Department of Primary Industries
Office of Water

RECYCLED WATER | INFORMATION SHEET NUMBER 2

Indicators, Reference Pathogens & Log_{10} Reductions: What does it all mean?

April 2015

Background

Previously, the industry's approach to setting quality requirements for water was to define a number of organisms/volume in the finished water. In recent years we have moved away from this approach. The Australian Guidelines for Water Recycling (AGWR) (2006), use a model of reducing pathogen concentrations from the source material through to the finished recycled water, with reductions required based on the end use. This reduction is measured in logs to the base 10 (log_{10}) and the terminology used in the AGWR is **LRV** or **l**og_{10} **r**eduction **v**alue. The LRV required for each end use of recycled water is based on the likely exposure volumes ingested from the use of the water. The AGWR also use other terms including 'surrogates' and 'reference pathogens'. Each of these terms is covered in more detail below.

Logs and Reduction Values

For the production of safe recycled water, the high numbers of pathogens in sewage need to be reduced to safe levels. Logarithms (or logs) can be used as shorthand to simplify large numbers and to indicate the reduction required.

The logarithm of a number is the **exponent** to which another fixed value, the base, must be raised to produce that number – as an example the number 1000 can be expressed as

$1000 = 10 \times 10 \times 10 = 10^{3} =$ **3** $\log_{10}$

Table 1 Example of pathogen numbers in sewage per litre

Pathogen	Number	Log $_{10}$
Cryptosporidum	10 000	4.00
Rotavirus	56 330	4.75

The reduction in the number of pathogens from the sewage source through to the finished water expressed in $Log_{10,}$ is the log reduction value or LRV. Table 2 shows how the LRVs can be calculated.

Table 2 Example LRV calculations

	Virus		Bacteria	
	Number	Log_{10}	Number	Log_{10}
Sewage	56 300	4.75	10 000	4
Treated	457	2.66	10	1
LRV		4.75-2.66 **2.09**		4-1 **3**

The important thing to remember is:

> *The higher the log reduction, the lower the concentration of pathogens in the finished water.*

The AGWR specifies a LRV for each pathogen group, for a given end use (see Table 3 for examples) but they do not specify the treatment train that should be used to achieve the desired LRV. For more information in calculating LRVs, see Information Sheet 3: *Calculating Log Reduction Values*.

Table 3 Common end uses and LRV requirements

Use	LRV Requirement		
	Protozoa	Viruses	Bacteria
Commercial food crops	4.8	6.1	5.0
Dual reticulation	5.0	6.4	5.1
Fire fighting	5.1	6.5	5.3

Source: *NSW Guidance for RWMS Table 4*

Reference Pathogens

There are many pathogens associated with waterborne disease, therefore it is not practicable to specify a LRV for each pathogen. Instead the AGWR adopts the concept of 'reference pathogens' for each pathogen group.

Reference pathogens are those that present a worst case combination of:

- High concentration in water to be recycled
- High pathogenicity (illness causing)
- Low removal in treatment
- Long survival in the environment.

If these reference pathogens are under control, risk from the hundreds of other waterborne pathogens should also be largely under control. Examples of reference pathogens are shown below in Table 4.

Table 4 Reference and indicator pathogens in AGWR

Hazard	Reference	Surrogate/Indicator
Protozoa	*Cryptosporidium parvum*	*Clostridium perfringens* (spores are used)
Viruses	Amalgam of rotavirus and adenovirus	Somatic coliphages F–RNA coliphages
Bacteria	*Campylobacter*	*Escherichia coli Enterococci*

***Source**: AGWR Section 3.2.1, Table 3.6, and Table 5.3*

Note that, while the above table contains information on reference viral pathogens from the AGWR, because of changes in scientific knowledge, Coxsackie B5 is now emerging as one of the more resistant viruses and therefore a candidate for reference viral pathogen (Black *et. al.* 2009). Proponents are advised to check information with the NSW Office of Water.

Indicators and Surrogates

Because microbial pathogens cannot always be measured, may not always be present or present in high enough concentrations to allow for valid measurement, the concept of indicator organisms exists. Indicator organisms are those organisms that are not usually pathogenic but tell us something about the quality of the water e.g. the presence of *Escherichia coli* (*E. coli*) indicates the likelihood of fresh faecal contamination. Indicators do not always provide a good correlation with pathogens but they do provide some information on water quality. Surrogate organisms may also be used as indicators for a particular group of organisms, for instance, bacteriophages (viruses of bacteria) can be used as surrogates for virus detection. In some circumstances, the surrogate does not even need to be the same pathogen type that it is an indicator for e.g. Clostridial spores can be used as surrogates for protozoan cysts.

- *Indicators provide an **indirect** measure of a particular characteristic e.g. water that is not of a fit quality for its intended use. They are generally lower cost and more reliable to monitor than pathogens.*
- *Surrogates are **substitutes** or **replacements** of the thing that we want to measure.*

Some examples of indicators and surrogates are shown in Table 4.

Surrogate organisms are often used to help establish process effectiveness during validation trials and to determine if a particular process train can provide the required LRVs for a particular end use. Process units (such as UV systems) can also be purchased pre-validated from the manufacturer in which case, a certificate of validation for a given pathogen or microbial type (such as viruses) will accompany the process unit.

Table 5 Purpose of indicator organisms

Group	Definition
Process indicator	A group of organisms that demonstrates the efficacy of a process, such as total heterotrophic bacteria or total coliforms for chlorine disinfection.
Faecal indicator	A group of organisms that indicates the presence of faecal contamination, such as the bacterial groups Thermotolerant coliforms or *E. coli*. Hence, they only infer that pathogens may be present.
Index and model organisms	A group/or species indicative of pathogen presence and behaviour respectively, such as *E. coli* as an index for *Salmonella* male-specific coliphages as models for human enteric viruses.

More information

Ashbolt NJ, Grawbow WOK, Snozzi M. Indicators of microbial water quality. In: Fewtrell L, Bartram J, eds. Water Quality: Guidelines, Standards and Health. London: IWA Publishing; 2001; 289– 315.

Australian Guidelines for Water Recycling (2006)

Black, S, Thurston, J and Gerba, C. (2009) Determination of Ct values for chlorine of resistant enteroviruses. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering, 44:4, 336-339.

For more information visit www.water.nsw.gov.au or contact: rwapprovals@dpi.nsw.gov.au

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