides an indication of the effectiveness of the treatment being applied.

Achieving an LRV is directly related to and affected by the critical limits applied at each critical control point.

> Default treatment LRVs are also outlined in WSAA's *Manual for the Application of Health Based Treatment Targets* and can be applied based on the performance measures of the critical limits for each CCP.

Validation

An alternative to using default values is undertaking specific treatment process validation to measure the pathogen removal of specific processes. This uses direct pathogen studies or surrogates and requires a detailed assessment and definition of critical operating parameters and CCPs. Guidance is provided in the department's *Guidelines for validating treatment processes for pathogen reduction,* (2013).

National initiatives are in progress to develop protocols for the validation of various treatment processes for pathogen reduction. Whilst the primary focus may be recycled water, the principles will be consistent with drinking water treatment processes and may provide useful information for the control of microbial pathogens in drinking water in the long term.

Limitations of water treatment assessment

While online monitoring capability is widely implemented the department has identified inconsistent approaches. Water RA's *Guidance on defining good practice and operational monitoring requirements (*2015) and Chapter 9 of ADWG provides information on good practices.

It is also recognised there are issues with erroneous data due to equipment, programs, format and data entry errors. Programs to code or qualify existing data are currently being developed by water businesses.

The ability to interpret SCADA data is also a skill that businesses will need to refine. Operation of treatment systems within the defined critical limits is essential to thoroughly monitor and review barrier performance.

Comparison of assessments

A comparison of the source water and treatment assessments is undertaken to determine if the treatment plant can effectively manage the risks present in the source water. In comparing the LRV required for the source water and the LRV provided by the water treatment processes there are three possible outcomes:

- that risks are adequately managed
- that risks are mostly managed
- that risks are not adequately managed

From this, short term and long term system improvements including control methods can be identified and detailed in the risk management plan.

If the overall LRVs for the water treatment plant are greater than the LRVs required for the source water for each pathogen group then the system is considered to have in place sufficient protection from microbial hazards. As this is dependent upon good operational practices, ongoing reviews of critical limits and any identified opportunities for improvement should be outlined in the risk management plan.

If any treatment LRV is less than the corresponding source water LRV then the system could be deficient in its ability to produce safe drinking water. In this situation an analysis of the deficiency is required.

Where risks are mostly managed optimisation of existing treatment systems may be sufficient to improve treatment performance. This will result in tighter critical limits being applied to CCPs.

Where risks are not adequately managed system optimization and upgrades may be required to address the deficiency. Risk reduction measures both short and long term must be recorded in the risk management plan. Examples of measures may include selective

harvesting, monitoring improvements, major maintenance and planned capital works.

Risk management plan implementation

Methodology

The risk management plan must include a description of the approach taken to assess microbial hazards in the source water and the approach taken to assess water treatment performance. This should reference the guidance materials used in the approach and identify any assumptions made.

Assessment outcomes

Following a comparison of treatment capability and source water risk, information related to the assessment outcomes must be documented in the risk management plan.

The assessment results should inform the CCPs and associated control limits and any adjustments should be detailed in risk management plans. Improvements to operational monitoring practices should also be identified and recorded in the risk management plan.

Implementation timeframes for system improvements should be included. This must incorporate periodic reviews and criteria that may initiate an earlier review of the system. Examples of situations that may initiate earlier reviews include natural events such as a landslip altering a river course; approval of a significant development in the catchment or; planned major maintenance at the treatment plant.

Related information

Department of Health & Human Services (2015) Guidance – Audits: Regulations 9-11

Department of Health & Human Services (2015) Guidance – Risk Management Plans: Regulation 8

Department of Health & Human Services (2013) Guidelines for validating treatment processes for pathogen reduction

European Commission Council Directive 74/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (OJ L 194, 25.7.75)

Health Canada (2013) Guidance for Providing Safe Drinking Water in Areas of Federal Jurisdiction, Version 2

Ministry of Health New Zealand 2005 revised 2008 Drinking-water Standards for New Zealand

NHMRC, NRMMC (2011) Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy, National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra

USEPA (1999) Disinfection Profiling and Benchmarking Guidance Manual for UV and chlorine

USEPA (2006) National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule

USEPA (2006) Source Water Monitoring Guidance Manual for Public Water Systems for the Final Long Term 2 Enhanced Surface Water Treatment Rule

USEPA (2006) Ultraviolet Disinfection Guidance Manual

Water RA (2015) Good practice guide to the operation of drinking water supply systems for the management of microbial risk

Water RA (2013) Health-Based targets for microbial safety of drinking water: Introduction

Water RA (2014) Log removal values in wastewater treatment

Water RA (2014) Treatment of Australian source waters to meet health based targets

Water Services Association of Australia (2015) Manual for the Application of Health Based Treatment Targets

WHO (2003) Assessing Microbial Safety of Drinking Water. Published on behalf of the World Health Organization and the Organisation for Economic Co-operation and Development by IWA Publishing, London, UK