Australian Water Recycling
Centre of Excellence

A national framework
for validating water-recycling technology

Validating multiple-barrier water recycling systems

based on Street map 9

Water is being recycled all over Australia for a variety of uses. To protect the health of people and the environment, treatment technologies used in water recycling schemes need to meet agreed performance targets. Across Australia there is currently no consistent approach to validating that they do so. The Australian Water Recycling Centre of Excellence engaged Water Quality Research Australia to deliver a national framework for validating treatment technologies.

After much consultation, the project team, comprising researchers, industry specialists and regulators, has designed a workable, accepted framework. The next steps are to fill some of the knowledge gaps and negotiate with industry and government to have the framework implemented.

What is validation?

The *Australian Guidelines for Water Recycling (2006)* require that a treatment technology or process be validated before the water recycling scheme is operational. Validation is the confirmation that the treatment technology meets the specified performance targets. The guidelines describe the concept of and need for validation but do not specify how the validation should be done.

What is a multiple-barrier system?

A multiple-barrier system uses more than one preventative measure against hazards during the water treatment process. Major hazards are pathogens and chemicals.

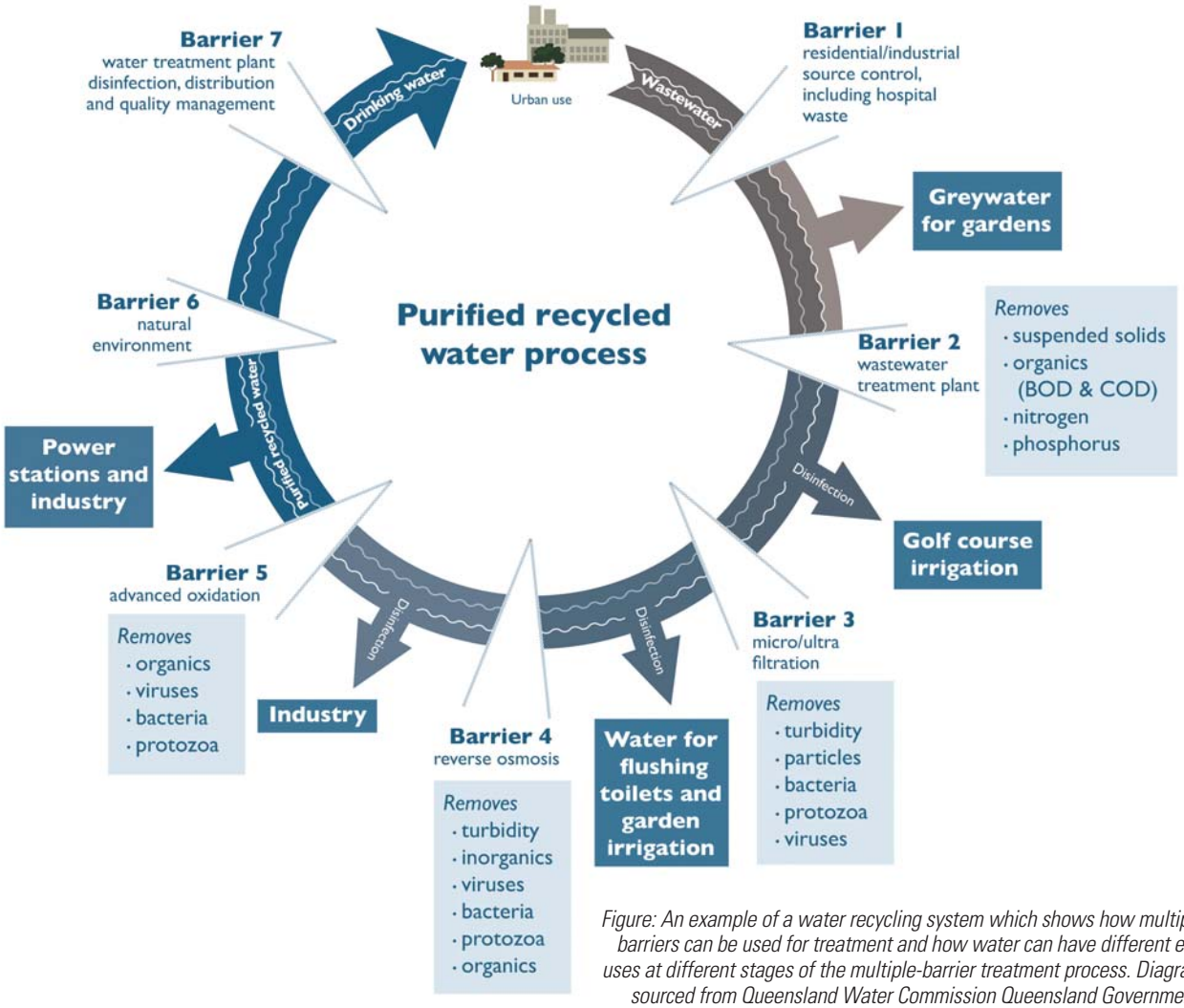

Figure: An example of a water recycling system which shows how multiple barriers can be used for treatment and how water can have different end uses at different stages of the multiple-barrier treatment process. Diagram sourced from Queensland Water Commission Queensland Government.

Validating multiple-barrier water recycling systems

based on Street map 9

Current and emerging validation techniques

Chemical, microbial and mixture validation processes have been used or considered as emerging techniques for validating multiple-barrier systems.

Microbial indicators

The *Australian Guidelines for Water Recycling* and the *Victorian Guidelines for Validating Treatment Processes for Pathogen Reduction* contain information about using microbial indicators for validating, monitoring and managing health risks in recycled water.

Microbial indicators are used to indicate contaminated water or predict pathogen presence. An ideal indicator mimics the behaviour and characteristics of a pathogen but is easier, faster and cheaper to measure, as well as is non-pathogenic. Microbial indicators that are of public health concern and are present in recycled water have been grouped as follows:

- Process indicator: A group of organisms that demonstrate the effectiveness of a process
- Faecal indicator: A group of organisms that indicates the presence of faecal contamination
- Index and model organisms: A group of organisms that indicates pathogen presence and behaviour.

Research suggests that microbial indicators need to be both sensitive and specific. Poor sensitivity leads to false negative results. Poor specificity leads to overestimation of pathogen levels in water.

Indicators and Surrogates

The use of chemical indicators (indicator compounds and surrogates) to assess and monitor the performance of water treatment processes has, to date, been validated conceptually.

An indicator compound is a chemical, occurring at a measurable level, which represents certain physiochemical and/or biodegradable characteristics of a larger group of trace chemicals.

A surrogate is a microorganism that operators measure instead to estimate target microorganism levels. For a surrogate to be suitable for treatment validation it must be either:

- reduced, removed or inactivated by the treatment process to a point where its level is equal to or less than the target pathogen, or
- demonstrated that there is a correlation between the reduction of the surrogate and the target pathogen.

The main advantage of the indicators and surrogates approach is that it requires the measurement of only a limited set of chemicals/microorganisms to assess and monitor treatment processes for a much larger group of chemicals.

Potential indicator compounds and surrogates have already been identified for a range of water treatment processes.

Indicator chemicals have been identified for:

- managed aquifer recharge systems
- membrane bioreactor treatment
- ozone treatment
- advanced oxidation processes
- chloramination processes
- chlorination processes
- ultraviolet (UV) disinfection processes
- PAC systems (powdered activated carbon)
- GAC processes (granular activated carbon)
- reverse osmosis processes
- nanofiltration processes.

Mixture indicators, also known as bioanalytical tools

Chemicals occur as complex mixtures in environmental water and wastewater.

The *Australian Guidelines for Water Recycling* and the *Australian Drinking Water Guidelines* combined provide guideline values for approximately 400 chemicals.

However, there are more than 61 million chemicals known today, with more than 100 000 in commercial and industrial use. Less than 10 per cent have some toxicity data and risk assessment, and the majority have little or no toxicity data.

Methods are needed to prioritise chemical testing and provide a toxicity-weighed measure of overall water quality.

Bioanalytical tools may be able to provide such a measure, complementing the existing range of analytical tools currently in use.

Organisms respond immediately, at the molecular and cellular level, to chemicals in water. Measuring toxicity at the cellular level, as is done with bioanalytical tools, could provide an invaluable tool to assess hazard.

Where many individual chemicals are below detection limit, bioanalytical tools may be able to assess the treatment efficiency of treatment steps.

> "Potential indicator compounds and surrogates have already been identified for a range of water treatment processes."

Validation limitations and difficulties

Chemicals or microbial organisms monitored as indicator substances are still only assumed to represent the presence, treatability or fate of a wider range of substances that are not individually monitored.

It is considered vital that the abilities or limitations of the indicator substance to represent other substances in a particular treatment process are properly validated under a range of conditions.

Chemical and microbial analysis is time consuming, labour intensive and expensive. It will be necessary to identify the most efficient approach to collecting statistically sound, suitably representative data.

Any mathematical manipulations or procedures should be highly accessible and understandable to reasonably technically trained people. Results of the validation procedures should not be hard to understand or interpret by health or environmental regulators.

The majority of existing chemicals have not been monitored in water and there is the risk of measuring an ever-increasing list of chemicals, many of which are of no health relevance.

Research gaps

More research is needed that compares the use of molecular- and culture-based techniques as well as investigates the suitability of lab-grown microorganisms for validating water treatment. There are indications that lab-grown strains may not be as robust as indigenous wastewater strains and hence questions arise about their suitability as indicator organisms.

More research is generally needed to understand pathogen reduction via some treatment processes used in water recycling.

The concept of using chemical indicators for assessing water treatment processes is still relatively new. Considerable knowledge and experience is required to fully assess and validate the performance of specific chemicals for monitoring most types of treatment processes.

While surrogate measures are required for continuous ongoing validation of treatment performance, there are still gaps where a clear relationship between the treatment performance for surrogate measures and some specific groups of chemicals is not always apparent.

Chemicals can undergo a variety of transformation processes once released into the environment or absorbed by living organisms. One chemical can have a variety of transformation products, for which there is no known toxicity data and which have generally not undergone risk assessment. Knowledge of transformation products presents a significant knowledge gap.

Existing guidelines are still based on single chemicals and little is known about how many different chemicals act together in mixtures.

Bioanalytical tools have the potential to close these gaps and are useful in benchmarking water quality, but it is unclear what role they would play in regulation.


Photo sourced from Seqwater

Validating multiple-barrier water recycling systems

based on Street map 9

A national framework
for validating water-recycling technology

Recommendations

For a multiple-barrier validation system, it is recommended that an integrated testing strategy using a multi-stepped approach be considered. The first step would conduct a screening with surrogate indicators. A second tier of screening would only be conducted if defined threshold limits are exceeded. This approach would facilitate the use of more comprehensive data collection and analysis only in situations when it is warranted, for example, depending on the size of a scheme or intended purpose of the recycled water.

> "Proponents suggested that validation processes need to be much clearer and more transparent, with much greater certainty regarding outcomes."

Photo sourced from SA Water

National Validation Framework factsheet suite

This brochure is based on a 'road map' report funded by the Australian Water Recycling Centre of Excellence. The 'road map' describes a national approach for validating treatment technologies, and was based on extensive consultation with stakeholders.

This brochure is one of a series that describes the outcomes of the first stage of this national validation project.

Other brochures in the series cover:

- An overview of the draft National Validation Framework
- Perspectives of water recyclers, technology suppliers and regulators
- Validation of various treatment systems
- Building capacity in the industry

Printed 2013

For further information visit www.australianwaterrecycling.com.au

Australian Water Recycling Centre of Excellence

Supported by the Australian Government through the *Water for the Future* initiative.