Australian Water Recycling
Centre of Excellence

A national framework
for validating water-recycling technology

# Validating biological treatment systems

based on Street map 4

**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 biological treatment system?

Biological treatment systems use microorganisms, predominantly bacteria, to treat wastewater. Most systems reduce the levels of:

- biodegradable organic matter (such as parts of dead plants or animals)
- nutrients such as phosphorous or nitrogen
- solid particles
- pathogens (microorganisms that cause disease).

If wastewater contains oxygen, microorganisms grow and reproduce by using energy from organic matter ('oxidation'), which they break into carbon dioxide, water and other waste products. This cleans the wastewater of organic matter.

Five common biological treatment systems are briefly described below.

### Activated sludge

In oxygen-rich wastewater, microorganisms grow into floating clusters. The clusters also trap particles, including pathogens, floating in the water, then settle to the bottom as a layer of 'sludge', leaving cleaner water above.

Photo sourced from SA Water

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## Extended oxidation or surface aerated basins

Aerators installed on the surface of a pond or lagoon mix air into the wastewater. As organic matter is broken down by bacteria and microorganisms, the biological oxygen demand (an indicator of organic matter pollution) decreases.

## Anaerobic systems

Some microorganisms can break down organic matter into energy for themselves in the absence of oxygen in the water. This process generates waste gases, such as carbon dioxide and methane.

## Trickling filters

When wastewater is trickled over a fixed bed of material (such as rocks), a film of microorganisms (biofilm) grows on the material. Organic matter in the wastewater is broken down by the biofilm as it passes over the filter bed.

## Lagoons/ponds

Using lagoons/ponds to treat wastewater allows more time for solids and organic matter to settle, and be broken down by microorganisms. Aquatic plants and invertebrates (such as insects and snails) can live in the lagoons and help with the treatment process.

> "The problems with the current arrangements indicate there is a clear and pressing need to clarify and harmonise scientific and regulatory approaches and requirements. "

Photo sourced from Mid Coast Water

## Current and emerging validation techniques

After wastewater is treated by biological treatment systems, plant operators typically monitor the levels of biological oxygen demand, solids and nutrients (ammonium, nitrate, nitrites, total nitrogen, phosphate, total phosphorous).

Operators may also monitor the ability of a treatment process to remove contaminants based on the level of pathogens and micropollutants before and after treatment. However, maximum removal capability of a treatment may be difficult to determine if pathogens and micropollutants are totally removed by the treatment process. This can lead to an underestimation of the treatment capability of a process.

Due to the difficulty in challenge testing biological treatment processes, the following methods may be used:

- Computer modelling – data about the water, chemical processes, and microorganisms are put into a model that predicts how, and how well, the water is treated. This method is used for activated sludge systems, anaerobic systems, trickling filters, and lagoons and ponds.
- Automated image analysis – images of water samples are analysed to find problem-causing microorganisms. This method is used for activated sludge systems.

### Two additional methods are being investigated:

- A more effective tool to predict pathogen levels – the principal components regression approach combined with neural nets.
- A continuously updated spreadsheet of pathogen levels – using Palisade's Neural (a spreadsheet-based tool) to automatically and continuously monitor physical and chemical characteristics of water.

## Validation limitations and difficulties

Validating the activated sludge process can be difficult for a number of reasons:

- Water is treated over a long time, from hours to days.
- Pathogens die in a variety of ways and over different times.
- What is happening in the water (for example, exact pathogen or chemical characteristics) at any one time is different from other times—a situation known as lack of a 'steady state'.
- Measured pathogen levels can vary a lot either in the incoming or outgoing water.

A difficulty with using computer models to validate a biological treatment system is that they do not take into account how the system removes indicator organisms (microorganisms that operators measure to estimate how much actual pathogen has been removed).

The data used by the water industry for risk management of pathogens for biological treatment systems was mostly collected 10 to 40 years ago. Current guidelines rely on published data which use different types of microorganisms.

Another difficulty arises in that molecular techniques, although they give more sensitive and faster measurements for water treatment, are not used routinely. They also provide no information about the viability of microorganisms. This can be important when assessing technologies that inactivate rather than remove microorganisms.

The way that pathogen removal is presented can also cause difficulties in validation. Peer-reviewed literature talks about percentages. Guidelines and reports use the $\log_{10}$ measure, reported as log reduction values over a process. But a percentage removal or log removal of a high concentration of disease-causing microorganisms in the incoming water can still leave the treated water with an unacceptable concentration of microorganisms. Numbers of actual microorganisms also need to be reported, particularly in the final product water.

Photo sourced from Seqwater

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## Research Gaps

There are gaps in knowledge about how biological treatment systems should be validated, and whether they are able to be validated accurately. The project has documented two activated sludge case studies which illustrate a useful way to validate a biological treatment system.

The people who know most about validating biological treatment systems are the plant operators and managers. This is one of the reasons that information about validating these systems is not contained in peer-reviewed journals. A survey of people at a wide variety of treatment plants should reveal how biological treatment systems are currently validated.

Photo sourced from Seqwater

## Recommendations

Much of the information on biological treatment systems may already be available from organisations and operators.

- An online survey followed by face-to-face/telephone follow-ups with plants using biological systems, as well as recycled water plants under construction or planned to establish how operators currently validate these systems and against which regulation requirements. This could create an inventory of existing validation data and studies, and inform development of guidelines.

  A suitable process needs to be developed to analyse how appropriate each chemical or microorganism measure is for validation. Data on correlating contaminant removal with operational conditions suitable for online testing is required, as well as baseline effectiveness levels of biological systems in removing pathogens and chemicals.
- Undertaking test studies over 12 months in various Australian locations could help to confirm understanding and fill knowledge gaps, including determining pathogen and indicator levels in untreated and then treated wastewater. Data could be compared with operational factors to determine which best correlate with reductions in microbial levels.
- Study how biological systems are affected by extreme events and daily flow changes, and how operators can check effects using online monitoring.

Based on these recommendations, a set of guidelines could then be drafted. That information should also be fed back to participating organisations.

## 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

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Australian Water Recycling Centre of Excellence

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