

Water reclamation

Water – precious resource to be used again, and again and again...

What do Beaufort West residents, Bill Gates and the International Space Station's astronauts have in common? It sounds like the setup of a corny joke, but in all seriousness the answer is ... they have all drunk 'reclaimed' water that has been produced by removing all the impurities in treated wastewater to ensure it meets drinking water quality standards. Article by Sue Matthews



The Omni Processor is being piloted in Senegal, where it will convert solid waste from pit latrines into drinking water.

In the International Space Station, a water-recycling system with approximately 85% recovery treats urine, kitchen wastewater and condensate to supply the astronauts with water for drinking and food preparation. The system, which uses distillation technology, an absorption bed and a catalytic oxidation reactor, cost US\$250 million and has been in operation since May 2009.

Last November, Bill Gates demonstrated his support of the Omni Processor – a sewage and water treatment machine

developed by Janicki Bioenergy with funding from the Bill & Melinda Gates Foundation – by drinking a glass of its reclaimed water. The container-sized machine was designed to provide a drinking water supply for communities without access to safe water and sanitation, and is being piloted in Senegal this year. Sludge from pit latrines is boiled to kill pathogens and generate water vapour, which passes through several filters before being condensed back to water for further treatment. The pilot model, which costs about \$1.5 million, can process 12.3 cubic metres of

sewage sludge and produce 10 800 litres of drinking water per day.

"The water tasted as good as any I've had out of a bottle," wrote Gates in his blog. "And having studied the engineering behind it, I would happily drink it every day. It's that safe."

Beaufort West bears the distinction of having South Africa's first direct potable reuse (DPR) plant, where treated wastewater effluent is conveyed directly to a water treatment facility for further treatment to drinking water standard.

It was built in 2010 when the town's main water supply, the Gamka Dam, dried up during a drought. Emergency relief funding from National Treasury covered the construction costs of about R24 million, and the plant became operational in January 2011. In June of that year, the drought was broken by a cut-off low that caused widespread flooding in the central Karoo and Garden Route. The Gamka Dam began refilling and reached 100% capacity by September, but the DPR plant continued operating nevertheless.

"From the outset the intention was always to blend no more than 30% reclaimed water with either surface water or borehole water, or a mix of the two," says Chris Swartz, a consulting engineer who chairs the Water Institute of Southern Africa's water reuse division. "Even when the dam filled, they kept the reclaimed water component at about the same level. The area has a very low annual rainfall, and in March of this year the dam was only 9% full, so the reclaimed water is still needed."

The towns of George and Mossel Bay also built water reclamation plants during the drought, but each took a different approach. The George plant

is an indirect potable reuse (IPR) plant, where the treated wastewater effluent is discharged to the Garden Route Dam for dilution and storage before it is piped to the water treatment plant for further treatment. In this case the reclaimed water replenishes the surface water supply, but in some schemes – for example in El Paso, Texas and Orange County, California – it is used to recharge groundwater that is subsequently extracted and treated to drinking water standard. Of course, the discharge of treated effluent from wastewater works into rivers, followed by diversion of river water to water treatment plants downstream, represents 'unplanned' indirect potable reuse, which happens the world over.

The Mossel Bay plant involves water reclamation for industrial purposes only. Final effluent from the regional wastewater works is treated further to provide the high-quality water needed for the PetroSA refining process. A similar scheme had already proved successful for the eThekweni Municipality, where the Durban Water Recycling Project was undertaken as a public-private partnership. The treatment plant was commissioned in May 2001, and to date the two largest customers for its

high-quality but lower-cost water are the Mondi Paper Mill in Merebank and the Sapref Refinery owned by Shell and BP.

Many other towns and cities recycle the final effluent from wastewater treatment works by making it available for industrial purposes or for irrigation of agricultural crops, golf courses, sports fields and public open spaces. This water is generally not treated further to bring it to a higher standard, but many of the advantages of water reclamation still apply. It conserves the available water supply, which reduces the need to abstract more water from surface or groundwater sources, or build new dams or interbasin transfer schemes, all of which have environmental and financial costs. It also reduces the volume of treated effluent discharged back into aquatic systems, where it may degrade natural water quality and cause the ripple-effect of ecological changes associated with nutrient enrichment.

But while recycling of wastewater effluent and advanced treatment for industrial purposes are often cheaper alternatives than using the normal potable water supply, water reclamation for drinking purposes is considerably more expensive. Australia's much



Bill Gates chats with Omni Processor's developer, Peter Janicki, after tasting its water.

Gates Notes

lauded Western Corridor Recycled Water Scheme, which collected effluent from six wastewater treatment plants in Brisbane and processed it at three advanced water treatment plants to augment the city's main drinking water reservoir, was mothballed in August 2013 because it was costing so much to operate. Authorised by the previous state government during a drought, the scheme was labelled an 'unmitigated disaster' by the then Water Minister. It is costing Queensland Aus\$150 million per year in interest repayments.

The cost of installing new pipelines and pumps is just one of the many factors to take into account when considering the implementation of direct or indirect potable reuse systems. Another is the quality of the feed water, because this will determine whether the more advanced treatment technologies are required, resulting in higher capital and operating costs.

In a recently completed WRC-funded project (K5/2119), a decision-support model aimed at assisting municipalities and water boards to evaluate, compare and select appropriate reuse systems was developed. Since cost is inevitably one of the most important selection criteria, a costing model called REUSECOST was developed in addition to the main REUSEDMS.

Potable reuse plants employing reverse osmosis as a treatment method have high energy costs, because the process relies on high-pressure pumping to overcome osmotic pressure. The Beaufort West DPR plant uses reverse osmosis as part of a multiple-barrier approach that also incorporates rapid sand filtration, ultrafiltration, UV-hydrogen peroxide and final chlorination.

Reverse osmosis also pushes up costs because the highly concentrated brine produced as a by-product is difficult to dispose of.

"If the plant is near the coast it can be discharged into the sea, but there are environmental impacts associated with that," says Swartz, who headed up the project. "If it's inland the options are very limited – it needs to be contained in evaporation ponds that are lined and have a large surface area. It's quite expensive, so that has a big impact on the capital cost of the plant."

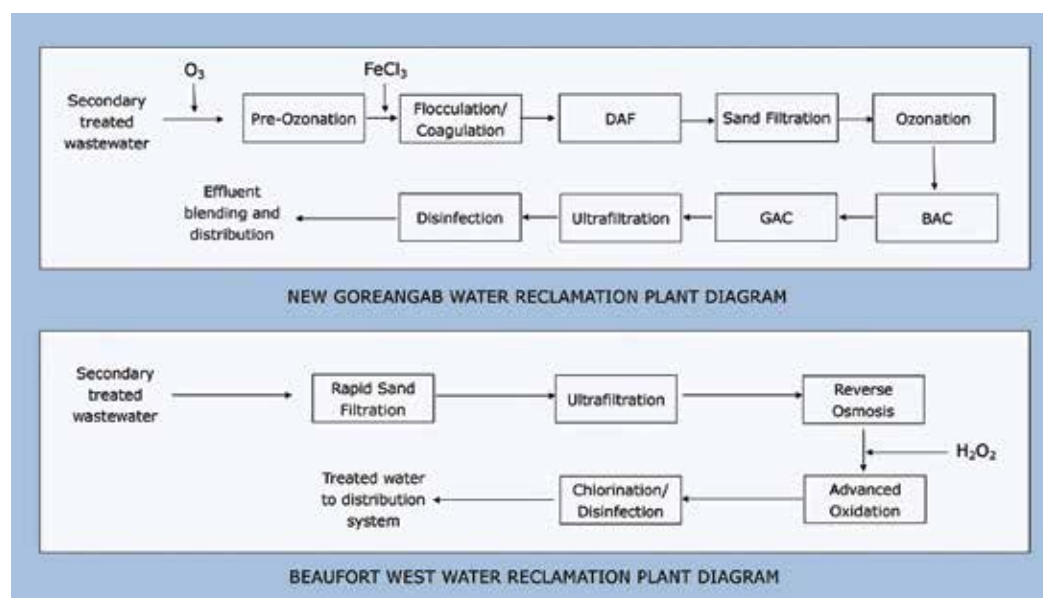
"At Beaufort West there were some extra ponds available at the wastewater treatment works, and fortunately the volumes are reasonably low, but for a bigger plant the cost can be a problem."

The membranes needed for reverse osmosis are also expensive, although prices are coming down all the time as the technology is more widely used. The

Beaufort West DPR plant includes a pre-treatment stage to reduce the loading on the membranes and hence limit the fouling rate, which helps ensure that the membranes last longer before needing costly cleaning or replacement.

But if there are so many negatives associated with reverse osmosis, why use it? The New Goreangab Reclamation Plant in Windhoek – commissioned in 2002 to replace the world's first, but less sophisticated, DPR plant that began operating in 1968 – certainly manages without it, and its capacity is ten times that of the Beaufort West plant. It just employs more 'treatment barriers' to bring the water to potable quality, including a number of ozonation and chemical dosing steps, dissolved air flotation, biological and granulated activated carbon filters, ultrafiltration and chlorination.

The advantages of using reverse osmosis in potable reuse plants are that pathogens, dissolved salts and some dissolved organics can be removed using less chemicals and labour (since the process is fully automated) on a smaller footprint of land. Reverse osmosis is also believed to be more effective in removing so-called contaminants of emerging concern (CECs). These include chemical compounds from pesticides, flame retardants, plasticisers, pharmaceuticals and personal care



The treatment processes used at the New Goreangab Water Reclamation Plant and the Beaufort West Reclamation Plant.

products, amongst others, which may be carcinogens, endocrine disruptors, or toxins that cause neuro-developmental defects.

Some CECs are still detected in the final water of both reverse osmosis and granulated activated carbon based treatment works, albeit at extremely low concentrations. In a WRC project (K5/2369) undertaken by Chris Swartz Water Utilisation Engineers in collaboration with the CSIR and the University of the Western Cape, a priority list of CECs in reclaimed potable water in South Africa is being developed, and guidelines for appropriate treatment barriers and monitoring programmes recommended.

It would be impossible to measure the concentrations of all possible CECs, because there are hundreds of them and detailed chemical analysis of water is expensive. Bioassays, which measure biological activity, and surrogate compounds, which suggest the presence of related CECs, are used instead. For example, the Enzyme Linked Immuno Sorbent Assay (ELISA) is widely used to measure the human hormone 17-beta estradiol, the most potent estrogen and a surrogate for other endocrine disruptors. Carbamazepine, an anticonvulsant and mood-stabilizing drug used primarily in the treatment of epilepsy and bipolar disorder, is one of the surrogates that could be used to indicate the presence of other pharmaceutical drugs.

Of course, some of the CECs in reclaimed water can be limited by keeping industrial effluents out of the wastewater treatment works, which is the approach taken in both Beaufort West and Windhoek. Last year, Windhoek opened its new Ujams industrial wastewater treatment plant, replacing an older plant that could no longer cope with peak effluent flows from the industrial zone. Although the plant cost R125 million, it ensures that industrial pollutants that may be difficult to remove or require costly treatment processes are largely absent from wastewater destined for the New Goreangab Reclamation Plant.

The project on CECs builds upon another WRC project (K5/2212), which developed guidelines for a holistic monitoring programme in potable reuse systems. This would involve not only compliance monitoring of the final water, aimed at protecting human health, but raw water monitoring of the incoming wastewater effluent and operational control monitoring of each treatment unit's performance too. The latter requires the selection of appropriate indicative parameters that will be measured either by regular sampling or by automatic instrumentation with built-in alarms or shutdowns if results are outside the acceptable range.

There can be no 'one size fits all' monitoring programme because water reclamation plants have different process configurations, feed water and possibly even different standards for final water quality. But the recommendations emanating from the project will no doubt assist the Department of Water and Sanitation in developing guidelines and standards for water reuse, and in incorporating the necessary monitoring into the Blue Drop and Green Drop programmes.

"Water reclamation is well recognised as an alternative to conventional water supply strategies," says Dr Nonhlanhla Kalebaila, WRC Research Manager, who oversees the water reuse projects. "However, its wide implementation in South Africa needs to be fast-tracked by building the required technical capacity in the water sector, and providing clear institutional leadership and financial incentives towards water recycling, reclamation and reuse. In addition to these specific factors, there is a need to educate, raise awareness and involve the public in water reuse decision-making, in order to change their perceptions and circumvent challenges with recycled water acceptance."

Indeed, the 'yuck factor' – consumer resistance to drinking what was once domestic wastewater – is the major challenge to overcome. But implementing a comprehensive monitoring programme, effectively

communicating the results, and raising awareness about the benefits of water reclamation can go a long way towards building the public's trust in water service providers and allaying fears about health risks.



Chris Swartz with students on a visit to the Beaufort West water reclamation plant.



The Beaufort West reclamation plant.



The low level of the Gamka Dam illustrates the importance of reclaimed water in Beaufort West.



Treated effluent from Beaufort West's wastewater treatment works passes through maturation ponds before entering the reclamation plant.