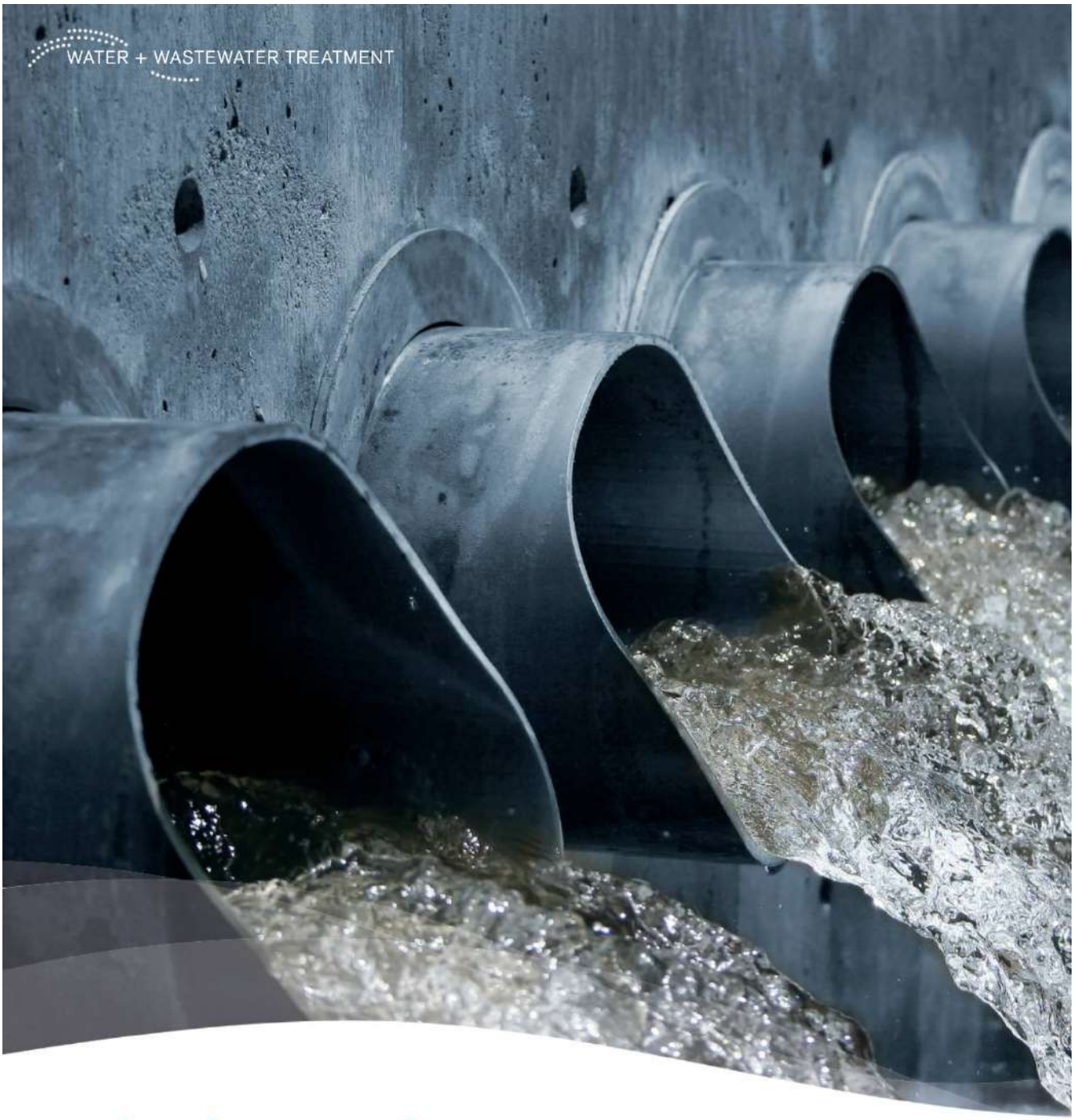

The future of wastewater in a circular economy

By Peter Hillis, Technical Director, pH2O Consulting; Professor Bruce Jefferson, Cranfield University; Professor Felicity Roddick, RMIT University; and Associate Professors Dr Kalpit Shah and Dr Linhua Fan, RMIT University

For more than 100 years, industry has relied on a combination of aerobic and anaerobic processes to treat domestic wastewater.

This approach has served the water industry, the environment and public health needs well. In the new paradigm of reduced energy, however, emissions reduction and resource recovery makes the future of wastewater look very different from the past.

The concept of the circular economy (CE) is one that is based on maximising the time that products remain in the economic cycle through recycling, re-using, repurposing or transforming into new and useful products, with the ideal being a waste-free, emissions-free and energy-neutral economy. In this article, we discuss how rethinking our approach to wastewater treatment, within the constraints of market-ready technology, can open up the opportunity to identify a clear vision of a circular approach to wastewater treatment and how this can be integrated into the strategic planning of future asset renewals.

The concept of the CE to wastewater treatment is not new, with plenty of examples of the production of valuable by-products from wastewater treatment, such as biogas and biosolids, being well established. Further, the production of recycled water from sewage has a long history and bright future, with regulators in the United States enabling direct potable use as part of a climate-resilient water strategy.

With so many advances in wastewater treatment, the question is, where to next? One of the biggest challenges is how to reduce Scope 1 (or direct) emissions from the mainstream treatment by reducing nitrous oxide production. This is pushing wastewater away from the traditional aerobic approach and more towards a purely anaerobic mainstream treatment. Again, this is not a new concept, with the Western Treatment Plant in Melbourne using anaerobic pre-treatment at the hundreds-of-megalitres-per-day scale. The challenge with this approach is dealing with nutrient removal, and what existing cost-effective technology exists to remove nitrogen and phosphorus in a sustainable manner without the production of harmful by-products.

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So, what would the next generation of wastewater treatment plants look like? And how do we get there in a short time frame? The time for new inventions and new technology may not meet the time frames needed – so how do we put together a process concept that both reduces emissions, is energy neutral and maximises resource recovery? Melbourne Water understood this challenge when they challenged the global water community to help them meet their emissions reduction target of zero by 2030 through their Scope 1 Emissions Innovation Competition.

Melbourne Water has the two largest wastewater treatment plants in Australia – the Eastern and Western treatment plants – hence adopting radical changes to how wastewater is processed is a challenge dominated by the sheer scale of operation. In order for Melbourne Water to meet its zero emissions target, a pragmatic approach to identification of technical solutions has to be taken. Technologies with a high technology readiness level (TRL) are desirable, and those with a proven track record are preferable. The legacy assets, land availability and near neighbours all influence what the level of acceptable risk is. Further, the integration of new technical solutions within an existing asset base presents further process and civil engineering challenges. Finally, the capital costs of doing anything at this scale will always draw attention and scrutiny to the cost benefit of the project.

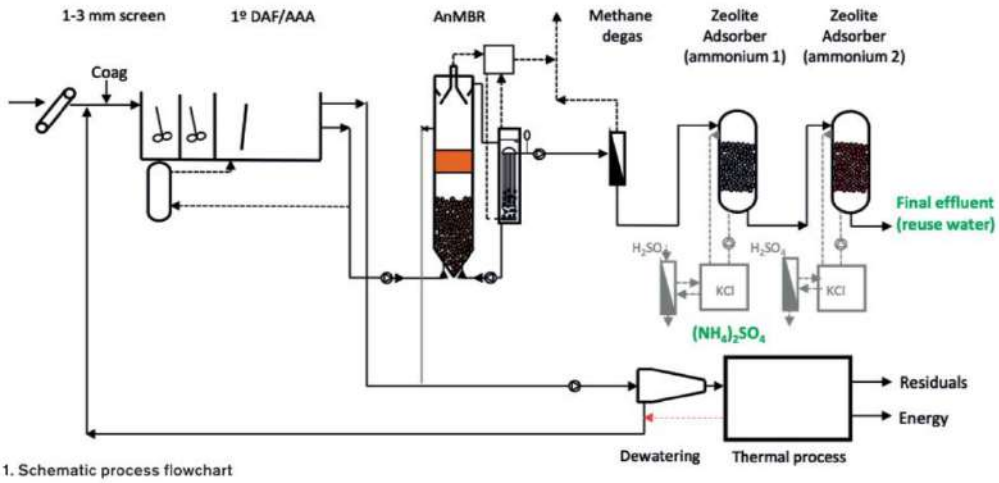

Figure 1. Schematic process flowchart

The approach we – as the team which won the Innovation Competition (pH2O Consulting, RMIT University, Cranfield University) – took was to put together existing proven or near-market technologies and combine them to develop a concept that maximised resource recovery, was energy-positive, enhanced recycled water opportunities and reduced Scope 1 emissions by up to 95 per cent. We proposed the use of enhanced primary treatment technology to maximise the capture of high-calorific-value solids and the subsequent use of thermal processing, such as gasification, to maximise energy recovery, and minimise solid waste volumes and the production of a high-value biochar. An anaerobic membrane bioreactor will be deployed to remove the remaining organic carbon, provide excellent pathogen removal and provide a barrier to microplastics. Finally, enhanced zeolites will be used to remove ammonia and recover the nitrogen in the regeneration process as a fertiliser. We also aimed to eliminate troublesome side streams or recycle streams that return concentrated waste to the inlet works. Figure 1 depicts that we are returning only the cent rate from the dewatering of primary sludge, which in essence will be a dewatered version of the raw sewage with little or no change to the liquid quality, other than residual polymer from the centrifuge operation.

The process concept developed strives to meet the needs of a circular economy in that it aims to minimise the production of non-value by-products, while being energy positive. We recognise the challenges to demonstrate the total expenditure (TOTEX) efficacy of the concept and are looking forward to a staged approach to proving the concept and confirming the assumptions we have made.

There will always be challenges and obstacles in trying to achieve full circularity in an economically acceptable manner, and the emerging threats to the re-use of sewage-derived products from recalcitrant chemicals of concern, microplastics and emerging pathogens all need careful consideration. We have started on a journey with Melbourne Water that we hope will benefit the wider water community in being responsible custodians of the environment. We have responsibility for – and ensure that – our legacy for the next generation will give them the opportunity to make further technical advances and appreciate the efforts we made.