WATER REUSE

Sipping the light fantastic - Demonstration project reveals more about the potential for water reuse

Direct potable reuse promises a top-up for our scarce drinking water supplies. A report on a new demonstration project is encouraging, but there's still work to do. Matthew Hattingh reports.

During commissioning it was noted that the pumps feeding the Granular Activated Carbon GAC filters were too small and this caused the GAC pumps to trip often. This was subsequently corrected.

A delightful beer ad on British television in the '80s, parodied *My Fair Lady*. In it a posh young woman battles with elocution lessons, making no progress until offered a can of Heineken. Crack, hiss… a single sip does the trick. Instantly shedding her cut-glass accent, she pours out her lines in the desired Cockney, to her tutor's delight. "The wa'ah in madge orca don't taste like wot it or'ah." (The water in Majorca [Mallorca] don't taste like what it ought to.)

Some things can be hard to get your tongue around (or swallow) without some help. We've long been able to treat wastewater to a high (drinkable) standard but have yet to acquire an appetite for it. Direct potable reuse is about treating wastewater to a potable standard and then putting it to good use directly, rather than discharging it into the environment.

In South Africa, finite water supplies are overstretched by a growing and increasingly urban population; demand from industry and agriculture is rising; while rainfall, particularly in the west of the country, is low. Droughts are frequent and evidence suggests climate change will worsen matters, while our water sources are being contaminated at a "deplorable and unsustainable rate".

Treating wastewater for direct reuse reduces demand on surface water. It cuts the amount of waste we discharge into our rivers and seas.

Over the past 15 years a handful of direct reuse projects have been brought into service in South Africa, including in Beaufort West and south Durban, where residential and industrial wastewater, treated to near-potable standards, supplies a Mondi paper mill.

But there's still much to learn. With this in mind, uMngeni-uThukela Water commissioned a direct potable project, an extension of its Darvill Wastewater Treatment Works in Pietermaritzburg, which was undergoing a major upgrade. This demonstration project is a way for the water utility, others in the sector and academics, to learn how to squeeze more out of the technology, and identify areas needing attention or research. As a bonus, it slashes the wastewater plant's municipal water bill.

President Cyril Ramaphosa and the then Minister of Water and Sanitation, Senzo Mchunu, opened the Darvill upgrade in July 2023. They were photographed hoisting beakers in a toast – if not actually chugging back – the sparkling SA National Standards 241: 2015 potable stuff. It was a moment to savour for uMngeni-uThukela Water staff. They surmounted formidable difficulties and delays bringing the upgraded wastewater works and the 2-megalitres a day reuse project on stream.

Why this was so and how the plant's technical and contractual hurdles were cleared is the subject of a Water Research Commission publication (**WRC Report No. TT 942/24**). The report, ***A demonstration of treatment technologies for direct potable reuse*** considers the pros and cons of the various processes at the plant. It assesses their effectiveness at removing different microorganisms and chemical nasties from wastewater. And it includes a focus on contaminants of emerging concern, a category that includes pharmaceuticals, pesticides, personal care products, pathogens, trace metals and tiny plastic particles not dealt with in water treatment regulations and standards, that may pose a risk to human and environmental health.

With refreshing candour, the report spells out developmental failures and fixes that could help others building full-scale plants, outlining the costs and benefits of the project over its lifespan. The report is the work of Presantha Maduray, Samuel Getahun, Bavana Maharaj and Kerisha Nayager. All are staff of uMngeni-uThukela Water, with Getahun also wearing a University of KwaZulu-Natal hat.

Beyond the deep dive into the costs and complications encountered, the authors investigated how the reuse project's processes might be improved, including by optimising chemical doses at different treatment stages and tweaking the order of the treatment train. They offered pointers and plans for potable reuse plant operation and maintenance, including contractual issues; safety; assessing risk; water quality monitoring; and engaging with the public.

Begun in 2017, the reuse project is part of the R1-billion upgrade to Darvill, increasing the wastewater works capacity from 65-megalitres to 120-megalitres a day. But early on, the project slammed into a speedbump when the upgrade's main contractor filed for business rescue in March 2019, miring the project in "lengthy delays and legal procedures".

Reuse project construction stalled for about 18 months. Then Covid-19 struck. Work stalled again, procurement bogged down, and technical troubles compounded in the absence of maintenance as idle machinery rusted, pumps and filters sprang

Flash mixing in the high-pressure wash plant disperses coagulants – aluminium sulphate and a polymeric coagulant – in the feed water. This helps suspended particles to clump together.

leaks, flooding damaged equipment and thieves stole cables and fittings. Throughout, loadshedding and outages proved an oversized fly in the commissioning ointment.

The report charts a slew of snags – real and potential. And provides recommendations on how these might be fixed or avoided in future projects.

The ***Water Wheel*** visited Darvill on a drizzly February afternoon. It's a few kilometres east of the N3, down a road that skirts a golf course and passes through grassland and bush, close to a municipal landfill site. It's near the Msunduzi, the uMngeni River tributary that gives its name to the canoe race.

Through the main gate you pass close to reactor basins, big circular secondary settling tanks, and the chlorine scrubber, designed to protect staff from emissions of the gas.
To the north sit four giant concrete eggs – anaerobic digesters which are the works' most visually striking feature. Inside the heated eggs, bacteria break down organic waste in the absence of oxygen.

A little to the north-east, the reuse project is a more modest structure with various filters, pumps and tanks, inside and out. Control room staff monitor the different processes for signs that equipment has tripped or sensor signals (say, for turbidity or chlorine levels) are outside the permitted range. A visitors' centre reflects the project's emphasis on public engagement.

Maduray and Maharaj, both chemical engineers, showed us around. Four distinct, but interlinked, advanced treatment processes produce potable water: advanced oxidation, with hydrogen peroxide and ozone; granular activated carbon filtration; ultrafiltration; and onsite electrolytic chlorination.

Wastewater, which has been through the main works, now of final effluent quality standard and on its way to the Duzi River, is drawn into a high-pressure wash plant. This includes conventional processes of coagulation, flocculation, lamella clarification and rapid gravity filtration. Coagulation uses aluminium sulphate, a positively charged aluminium salt, as well as a polymeric coagulant, to draw suspended particles together, to clump and settle. Lamella clarification uses a series of inclined plates to make settling more space efficient. Layers of coarse and fine sand provide rapid gravity filtration.

The advanced treatment sequence is designed to be swapped around – and will be the subject of future research to evaluate results. For now, the treated wastewater is first exposed to advanced oxidation. Strong oxidants, hydrogen peroxide and ozone, oxidise organic and inorganic compounds in the wastewater transforming pollutants into less toxic products. Ozone is generated on site.

Next, the activated carbon process uses a porous, sponge-like form of granular carbon as a filter media through which the contaminated water passes. Thereafter, ultrafiltration forces wastewater through membranes, sieving out successively smaller particles. Onsite electrolysis generates chlorine for disinfecting the final water.

Advanced oxidation can remove more than 95% of antibiotics, hormones and industrial chemicals; 80% of pesticides; and 50-80% of pharmaceuticals and metabolites. Unfortunately, the proprietary, "black box" technology used for this process was out of action at the time of our visit, awaiting repair by the suppliers.

The anaerobic digesters, the Darvill works' most visually striking feature. Inside the heated eggs, bacteria break down organic waste in the absence of oxygen.

Treated water, the end product of the reuse project, is stored in a 600 000-litre reservoir for supplying process water to Darvill Wastewater Treatment Works.

The granular activated carbon filters absorb organic matter and the ultrafiltration can eliminate several types of contaminants of emerging concern: more than 90% of antibiotics, hormones, pharmaceuticals, metabolites and industrial chemicals; and 80% of pesticides.

The different processes have their pros and cons. Membranes can foul and ultrafiltration requires considerable pressure, meaning bigger electricity bills. Advanced oxidation process chemical reactions also draw power. Maintenance can be complex, requiring specialist outside contractors. The downtime and expense this entails must be weighed when selecting processes. Then there's the costs of the chemicals used in treatment.

Understanding how the different processes cope with different source-water contaminants – which vary from one wastewater works to another – can help with selecting the most suitable process, says the report. The report is clear: Advanced water treatment with its hi-tech equipment and operating costs is "often more expensive than conventional water treatment methods". But Maduray says rands and cents were never the project's main consideration. It's about learning to use the technology – "it's not plug and play" – and honing processes so the utility and others in the sector are sharp, "ready to go" when necessary.

The authors priced the reuse project at R155-million over a 20-year lifecycle. However, their analysis leans heavily on estimates and assumptions. Delays and difficulties during commissioning meant comprehensive operational data, ideally captured over six months to a year, were not available. It was also difficult to nail down the energy costs of the different processes in the absence of dedicated metering for the reuse project. Similarly, putting a monetary value on the environmental and social benefits of the project is hard to do.

Gauging the effectiveness of the project at removing pollutants from wastewater is central to the study. But it demands testing for microbial and chemical water quality beyond what's required for conventional treatment. The authors identified a bottleneck at uMngeni uThukela's own lab, which is already handling testing work for the utility's operations across KwaZulu-Natal as well as for external clients. Therefore, additional laboratory resources must be planned for.

Capacity constraints are still more acute when it comes to testing for contaminants of emerging concern, which requires advanced techniques. Samples had to be sent to Umea University, in Sweden for analysis, resulting in "significant delays". The study focused on 28 compounds commonly detected in South African wastewater, including antiretroviral drugs, antibiotics, antidepressants, antihistamines, antihypertensives, statins, and anti-inflammatory anticonvulsants.

Maduray says an important lesson was that South Africa must invest in its laboratories, universities and training if we are to analyse contaminants of emerging concern. "If we need to go to reuse, we need to develop this. It must be affordable," she said, adding that research showed the presence of pharmaceuticals in reused water was "people's main worry".

Also key, the project aims to involve and educate a sceptical public who strongly favour using direct reuse water for industrial purposes rather than for drinking. "Public perceptions and community acceptance of direct reuse of treated wastewater remains a challenge to direct reuse," says the report, citing a WRC project (**WRC report no. KV 320/13**). Addressing this will be vital if reuse is to gain wider support.

The authors point out that a single incident could compromise the community's health, with a "high probability of causing the plant's closure in extreme or significant financial losses due to lawsuits". This the report covers in a chapter on developing a safety plan. Public engagement gets its own chapter too, including the establishment of a KZN Water Reuse Chapter, of the Water Institute of Southern Africa. The authors share their findings on forums and at conferences, while the project collaborates with researchers from several universities, "nurturing the next generation of experts".

These engagements help reassure the public about perceived health risk of direct potable reuse, but the report warns that municipalities must first get the basics right. "It is fruitless for local authorities to consider implementing wastewater reuse when existing service levels are low."

The authors plan to present water quality results once sampling and analysis lets them "draw more robust conclusions". "However, based on the available data, the findings thus far are promising," says the report.

Although the ozone generator is offline awaiting repair, the project as a whole is working. The combined processes form a multi-barrier system with "demonstrated effectiveness".

Once through the final process of chlorination, the now-clean water is pumped into a 600 000-litre holding-tank, ready to be used as service water. Your correspondent didn't sneak a sip, nonetheless, we are confident the water has been purged of harmful substances. Indeed, it looked clear and colourless with no odour and there's no reason to doubt it's palatable.

Surely, it tastes like wot it or'ah.