WATER REUSE

Water in a circle: A new guide for towns and cities to save and reuse water

The first studies on recycling contaminated water in South Africa started in the 1960s with a pilot project at the Daspoort wastewater treatment works in central Pretoria. Decades later, however, the country still reuses just 4-5% of water, whereas Israel reuses up to 85% of its domestic wastewater for agriculture. Now a newly released guide for municipalities hopes to encourage safe and responsible water reuse in South Africa. Tony Carnie reports.

The thought of drinking or reusing wastewater that has passed through our homes, offices or industries may remain unsavoury for many South Africans, even when it is retreated and purified to the highest standards. Yet, as the recent water shortage in Cape Town, Nelson Mandela Bay and other major centres has shown, South Africa is running short of water fast. Municipalities will, therefore, have to come up with safe but unconventional alternative plans to ensure supplies for a growing human population and economy, while also allaying safety fears and overcoming the 'yuck factor' associated with water effluent reuse.

To provide guidance on some of the many safety, technical and financial aspects of reusing water, the Water Research Commission (WRC) and the Institute for Municipal Engineers of Southern Africa (IMESA) recently published a new *Water reclamation and reuse guide for South African municipal engineers* (**WRC Report No. TT 882/22**). Led by Cape Town-based water engineer Chris Swartz, the main aim was to develop a comprehensive guide for municipal engineers and to disseminate knowledge on how to plan and implement further reclamation and reuse schemes.

The report notes that the drought-prone city of Windhoek is a pioneer in this field and has been recycling domestic effluent safely for direct human use since 1968. Singapore is another example of a city that recycles large volumes of effluent into high grade water mainly for industrial use – as well as a new craft beer named NEWBrew, which is made by disinfecting sewage water effluent with ultraviolet light and passing the liquid through advanced membranes to remove contaminants.

The states of Texas and California also treat and reuse water effluent indirectly, while several Australian and Gulf region cities have established major desalination or water reclamation plants.

Closer to home, Durban has been recycling sewage plant effluent to drinking water quality for over 20 years (albeit for use by the Mondi Paper factory and Sapref fuel refinery). Now the city is investigating a more ambitious 100 ML/d Remix Plant to blend 50% seawater mixed with 50% treated wastewater.

Struck by severe drought, Beaufort West developed a new water reclamation system in 2011 that is the country's first direct potable reuse plant. With a treatment capacity of 2.3 ML/d, it uses wastewater from the town's effluent treatment plant as its only raw water source.

Drought on the KwaZulu-Natal coast also compelled the Ilembe District Municipality and a private service provider to establish a new recycling plant, with a capacity of 3 ML/d. Commissioned in 2016, the plant supplies reused water to communities in the Ballito area.

Other coastal towns have opted for schemes in which effluents are used indirectly to alleviate potable water shortages. George, for example, treats final effluent from the Outeniqua wastewater treatment plant to a very high quality through ultrafiltration and disinfection, prior to it being returned to the main storage facility, the Garden Route Dam. Mossel Bay commissioned a new 5.5 ML/d water reclamation plant in 2010 to treat domestic effluent for industrial reuse, effectively making more water available for urban potable water supply.

As these examples show, more municipalities nationwide are likely to pursue similar options. And while several scientific studies have investigated this issue in detail, Swartz and his research colleagues note that South Africa has substantial potential to reuse more wastewater for a variety of purposes – not just for drinking, but also for industrial use, agriculture, power station cooling or irrigating public parks, home gardens or car-washing.

Indirectly, this can free up limited freshwater supplies in dams and rivers for direct human use.

Though the first WRC guide for the planning, design and implementation of water reuse schemes was published in 1982, the latest 155-page guide for municipal engineers consolidates previous research and includes several recent case studies, while also setting out the relevant legislation and finance and technical options for new projects.

The guide further notes that in 2013, the Department of Water and Sanitation launched the second edition of the National Water Resources Strategy, which includes a section setting out the department's vision for the implementation of further water reuse in South Africa. Recently, the National Planning Commission also reflected on a national pathway to water security up to 2050 and identified the need for a national facility for research, development, innovation and testing with a focus on water reuse and desalination.

Swartz and his colleagues have further recommended the establishment of a new expert advisory panel for water reuse projects. They note that desalination and reuse projects are relatively new in South Africa, with no long track record of experience. Because there is not yet a comprehensive regulatory framework for reuse, there is still uncertainty on interpretation on certain emerging water quality aspects and monitoring issues.

Water reuse potential in South Africa (2019 figures)

Annual water use, effluent production and water reuse	
Total water requirement	20 045 million m^3/a
Urban / domestic water use	2 170 million m^3/a
Industry / mining water use	1 600 million m^3/a
Agriculture / irrigated agriculture water use	10 221 million m^3/a
Urban / domestic effluent return	1 100 million m^3/a
Water reuse (direct)	50 million m^3/a

Image Supplied

Project leader Chris Swartz samples a glass of purified water from the Beaufort West reuse plant.

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An aerial view of the Windhoek water reclamation plant and Goreangab dam. The Namibian facility, the first such plant in the world, was established in 1968.

Veolia

Windhoek has been reclaiming potable water from municipal wastewater for over 50 years. The newest plant features multi-barrier technology (ozone treatment, ultra-membrane filtration and residual chlorination) to eliminate pollutants and contaminants.

There is also uncertainty on whether reuse should be regulated according to a new local guideline (SANS 241) or the existing World Health Organisation guidelines or a combination of the two. The WRC report suggests the South African advisory panel be made of up 8-10 independent water sector experts, providing inputs on a voluntary basis.

The panel should have an independent chairperson and its findings and recommendations should be binding and have legal status. Its tasks would include providing independent review and critical input on the scope and direction of desalination and reuse projects; reviewing desalination and reuse water quality programmes and making recommendations and comments to clients, regulators, engineers and contractors. (In late August, the City of Cape Town became the first municipality to establish such a panel).

The guide authors also emphasise the importance of ensuring adequate skills, training and safety measures to safeguard the quality of reused water as this often incorporates more advanced treatment processes and technologies compared to conventional surface water and groundwater treatment. "The importance of process controller capability is often underestimated," states the guide, also noting that new employees need to receive sufficient training before being given responsibility for key processes.

The overall operation of treatment trains — including the performance of operators and contractors — has to be supervised by managers with appropriate engineering and quality assurance expertise to prevent harmful microorganisms and chemical constituents from passing into the treated water system.

Due to health risks associated with polluted water it was also essential to incorporate a series of multiple barriers into the treatment process – so that if one barrier failed, there would still be at least two further barriers to ensure water safety. Systems also need to be in place to cope with rare or unexpected events such as:

- Equipment breakdown and mechanical failure
- Prolonged power outages
- Extreme weather events (flash flooding and cyclones)
- Natural disasters (fire, earthquakes, and lightning damage to electrical equipment)
- Human actions (serious error, sabotage, strikes or chemical accidents)

Swartz says public acceptance is critical due to safety concerns, emotional or religious reasons and the 'yuck factor'. "Such projects will not be sustainable (i.e., will fail) if they are not based on sound scientific and engineering knowledge and principles . . . Public and stakeholder concerns can be very powerful and can mean the difference between acceptance and rejection of recycled water schemes.

"The aim of consultation needs to be to arrive at a sustainable outcome rather than to seek acceptance of a system preferred by its proponents. Informed deliberations need to include complete information on the status quo, the full range of alternatives available, and the costs and risks associated with each of these alternatives."

Swartz quotes a recent survey which found that South Africans across all demographic groups have poor knowledge and understanding of the basic terminology needed for a meaningful public discussion on water reuse. For example, only 35% of South Africans knew that 'greywater' was the term for wastewater from bathing, washing clothes and dishes and only 28% knew what 'potable' water meant.

Nevertheless, the survey indicated that around 48% of South Africans would support water reuse in a severe drought situation, including direct reuse in drinking water.

Quite apart from the need to remove salts, faeces, urine, toxic heavy metals and other substances, more recent research has identified a variety of contaminants of emerging concern (CECs). CECs are not yet regulated in South Africa, but it is believed that the most important types of chemicals indicators or surrogates will be included in future SANS 241 versions or in formal guideline documents of the Department of Water and Sanitation.

PUB Singapore National Water Agency

Singapore has become a world leader in the water reuse arena through the development of a multiple-barrier water reclamation process known as NEWater. The three-stage process involves microfiltration and ultrafiltration, followed by a second stage of reverse osmosis and a final tertiary stage of ultraviolent disinfection capable of killing both bacteria and viruses.

Chris Swartz

Reusing water treated with advanced technology can free up limited freshwater supplies in dams and rivers for direct human use.

These dissolved organic constituents include low concentrations of a wide range of organic chemicals from industrial and domestic sources (micro-pollutants). Examples include pharmaceuticals and personal care products pesticides, preservatives, surfactants, flame retardants, disinfection by-products and chemicals released by humans such as dietary compounds and steroidal hormones.

In the 1990s, steroid hormones in wastewater were linked to ecological impacts in lakes and rivers. There are now well over 1 000 research articles documenting the presence of trace chemical constituents, such as per- and polyfluoroalkyl substances (PFAS), in aquatic ecosystems impacted by human populations worldwide.

However, international studies have shown varying results on the removal efficiency of CECs using conventional wastewater treatment processes alone. A recent study in South Africa also showed variable removal efficiency (from 0 to 100%) for certain endocrine disrupting chemicals (EDCs) though activated sludge processes were found to be more efficient than biological filtration systems.

"The available data is sufficient to confirm that there is reason for concern, as EDCs are discharged into water resources and evidence of endocrine disruption in the aquatic environment is undeniable. However, more research is needed to relate the operating conditions in a plant to the removal efficiencies for the different EDCs."

Adequate funding and proper financial management will also be critical, says the report, especially considering the advanced nature of some of the newer treatment technologies. These include ultraviolet light radiation (UV) technology, which penetrates the cell wall of a pathogenic organism, destroying the cell's ability to reproduce.

Advantages of the UV process include a high disinfection efficiency against a wide range of microorganisms including chlorine resistant ones. It is considered environmentally safe, compared to chemical disinfection technologies, with no by-products or danger of overdosing.

Chris Swartz

The Wellington wastewater treatment works.

The UV disinfection process only takes 1-10 seconds. There is no corrosion of process equipment and the systems are compact and easy to operate. Other options include reverse osmosis (RO) which is used for desalination, or nanofiltration (NF) which removes very small organic compounds. However, RO membranes are prone to fouling, so adequate pre-treatment is required to ensure optimal performance.

In the US, some plants are now evaluating alternative treatment trains such as Ozone-BAF, which do not produce a brine stream. However, one of the potential disadvantages of using ozonation in direct potable reuse is the formation of bromate, which is a disinfection by-product formed during ozonation that has been shown to have health risks.

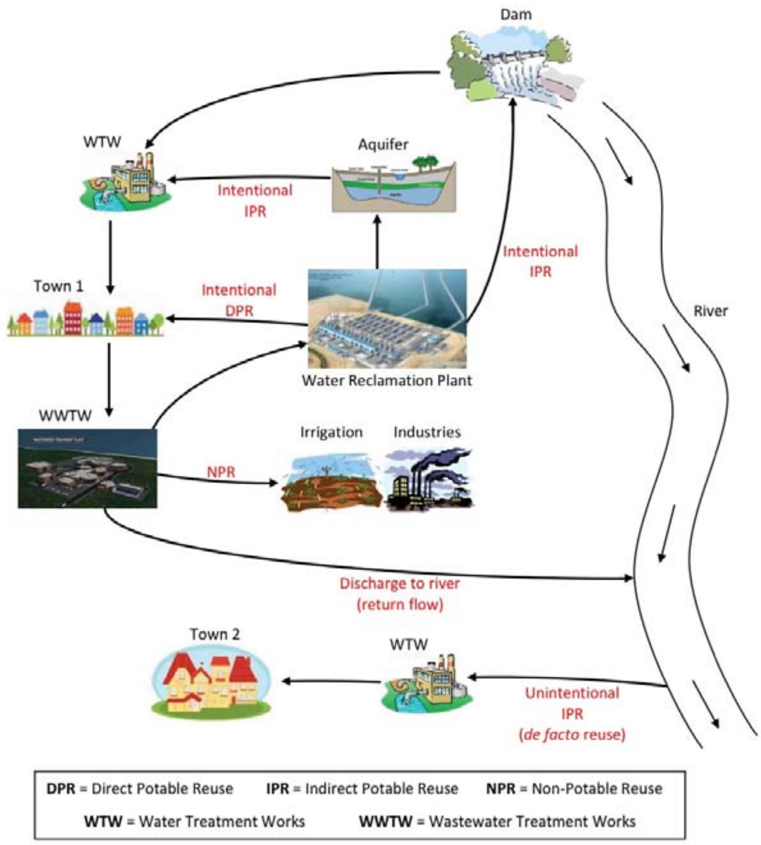
The report by Swartz and his colleagues also emphasises the need for careful planning and evaluation of different treatment options. The revenues from water rates should also be adequate to cover annual operating, maintenance and repair costs.

Because energy is one of the largest operational cost components, water reclamation costs are also very sensitive to changing energy prices. Poorer quality feedwater also requires more advanced treatment technologies, resulting in higher capital and operating costs.

Another critical consideration in water reuse concerns the environmental impacts, especially the disposal of waste streams into rivers or the sea and energy consumption from pumping. On the plus side, advanced water reuse can reduce the flow of pollution from wastewater discharges, while also reducing demand on scarce natural resources or the need to build new dams.

Nevertheless, the main impact is the discharge of concentrated waste streams, brine and other residuals to the environment and disposal options therefore require strict control.

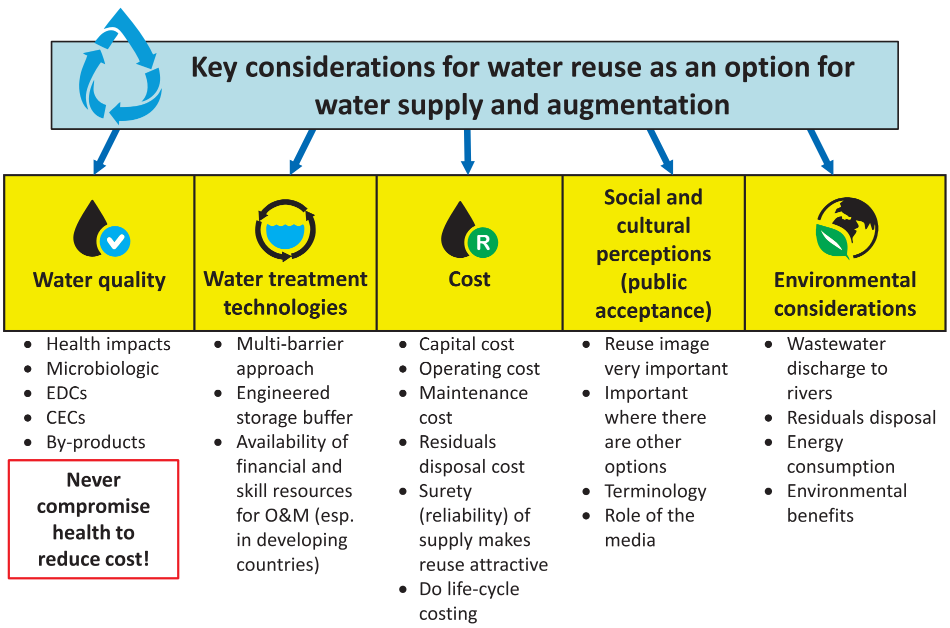
Swartz et al 2013



Different types of water reuse.

The project team was led by Chris Swartz of Chris Swartz Water Utilisation Engineers reporting to WRC Research Manager Dr Nonhlanhla Kalebaila. The other team members were Jurgen Menge (Innovative Research for Water Solutions) Prof Kobus du Plessis (Stellenbosch University and IMESA) and Prof Gideon Wolfaardt (Stellenbosch University Water Institute) The project was funded by the Institute for Municipal Engineers of Southern Africa (IMESA) and the Water Research Commission.

To download a copy of the publication, *A water reclamation and reuse guide for South African municipal engineers* (**WRC Report No. TT 882/22**), Visit: https://bit.ly/3wfiOBv



Key considerations for water reuse schemes as options for water supply augmentation (Swartz et al., 2014). If not treated properly, reclaimed water can act as a possible exposure pathway to a high number of emerging contaminants and their metabolites. The possible presence of emerging contaminants in the final reclaimed water is therefore of critical concern because of potential adverse impacts to human health. (Source: Water Research Commission).