

THE WATER WHEEL

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WATER REUSE

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

WATER CONSERVATION

Savvy showers helping SA's top nature reserve save water

Controlled free distribution

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THE WATER WHEEL is a two-monthly magazine on water and water research published by the South African Water Research Commission (WRC), a statutory organisation established in 1971 by Act of Parliament. Subscription is free. Material in this publication does not necessarily reflect the considered opinions of the members of the WRC, and may be copied with acknowledgement of source.

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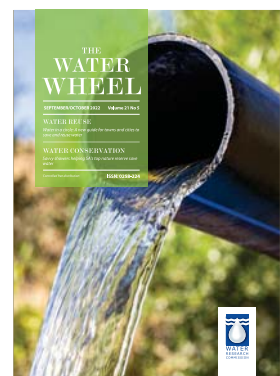
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A new water reuse guide from the Water Research Commission offers municipalities a safe and responsible way to augment their water resources. See article on page 12.

NEWS

New publication celebrates SA water's pioneers, pathfinders and mavericks



South Africa's complex water situation has called on the local water and sanitation community to continuously explore innovative and creative solutions in the country's pursuit of water security for its entire citizenship.

Over time, some of these specialists have risen to become world renowned and award-winning pioneers – doyens who have dedicated their careers to new discoveries, trailblazing a new path towards South Africa's sustainable development. In the process, these thought leaders and innovators have not only steered the South African water

sector in their respective fields but have inspired whole new generations of young water professionals to follow their example. In recent years, their generous mentor contributions have also aided the transformation of the sector.

Now the Water Research Commission (WRC) has profiled 34 of these trailblazers in a new publication, *Legacy – Celebrating SA's water pioneers, pathfinders and mavericks*. The profiles include among others, hydrological modelling and climate change doyen, Prof Roland Schulze; Stockholm water prize winner, Dr Jackie King; indigenous crop torchbearer, Prof Albert Modi; Africa Water Leadership award winners, Prof Alison Lewis; winner of the Presidential Order of Mapungubwe, Prof George Ekama and Dr Thokozani Majozi; and sanitation guru, Prof Chris Buckley, to name a few.

"Many of those featured in this publication started their careers as students on WRC-funded projects. Their tales are truly remarkable, and speak of passion, dedication and hard work," notes WRC CEO, Dr Jennifer Molwantwa, in the foreword of the book. "While all their life

stories might be unique, their goal has been the same – to make South Africa a better place for all who live in it through practical application of water security research, development, innovation and technology."

Not only does the publication capture the profile and career histories of these water and sanitation experts, it also serves as inspiration for younger people interested in pursuing a career in the sector. General learnings from those profiled are captured at the back of the book. "For those students that want to take up the baton and run with it, these stories can serve as a roadmap to follow. Though each one is different, there are similarities that can act as markers along the way for the next generation's journey ahead," notes author Petro Kotzé.

Legacy – Celebrating SA's water pioneers, pathfinders and mavericks (WRC Report no. SP 147/21), is available online at <https://bit.ly/3Qm4FtL> or in free hard copy from orders@wrc.org.za

UP academic wins water prize at SA science 'Oscars'

University of Pretoria (UP) academic, Prof Evans Chirwa, walked away with the NSTF-Water Research Commission (WRC) award during the 24th National Science and Technology Forum in partnership with South32 (NSTF-South32) Awards in July.

Prof Chirwa, a professor and the Rand Water Research Chair: Water Utilisation in the Department of Chemical Engineering, was awarded for his work on 'the introduction into South Africa of the use of biological analogues in advanced water treatment and water recovery with applications in metal-halide heterogeneous photocatalysis'.

Reacting to his win, Prof Chirwa said just being nominated for the award alone had been an honour. "Being nominated for this award by UP was the greatest recognition I'd received since I joined the university. My research group and I are overjoyed by this achievement. My postgraduate students work very hard every day; they are the true winners of this honour. My family supported and encouraged me through the process, and I thank them from the bottom of my heart for the love and support," Prof Chirwa said.

According to Deputy Minister of Higher Education, Science and Innovation,

Buti Manamela, platforms such as the NSTF-South32 Awards are important in recognising the impact of members of the science community. "It does not require a science degree to appreciate the danger of having a scientific community that believes that science much not actively concern itself with the well-being of, or sustainability of human life. We need more socially conscious scientists and innovators. I believe that platforms such as [these awards] are useful in helping us identify and support such scientists and innovators."

Kalahari site points to water-rich periods that attracted early humans

Research on the tufa rock formations on Ga-Mohana Hill in the southern Kalahari has shown that waterfalls, flowing streams and pools once attracted early humans to this dry plateau.

Until recently, most evidence for early human development in southern Africa has stemmed from the country's southern coast.

Evidence of a wetter Kalahari has been published in the journal *PLOS ONE* by University of Cape Town (UCT) PhD candidate Jessica von der Meden of the Department of Geological Sciences and UCT's Human Evolution Research Institute.

Tufa deposits are soft, porous sedimentary rocks composed of calcium carbonate. They are formed by the evaporation of fresh groundwaters that emerge as

springs. The striking tufa formations at the Ga-Mohana Hill archaeological site, 12 km from Kuruman in the Northern Cape, are evidence that water was once abundantly available in the region.

Dating sequences of samples extracted from the tufas show that these rocks were formed during five distinct episodes over the last 110 000 years. Three of these episodes coincide with evidence for human occupation at the rock shelter.

Von der Meden's investigation shows that there are links between human occupation and water availability in the southern Kalahari before 71 000 years ago. Around 20 000 years ago, during the Last Glacial Maximum, this link seems to break down as there are no tufas that date to this time (indicating drier conditions) although human occupation persisted.

The findings are significant because this evidence challenges the thinking that humans occupied these arid regions only during wetter periods, and it may suggest arid-adapted behaviours. "Tufas are not actively forming today. That is really a clue that the environment was different in the past," notes Von der Meden. "We've shown a record of water in the tufas that not only matches the archaeological record but also provides evidence of a crucial resource for the people living at Ga-Mohana. These findings shed light on climate change and the impact of this on human evolution."

* To read the full article, Visit: <https://www.news.uct.ac.za/article/-2022-08-15-kalahari-site-points-to-water-rich-periods-that-attracted-early-humans>

WATER DIARY

Global water sector

11 – 15 September 2022

The International Water Association's World Water Congress and Exhibition will be held in Copenhagen, Denmark.

Visit: www.worldwatercongress.org

Land use and water quality

12-15 September 2022

The fifth International Conference on Land Use and Water Quality (LuWQ2022) with the theme 'Agriculture and the environment' will be held in Maastricht, the Netherlands. LuWQ2022 is an interdisciplinary conference on the cutting edge of science, management and policy to minimise effects of agriculture and land use changes on the quality of groundwater and surface waters.

Visit: <https://www.luwq2022.nl/>

Groundwater

18 – 23 September 2022

The 49th International Association of Hydrogeologists (IAH) Congress on 'Groundwater sustainability and poverty reduction' will be held virtually and in Wuhan, China.

Visit: <http://iah2022.com>

SA water sector

28 – 30 September 2022

The biennial conference of the Water Institute of Southern Africa is taking place virtually and at Sandton Convention Centre under the theme 'Navigating the course'.

Visit: <https://wisa2022.co.za/>

African water sector

19 – 21 October 2022

North-West University is the lead host of the 23rd WaterNet/WARFSA/GWP-SA Symposium. These symposia have been held annually in eastern and southern Africa for the past 22 years to promote interaction among policymakers, academics and practitioners from water and water-related sectors. The event will be held at Sun City.

Visit: <https://www.nwu.ac.za/date/23rd-waternetwarfsagwp-sa-symposium>

Wetlands

25 – 28 October 2022

The National Wetlands Indaba will be hosted by the Free State Wetland Forum (FSWF) and supported by the SA Wetland Society with the theme 'Wetlands action for people and nature'.

Visit: <https://indaba.org.za/>

Municipal engineering

2 – 4 November 2022

The 85th conference of the Institute of Municipal Engineering in Southern Africa will be held at Birchwood Hotel and Conference Centre in Gauteng.

Visit: www.wisa.org.za

Water storage and hydropower

29 November – 1 December 2022

The 4th International Conference and Exhibition on Water Storage and Hydropower will be held in Lake Victoria, Uganda.

Visit: <https://hydropower-dams.com/africa-2022/>

Resource recovery

15 – 18 January 2023

The 8th International Water Association Water Resource Recovery Modelling Seminar will be held in Stellenbosch. Topics will include activated sludge and biofilm processes, advances in sludge treatment and management of solids, resource recovery, separation processes, and aquatic chemistry (including micropollutants of concern), among others.

Visit: www.iwawrrmod2022.co.za

GLOBAL

Healthy environment declared a universal human right



The United Nations (UN) General Assembly has adopted a historic resolution, declaring access to a clean, healthy and sustainable environment a universal human right.

The resolution, based on a similar text adopted last year by the Human Rights Council, calls upon states, international organisations, and business enterprises to scale up efforts to ensure a healthy

environment for all. UN Secretary-General, António Guterres, welcomed the 'historic' decision saying that the landmark development demonstrates that member states can come together in the collective fight against the triple planetary crisis of climate change, biodiversity loss and pollution.

"The resolution will help reduce environmental injustices, close protection

gaps and empower people, especially those that are in vulnerable situations, including environmental human rights defenders, children, youth, women and indigenous peoples", he said in a statement.

The text notes that the right to a healthy environment is related to existing international law and affirms that its promotion requires the full implementation of multilateral environmental agreements. It also recognises that the impact of climate change, the unsustainable management and use of natural resources, the pollution of air, land and water, the unsound management of chemicals and waste, and the resulting loss in biodiversity interferes with the enjoyment of this right – and that environmental damage has negative implications, both direct and indirect, for the effective enjoyment of all human rights.

Millions more children to benefit from world's first malaria vaccine

Julien Harneis



The pharmaceutical company GSK has been awarded a contract by the United Nations Children's Fund (UNICEF) to produce the world's first malaria vaccine so that millions more children will be protected against the killer disease.

The award, valued at up to US\$170 million, will lead to 18 million doses of the vaccine being available over the next three years, potentially saving thousands of young lives annually. Malaria remains one of the biggest killers of children under five. In 2020, nearly half a million boys and girls died from the disease in Africa alone.

Etleva Kadilli, Director of UNICEF's Supply Division, said the rollout sends a clear message to malaria vaccine developers to continue their work. "We hope this is just the beginning. Continued innovation is needed to develop new and next-generation vaccines to increase available supply, and enable a healthier vaccine market," she noted.

"This is a giant step forward in our collective efforts to save children's lives and reduce the burden of malaria as part of wider malaria prevention and control programmes."

Monsoon 'pulls' climate-changing chemicals into atmosphere



While the Asian monsoon brings rain that is vital for the agricultural economy of the vast region, it is also known to suck up into the upper atmosphere chemical pollutants that accelerate climate change.

Scientists are eagerly awaiting the results of a US-led international project that seeks to confirm earlier findings that pollutants generated by human activity get transported upwards by the monsoon system and impact atmospheric chemistry and, in turn, change climate.

Atmospheric chemistry is the study of the components of planetary atmospheres, which includes the troposphere, the stratosphere and other upper atmosphere layers.

Laura Pan is a principal investigator on the project and a scientist at the US National Centre for Atmospheric Research, which is leading the Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP) along with the National Aeronautics and Space Administration

(NASA). "In recent decades, satellites have revealed that the monsoon creates a distinct layer of chemicals about 16 km above the Earth, but we know very little about its composition and evolution," Pan said. "ACCLIP will give us an opportunity to sample what's there, but we know that whatever its composition, it connects to the climate.

The monitoring programme involves scientists from Korea, Japan, Italy and Germany, who will focus on the powerful circulation of the monsoon and sample the chemical pollutants that are pulled upwards into the higher atmosphere where they affect rainfall over Asia in different ways – leading to both droughts and floods.

- To learn more, Visit: <https://espo.nasa.gov/acclip/content/ACCLIP>

Global conservation organisation calls on states to join fight against plastic pollution

International conservation organisation, WWF has commended the move of 20 states to form The High Ambition Coalition to End Plastic Pollution, which will work to ensure the world's first ever plastic pollution treaty includes global rules and regulations for the production, design and disposal of plastic rather than a patchwork of national standards.

This, the Coalition hopes, will be key in securing the elimination of plastic pollution by 2040, just 16 years after the world is set to finalise the treaty in 2024.

WWF calls on remaining UN member states to join the Coalition as it has set ambitious performance indicators of success that can increase the world's chances of swiftly ending plastic pollution. These indicators include global measures such as developing global bans, restrictions and standards for plastics as well as setting global baselines and targets for sustainability throughout the lifecycle of plastics. The Coalition is calling

for a global ban on problematic plastics, which the WWF understands includes unnecessary single-use products.

Such rules and regulations will have an undeniable impact on companies that make virgin (rather than recycled) plastic, as well as those that market products that use disposable packaging. However, the widespread environmental damage that plastic pollution has caused and will continue to wreak globally requires a joint legally binding effort by all nations, common standards for plastic products and increased transparency for how plastic is made and used.

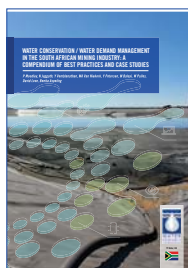
"Ending plastic pollution starts with global leaders acknowledging the destructive lifecycle of plastics. That's why the world agreed earlier this year that we need a global treaty to end plastic pollution. The next step is to get serious about banning problematic plastics such as unnecessary single-use plastics, establishing common standards for plastic production and

regulating greater transparency of the plastics value chain," said Marco Lambertini, Director General, WWF International.

"The High Ambition Coalition is yet again a demonstration of the determination across the world to seriously tackle the plague of plastic pollution. Now we need more states to join!"

WWF envisions a global plastic pollution treaty that, when finalised, would be comparable to or exceeds the accomplishments of the Montreal Protocol, an international treaty finalised in 1989 that successfully phased out the production of harmful substances responsible for ozone depletion. Hailed as the "single most successful international agreement", the Protocol succeeded due to the unprecedented level of cooperation and commitment shown by the international community.

NEW WRC REPORTS



Water conservation / water demand management in the South African mining industry: A compendium of best practices and case studies

Water is a valuable resource and should be treated as such by the mining industry, especially in light of it being a shared resource within a catchment and security of supply will in the future be an important consideration. As a shared resource water can be a key part of providing support for the regional and community growth and development. This can only be done by the efficient use of water and consideration of water conservation / water demand management (WC/WDM) considerations. The Water Research Commission (WRC) commissioned a project to compile a compendium of best practices and technological innovations in the mining industry with regards to WC/WDM. Among others, the compendium presents some case studies of best practices and innovations in the mining industry.

WRC report no. TT 846/20

Web link: <https://bit.ly/3RbW79I>



Guidelines for deep row entrenchment of faecal sludge and secondary wastewater sludge

Deep row entrenchment of sludge can be used to safely dispose of untreated or partially treated faecal material while achieving several benefits, including improved soil fertility and increased agricultural productivity: enhanced growth of timber or other non-edible commercial crops; Food security: improved nutrient value of fruit grown by households and environmental rehabilitation: restoration or enhancement of ecosystems through remediation of poor or disrupted soils and stabilisation of carbon in the soil, thus reducing greenhouse gas emissions. These guidelines are intended to provide a practical framework for entrenchment of both biosolids (i.e. sludge from wastewater treatment works) and faecal sludge (i.e. sludge from on-site sanitation systems) which adequately protects the environment and public health while avoiding excessive measures which could prove prohibitive to the implementation of this method both in terms of costs and time.

WRC report no. TT 880/22 (Guidelines), 2899/1/22 (Main research report)

Web link for Guideline: <https://bit.ly/3KnIhQc>

Web link for Main report: <https://bit.ly/3Ct6cdR>

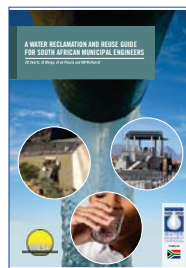
New models for the sustainable operation and maintenance of school sanitation facilities

The lack of functioning school sanitation infrastructure at thousands of South African schools can be attributed to twin causes, first, the backlog of new/replacement school toilets waiting to be built and, second, existing toilets are, in many

cases, not cleaned or maintained adequately and quickly fall into a state of disrepair and become completely unusable. A destructive cycle exists of investment in infrastructure delivery, followed by unsuccessful management of that infrastructure, leading quickly to failed sanitation, which then requires further investment to replace that same infrastructure (in many cases only recently built). Five different models for raising external revenue for sanitation operations and maintenance (O&M) were developed under this study and reviewed with stakeholders working in the sector, including the Department of Basic Education and representatives of private sector entities. The models were based on schools offering a product or service (for example advertising space and access to consumer data) in return for fees. The most promising model is based on a school hosting a free public Wi-Fi hotspot, with Wi-Fi access exposing the user to advertising and/or requiring them to complete a market research survey. A company would own the hotspot and pay for a capped free monthly data package. Additional data could be sold to the public with a small Page mark-up to raise revenue for O&M activities. Companies benefit from advertising with guaranteed views and from collecting consumer data from hard-to-reach markets. Schools benefit from a free WiFi allowance for their own use and from increase funding for O&M.

WRC report no. 3025/1/22

Web link: <https://bit.ly/3cn8TTx>

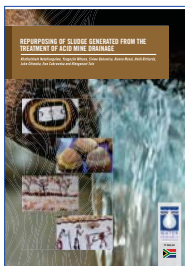


A water reclamation and reuse guide for South African municipal engineers

With South Africa being a water-scarce country, alternate sources of water supply and optimisation are critical. The reuse of water is one of the best solutions in optimising limited water resources. The reuse of water is widely practiced in both developed and underdeveloped countries. Utilising reclaimed water for urban uses like irrigation of parks, golf courses, sport fields, etc. is becoming increasingly critical. Even for certain industrial use, potable drinking water is not necessary for many industries, especially wet industries. To become a more water sustainable country, wastewater reuse is the way to go. The main aim of this project was to develop and compile a guide for municipal engineers, and disseminate knowledge on the planning and implementation of water reclamation and reuse schemes. The project to develop and compile the Guide was jointly funded by the WRC and the Institute of Municipal Engineering of Southern Africa (IMESA). This guide provides knowledge on state-of-the-art practices of all aspects of water reclamation and reuse systems, including process selection, decision-support, planning, design, implementation, and operation, maintenance and management of reuse projects and schemes. These guidelines should support sound decision-making and implementation.

WRC report no. TT 882/22

Web link: <https://bit.ly/3PQbza3>



Repurposing of sludge generated from the treatment of acid mine drainage

Acid mine drainage (AMD) continues to pose a threat to water quality in active and abandoned mining areas globally. Stages of mining development (e.g. active and abandoned) result in the exposure of sulphide minerals (pyrite, chalcopyrite, galena, etc.) to atmospheric oxygen and moisture, resulting in the oxidation of these

minerals (mainly pyrite) and subsequent release of sulphuric acid and potentially toxic trace elements, e.g. Pb, Cu, Zn, Ni and As among others. Chemical precipitation (neutralisation) is the commonly used technique in large-scale AMD treatment plants such as the high-density sludge (HDS) treatment plants where polymeric components are added for flocculation and to densify the sludge. While the treated water, which is usually discharged into streams, contains elevated SO_4^{2-} concentrations, most of the potentially toxic trace are removed through precipitation onto the sludge. The HDS process results in the generation of large volumes of sludge, which poses an environmental challenge in its disposal as it tends to act as a secondary source of pollution. The main aim of the project was to explore the possibility of repurposing sludge produced from AMD treatment.

WRC report no. TT 886/22

Web link: <https://bit.ly/3RdTO5H>



The detection of antibiotic resistance organisms and the development of a qPCR Protocol for the enumeration of ARGs in domestic greywater systems: A case study conducted in Cape Town

The use of greywater is often encouraged, especially during periods of drought. Greywater is highly variable in composition and often contains significant microbial contamination, including pathogenic

and resistant organisms. The risk of infection from pathogens and dissemination of resistant genes present in greywater is considered to be the most significant human health risk associated with greywater use. This project was aimed at detecting and enumerating antibiotic resistant genes (ARGs) in domestic greywater systems, and to assess whether these systems can support the growth and proliferation of resistant organisms. The specific objectives included determining whether domestic greywater is a source of antibiotic resistance genes and pathogenic organisms; enumeration of ARGs in various greywater sources using qPCR; water analysis to measure the levels of antibiotics present in greywater; and the development of novel FACS assays to screen for ARGs from environmental samples.

WRC report no. TT 891/22

Web link: <https://bit.ly/3Ao3CD3>

Water use and yield of selected indigenous fruit tree species in South Africa

Indigenous fruit tree (IFT) species are trees that grow in the wild, bear edible fruit, and they have their origin in South Africa. More than 20 types of IFTs have been identified in South Africa and these grow under a range of bio-climatic conditions across the country. So far, no detailed studies have determined the water use by indigenous fruit tree species in South Africa. This

information is essential for maintaining the country's biological diversity, meeting environmental flow requirements for sensitive riparian species, as stipulated in Section 36 of the country's Water Act (1998), and supporting efforts to identify alternative crops through IFT domestication and agroforestry programmes. The Water Research Commission therefore initiated and funded this five-year project to close these important information gaps. The goal was to provide critical information relating to the ecophysiology of various IFT species that have the potential for domestication and commercialisation. To ensure that data were collected on priority species, the project commenced with a stakeholder engagement involving participants from various sectors, e.g. NGOs, universities, nurseries, etc. The aim of this engagement was to identify at most five IFT species that have a high domestication and commercialisation potential out of the more than 20 species found in South Africa.

WRC report no. 2720/1/22

Web link: <https://bit.ly/3CALJnz>

Willingness to pay for re-engineered sanitation systems for households: A market trend analysis

Several re-engineered toilet facilities have been investigated and research has shown that these toilets or toilet systems such as urine diversion/separation or composting toilets can contribute immensely towards reducing water consumption. However, despite the extensive research and development and great exploration by government, private sector and civil society, the adoption rate by households remains minimal, with only 0.3% of households having adopted these re-engineered water-saving toilet systems while domestic water usage remains high. This study's aim was to solicit households' willingness to pay to change to using water saving sanitation technologies.

WRC report no. 3014/1/22

Web link: <https://bit.ly/3pM6HYV>

Nanotechnology innovations and commercial opportunities for water and sanitation management: A South African perspective

In this report, the current state-of-art of commercialisation of nanotechnology products, systems and processes for use in water and sanitation are evaluated and a clear viewpoint on further research and development (R&D), innovation and commercial opportunities is established. Each type of the nanotechnology-based product, system and process is evaluated to provide a clear viewpoint and future perspective on its commercial potential in South Africa. This report therefore offers an overview of nanotechnology applications in water and sanitation in South Africa. The report provides useful information for government policy makers, industry, funders, R&D and innovation centres and researchers who have interest in nanotechnology. The document further examines how nanotechnology developments, and the solutions they enable, can help address some of the problems related to water and sanitation. It consequently identifies nanotechnologies and their potential contribution to solve some of societies' most challenging problems including water scarcity and pollution, energy-related challenges, poor sanitation, and many others.

WRC report no. TT 888/22

Web link: <https://bit.ly/3TiryQU>

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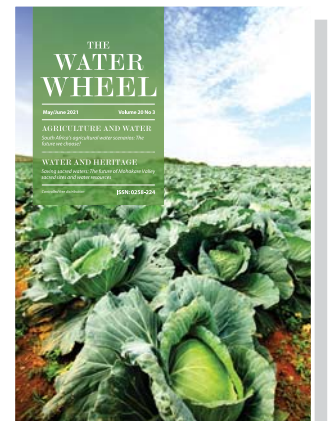
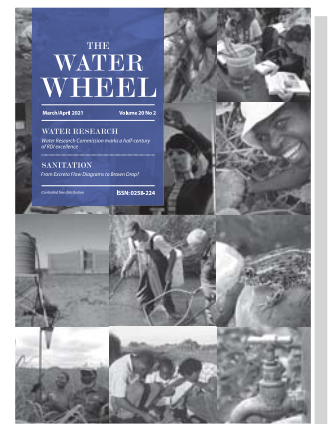
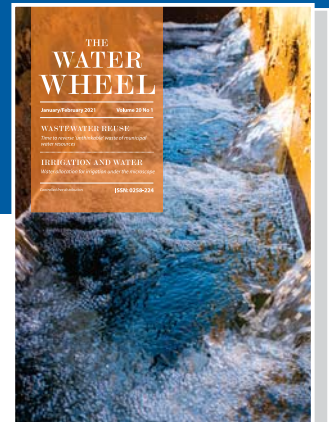
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An RDI Value Framework: A framework toward empowering research institutions to deliver demonstratable value to their stakeholders

Globally, water research organisations grapple with the same challenge, namely, that in some cases, research and innovation are conducted to produce new knowledge and innovations that are poorly, or not taken up by the water and sanitation sector or industries. The research team was tasked to address this challenge with the WRC as a case study. The study forms part of an initiative of the Global Water Coalition (GWRC), of which the WRC is a member. Among others, this study developed a water and sanitation RDI framework for the WRC based on core values and the insights from a literature review and stakeholder research.

WRC report no. 3028/1/22 (Volume 1: Review of theory and situational analysis) and 3028/1/22 (Volume 2: The Development of the Framework and Practical Tools)

Web link Volume 1: <https://bit.ly/3TfAzuc>

Web link Volume 2: <https://bit.ly/3R6OZef>

Rapid, efficient Ag-Au NPs interdigitated nano biosensor arrays for water quality analysis

Escherichia coli (*E. coli*) and *Salmonella typhimurium* are commonly known bacterial contaminants in water and food. The presence of these bacteria in consumables remains a public health concern due to their high virulence and pathogenicity; causing common infectious gastrointestinal tract diseases in humans with symptoms such as diarrhoea. Nanoparticles (NPs) have been shown as promising alternative chemicals for pathogen detection in biological samples. Thus, the project was aimed at combining the qualities of electro-analytical techniques and NPs in developing a sensor that is able to detect and quantify these bacteria in minutes. Electro-analytical techniques are preferred because they have unique advantages, such as high sensitivity, selectivity, low cost and are usually rapid.

WRC report no. 2889/1/22

Web link: <https://bit.ly/3Tlbt8k>

Inactivation of waterborne pathogens using medicinal plants

Worldwide, pathogenic organisms are a serious public health concern because of their prevalence in the environment. They are shed in high numbers through the faeces of infected individuals and are transmitted via the faecal-oral route. This study investigates the prevalence of SARS-CoV-2 RNA and Noroviruses (I and II) in raw and treated wastewater from four wastewater treatment plants as well as four rivers within eThekweni, Durban, KwaZulu-Natal, South Africa. The study is a wastewater-based epidemiology investigation, an emerging area in the environmental field that aids in providing an early warning signs of waterborne enteric viruses within the environment. Their identification is critical for preventing infection and responding to an outbreak. The study further evaluates the phytochemical composition, antimicrobial and antioxidant activities of aqueous, methanolic and ethanolic extracts of *Ocimum gratissimum*, *Moringa oleifera*, *Azadirachta indica* (Neem) and sesame plants.

WRC report no. 3027/1/22

Web link: <https://bit.ly/3Ra35vp>



The role of emerging innovative wastewater sludge to energy technologies in transitioning to a circular economy in the water sector: A South African case study

Similar to other sectors, the benefits of transitioning to a circular economy (CE) in the water and wastewater (collectively water) sector have been demonstrated through both theoretical models and

practical experience in those areas where partial circularity has been achieved. However, full transition still faces significant challenges and barriers. As in most countries, the current water and wastewater business cycle in South Africa is predominantly based on the linear economy approach. To address current and future water security challenges in a sustainable manner, there is a need to rethink the South African water and sanitation value chain and accelerate transitioning to a CE. This project was funded by the WRC as part of the research into innovative water and wastewater management solutions that can assist WSAs successfully transition to a CE. The project evaluated the role of sludge to energy technologies in accelerating the adoption of CE principles by converting wastewater treatment plants (WWTPs) into resource recovery facilities at the centre of that transition.

WRC report no. TT 883/22

Web link: <https://bit.ly/3e0cHur>

Essential considerations for the implementation of membrane distillation crystallisation in the treatment of hypersaline brines

The generation of brine waste streams emanating from water treatment processes such as reverse osmosis (RO), multi-stage flash (MSF) and multi-effect distillation (MED) are a major concern for the environment. Brine waste-handling and disposal methodologies are largely contingent on the geography in the vicinity of the plant generating the brine and include discharge into oceans, inland water bodies such as rivers, surface dams and sewers, as well as deep-well injection and brine storage in waste evaporation ponds. Membrane Distillation Crystallisation (MDC) offers a sustainable wastewater treatment option for saline and hypersaline effluent streams. The objectives of this study were to identify quintessential considerations, mainly related to key membrane characteristics and performance criteria, when assessing the viability of implementing and selecting MDC over alternative technologies.

WRC report no. 2763/1/22

Web link: <https://bit.ly/3pMNSok>

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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



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



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 ultraviolet disinfection capable of killing both bacteria and viruses.



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,



The Wellington wastewater treatment works.

compared to chemical disinfection technologies, with no by-products or danger of overdosing.

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.

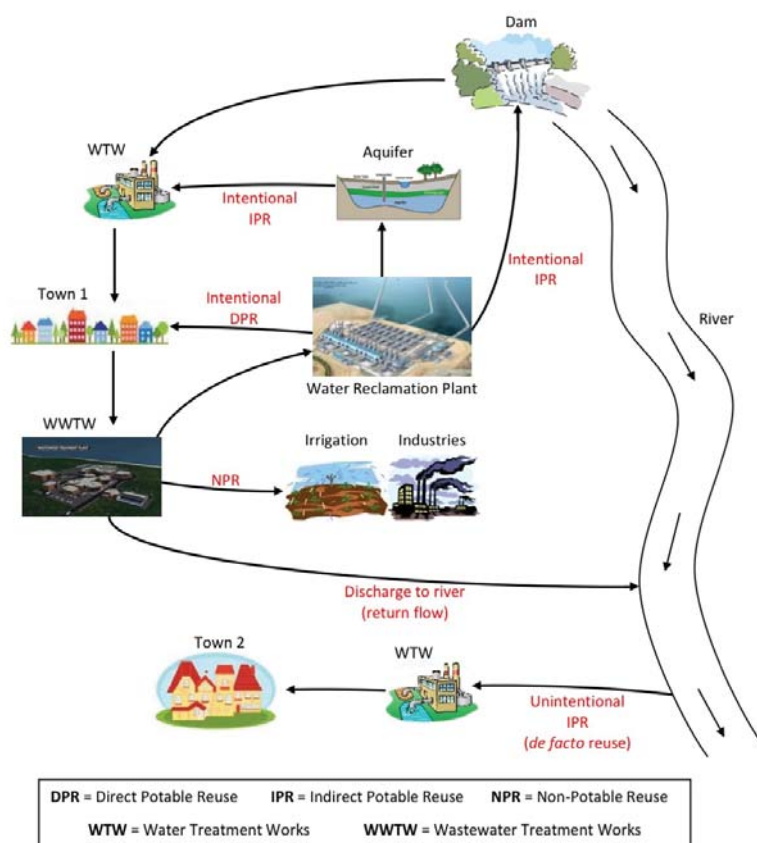
In the US, some plants are now evaluating alternative treatment trains such as Ozone-BAF, which do not produce a brine stream. However, one of the potential disadvantages of using ozonation in direct potable reuse is the formation of bromate, which is a disinfection by-product formed during ozonation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

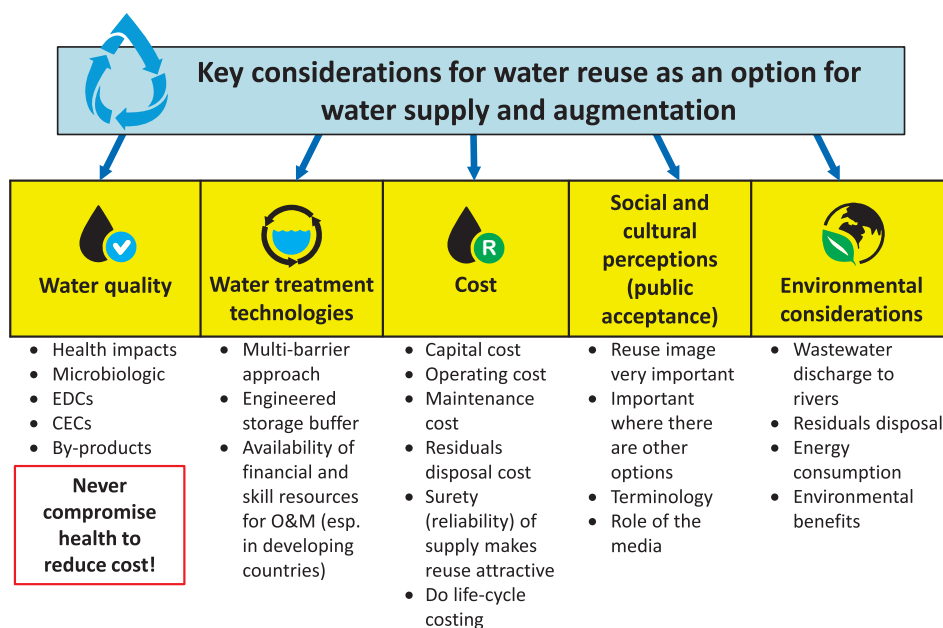
Nevertheless, the main impact is the discharge of concentrated waste streams, brine and other residuals to the environment and disposal options therefore require strict control.



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).

AGRICULTURE AND CLIMATE CHANGE

Projected climate change threatening production of SA's unique tea

A research project that the Water Research Commission (WRC) funded on water use and yield of rooibos also investigated the potential impact of climate change. Article by Sue Matthews.



Media Club/Rodger Bosch

Coffee aficionados everywhere have likely been alarmed by news headlines over the past decade about the effect of climate change on coffee production. Will they still be able to get their regular 'fix' in future, and at what price? The headlines refer to findings from research done primarily on *Coffea arabica*, which yields 60 – 70% of global coffee bean production. The species is grown in tropical highlands, and modelling studies have shown that areas suitable for its cultivation will decrease significantly by 2050 and shift to higher elevations. Fortunately, though, these areas are distributed over three continents. Brazil is currently the dominant producer, but Arabica coffee is grown in other South and Central American countries too, as well as in Asia and Africa – there is even very limited cultivation in South Africa.

By contrast, our country's world-renown tea, the caffeine-free rooibos, is produced only in a relatively small part of the fynbos biome in the Northern and Western Cape. Since production is

based on forms of the leguminous shrub *Aspalathus linearis* that are endemic to the Cederberg mountains, the industry is centred in Clanwilliam, but the main growing area extends about 200 km from the vicinity of Nieuwoudtville in the north to Piketberg in the south, with some additional small-scale cultivation in the Cape Agulhas area of the Overberg. Two community cooperatives also harvest rooibos from the wild according to sustainability guidelines, and market it with fair-trade certification. Overall, annual production of rooibos over the past decade has fluctuated within the range of 10 000 to 20 000 tonnes.

The crop is harvested once per year, between January and April as conditions dictate, by cutting off thin branches bearing the soft leaves. Once transported to the processing factory, these are machine-cut into fine pieces, which are heaped in rows in the yard, dampened and then bruised by crushing or tumbling,

before being left to ferment for about 12 hours. During this time a process of enzymatic oxidation takes place, turning the leaves from green to reddish-brown. Next, the rooibos is spread out in the sun to dry and then gathered up for sorting, grading and packaging, although many producers have a sterilisation step relying on steam pasteurisation too.

Green, unoxidised rooibos that has not undergone fermentation is also produced, and the polyphenol antioxidants and other properties of both forms are reputed to have a variety of health benefits. Apart from teas, rooibos extracts are used in other beverages, foods and skincare products made in South Africa and the more than 60 other countries around the world that currently import rooibos in leaf or powdered form.

In May last year, rooibos made history when it became the first African product to be granted Protected Designation of Origin (PDO) registration by the European Union (EU). Joining the likes of champagne, Parma ham and Stilton cheese on the list of foods and beverages with PDO status, the names rooibos and red bush can now only be used within the EU for products using rooibos leaves grown and processed within a defined area incorporating 15 municipalities in the Western Cape and Hantam Municipality in the Northern Cape.

Given this limited area of production and the fact that much of it is semi-arid, with very hot, dry summers, there have long been concerns about how the sector will be affected by climate change. Research has been ongoing over the past two decades, initially focusing on potential impacts on small-scale tea farmers from local communities, and ways of increasing their resilience. Emma Archer, then with the University of the Witwatersrand but now a professor at the University of Pretoria, was heavily involved in that work, and also led a study on climate change impacts on groundwater, which was commissioned by Cape Nature's Greater Cederberg Biodiversity Corridor (GCBC) project, the South African Rooibos Council and Potato South Africa – potatoes being another primary agricultural sector in the Sandveld.

Daleen Lötter was a co-author of the 2009 paper on the study, having been employed at the time as the GCBC conservation officer, based at Cape Nature's Porterville office. The research ignited her interest, and before long she took up a climate science post at the CSIR in Stellenbosch. She subsequently embarked on a PhD, co-supervised by Archer and awarded by the University of Cape Town in 2015, on the potential implications of climate change for rooibos production and distribution in the greater Cederberg region. The climate envelope modelling she conducted for her PhD suggested that rooibos would experience substantial range contraction, as well as south-eastward and upslope shifts. Lötter also conducted glasshouse and field experiments to assess the physiological response of rooibos seedlings to water limitation, and compared the seasonal variation in photosynthetic activity and nutrient cycling of wild and cultivated rooibos through isotope studies.

Lötter is now a senior climate researcher at the CSIR in Stellenbosch, and recently led a three-year, WRC-funded project that investigated the water use and yield of rooibos. The other members of the team – Sebinasi Dzikiti, Wasanga Mkhazani and Sarel Haasbroek – have current or past associations with the CSIR, the University of the Western Cape or Stellenbosch University.

Since the main production area has a distinct rainfall gradient from the coastal regions to the central Cederberg, as well as widely varying air temperature, the project team selected two different study sites. The first year's fieldwork was conducted at a site near Porterville, approximately 150 km north of Cape Town, where the area's long-term average rainfall is just over 400 mm per year. In the second year the focus shifted further north to the Clanwilliam area, where rainfall averages less than 250 mm per year. Fortunately, the Agricultural Research Council had established weather stations within 5 km of these sites, so the project team was able to access hourly data on maximum and minimum air temperature, maximum and minimum relative humidity, wind speed and direction, rainfall and solar irradiance.

CSIR



Dr Daleen Lötter measuring leaf area index (LAI) in a rooibos field during overcast conditions.



The rooibos crop is harvested in summer, typically hand-cut using a sickle.

Some of the more physically demanding fieldwork entailed digging pits more than a metre deep to collect samples down the soil profile for laboratory analysis, and to install soil moisture sensors at 20 cm depth intervals in the root zone of rooibos plants. The sensors monitored the volumetric soil water content at hourly intervals throughout the study period, while a rain gauge installed in the same field allowed rainfall to be quantified.

The project team also installed stem heat balance sap flow sensors on branches of three randomly selected rooibos plants, and these were moved to other plants once per month to avoid causing further stress over and above the hot ambient conditions the plants are naturally adapted to. Ten plants per field were labelled, and their growth monitored on a monthly basis. A leaf area meter was used to measure the leaf area index (m^2 of leaf area per m^2 of ground area), and canopy dimensions and plant height were also recorded. In addition, open path eddy covariance and surface renewal systems, comprised of a variety of sensors above and below ground, were installed in the rooibos fields for evapotranspiration measurements.

Having collected all their data in the first two years, the project team focused on data analysis, modelling and gap-filling in the third year of the study. They were able to model daily evapotranspiration by the rooibos crop using a simple combination Penman-Monteith equation, based on a big leaf approach in which the whole field is assumed to be a single uniform surface.

“The relationship between the measured cumulative evapotranspiration and biomass accumulation data through the season was used to develop the yield model,” they explain in the final report. “The water-use model was calibrated using data collected from the Porterville site and validated with that from the Clanwilliam site. Lastly, the model was used to estimate

changes in crop water requirements under the envisaged climate change scenarios for the key rooibos producing areas.”

In her PhD, Lötter found that maximum temperatures in the Greater Cederberg region had increased by more than 2°C over the past half-century, most significantly during March, April and May, and there was strong evidence of localised changes in rainfall characteristics. Looking forward, other researchers have projected that average annual temperatures will rise $2\text{--}3^\circ\text{C}$ by about 2050 in the Western Cape, and there will be drying across all seasons, with largest rainfall reductions occurring during June, July and August.

In the current study, simulation modelling for the period 1960 to 2100 – assuming the ‘business as usual’ RCP 8.5 greenhouse gas emission scenario – predicted an increase of $4\text{--}5^\circ\text{C}$ in both the maximum and minimum air temperatures for the study area. In response to the inevitable increase in atmospheric evaporative demand, annual total evapotranspiration is expected to rise by $7\text{--}13\%$. Perhaps surprisingly, six coupled climate models, which were dynamically downscaled for the region by means of the conformal-cubic atmospheric model (CCAM), predicted that crop yield would increase by $8\text{--}15\%$. The project team note the possibility of higher increases in yield if the CO_2 enrichment of the atmosphere is taken into account.

Under the prevailing climate conditions, though, the field experiments indicated that transpiration declined with increasing soil water deficit. It peaked in mid-December at almost 1 mm/day – confirming the plant’s very low water usage – and then decreased as the average soil water content in the root zone dropped below 4% , even though the canopy cover was still increasing before the crop was harvested in February.

Transpiration is known to be linearly and strongly correlated to crop yield, and the rooibos sector certainly endured substantially

CSIR



Rooibos production takes place primarily in mountainous and lowland areas of the West Coast, but there is limited cultivation in the Overberg as well.

lower yields during the Western Cape's severe drought between 2016 and 2018, when soil water deficits were high. Rooibos is a rainfed crop, and although some farmers have experimented with supplementary irrigation, it's understood that irrigation must cease at least a month before harvesting starts if the level and type of polyphenols in the final product are to be assured.

Importantly, the team's data showed that more than a third of the annual total evapotranspiration was consumed between September and November – the first three months of the growing season – but this was mostly evaporation of soil moisture after winter rains and transpiration by weeds, rather than water use by the rooibos crop itself. Weed and grass growth has become more of a problem in rooibos fields, especially newly planted ones, with the increasing adoption of conservation (no-till) farming methods, which minimise soil disturbance.



Media Club/Rodger Bosch

Rooibos leaves following the processing stage with their distinctive red colour.

"Careful management of weeds and cover crops early in the season is critical to preserve the soil water reserve for later use," note the project team. Implementing other water demand management practices, such as green mulches between plant rows to limit water losses and contour ridges on sloping terrain to trap runoff, would also be appropriate adaptation strategies to cope with the expected dry conditions in future.

Asked to comment on the project, Managing Director of Rooibos Limited, Martin Bergh, said: "We in the rooibos sector are all aware of the threat of climate change, but we also understand that old-style farming has been detrimental to soil, so we need to improve our methods and hopefully preserve more moisture."

"Every one of these studies adds to a greater body of knowledge," he added. "This was the first to monitor evapotranspiration and energy balance of a rooibos crop from the beginning of the growing season until harvest, so that was novel, and although we knew that rooibos uses water very efficiently, the research has quantified it."

The report, *Water-use and yield of rooibos tea (Aspalathus linearis) in the winter rainfall areas of South Africa (WRC Report No. TT 878/22)*, will be published later this year.

Recognising the traditional knowledge of SA's first nations

In mid-July it was announced that payment of just over R12,2 million had been made to the San and Khoi people of South Africa in accordance with the rooibos traditional knowledge benefit-sharing agreement. The agreement was signed by the South African Rooibos Council, the National Khoi-San Council and the Department of Environment, Forestry and Fisheries (DFFE) in November 2019, after nine years of negotiations.

In terms of the agreement, the San and the Khoi people will receive 1.5% of the farmgate price from the 10 rooibos industry processors. The payment represents the annual levy from the first year of farmgate purchases, and was deposited into the DFFE-administered Bioprospecting Trust Fund account before being transferred in equal amounts to two community trust accounts established by the South African San Council and the National Khoisan Council.



Rooibos leaves are green when harvested, but turn reddish brown as a result of enzymatic oxidation during the fermentation stage of processing.

CROP WATER USE

Water use study points to potential of bamboo in South Africa

Bamboo is a useful and sustainable crop. But is it a wise bet for our water-scarce country? A recently completed Water Research Commission (WRC)-funded project aimed to provides some answers. Matthew Hattingh reports.



Panda bears chew it up like rugby fans munching on *droëwors*. Some of the world's first firearms were fashioned from it and it's the key material in a host of biodegradable consumer goods, from kitchen spatulas to toilet paper. Bamboo, with its relatively strong resistance to breaking, remains a mainstay of construction in the East. Around the globe, people are increasingly looking at cultivating this versatile member of the grass family.

In South Africa, there's growing interest in bamboo as a building material and a fuel source. South Africa's indigenous forests are few and far between. Heavy harvesting means there's little firewood to go around and erosion has depleted soils leaving them less able to store water to support life.

What if bamboo was cultivated at scale here, particularly on land already degraded by agriculture? It matures in six or seven years and produces new shoots at the base of the plant every year. Half a dozen stems can be harvested in a season from a single plant for perhaps decades without killing it, making bamboo a self-replenishing source of timber and firewood.

It certainly sounds promising, but at what cost to the country's scarce water resources? These and related questions were the subject of a recent report for the Water Research Commission (WRC), with the findings laying the groundwork for further research on bamboo's commercial cultivation. The report, *Quantification of the evapotranspiration and streamflow reduction caused by bamboo species on water resources in South*

Africa (WRC Report No. TT 875/22) found the increase in stem diameter of bamboo under study was lower than for eucalyptus trees as well as that notorious alien invasive species, black wattle. On the plus side, bamboo proved nowhere near as thirsty. Nor, according to the literature, does it spread unchecked, provided the right species are planted. It is, however, hard to remove.

The report's authors, Colin Everson, Mxolisi Gumede, Terry Everson, Alistair Clulow and Richard Kunz, noted that the departments of Trade and Industry and Agriculture, Forestry and Fisheries and the Environment have been promoting bamboo planting to encourage rural development. They cited the Bamboo Association of South Africa which said 40 000 hectares had been earmarked for cultivation in KwaZulu-Natal and the Eastern Cape.

But before bamboo growing can begin on this scale, we need to know how much water it uses. There had been no research on the subject under South African conditions so the authors, representing the University of Kwazulu-Natal's Centre for Water Resources Research, set out to remedy this. Their aim was to determine annual and seasonal bamboo water-use figures to assist with water management, achieve an optimum crop yield and support applications for water-use licences.

The National Water Act lets the government declare farming, mining and other endeavours as "stream flow reduction activities", requiring approval and licensing. To date, for agriculture, this has applied only to commercial forestry plantations. The researchers wanted to learn if bamboo should join the list.

From September 2018 to February 2020, the team gathered data from two study sites with very different climates and conditions: Shooter's Hill farm, a few kilometres west of the Albert Fall Dam, north of Pietermaritzburg in KwaZulu-Natal; and at Kowie farm, near Bathurst in the Eastern Cape.

At least 15 different species have been planted on 10 ha at Shooters Hill and 330 ha of the 485 ha Kowie, said to be the country's first large-scale commercial bamboo farm.

The study focused on two varieties of the species *Bambusa balcooa*, known as balcooa and beema. This is a clumping bamboo native to the Indian subcontinent and Indo-China that's not considered invasive – as opposed to species with long underground stems or runners that can worm great distances in search of water. It's also drought-resistant and easy to manage and its aerial stems are strong and are known to reach a useful 25 m in height.

In-depth growth studies were beyond the scope of the project, but pilot studies determined the increase in stem numbers and diameters. In KwaZulu-Natal, stem diameter increased by 0.2 mm and 0.12 mm a month for beema and balcooa respectively. The total number of beema stems was up by 18% and balcooa by 12.5%. These figures coincided with good rainfall – 2104.5 mm over 17 months.

Drought in the Eastern Cape may explain the lower growth figures recorded at Kowie (a mere 0.005 mm a month). The state

of the soils at Kowie, impoverished by years of uninterrupted pineapple farming, may have been a factor too.

By contrast, the black wattle and eucalyptus at Shooter's Hill grew vigorously – by a monthly average of 3.0-4.0 mm and 5.4 mm respectively.

Back to water-use considerations. Plant water-use has two components: transpiration and evaporation. Evaporation happens when water changes to vapour from soil or plant surfaces. Transpiration refers to water lost to the atmosphere through leaves during photosynthesis. During this process plants turn the sun's energy into chemical energy, which is stored as sugars and starches. Collectively, the two are known as evapotranspiration.

Indirect and direct methods can be used to measure evapotranspiration. Indirect methods include gathering and analysing microclimate data.

Vaporisation requires energy, which comes directly or indirectly from the sun. The amount of solar radiation available has a direct bearing on water-use. But air temperature, relative humidity, wind speed and rainfall play a big role and must be measured too. To this end, the team set up automatic weather stations at the study sites. They also studied soil structure and water content, which affects water flow to roots.

The equipment to do all this is costly and pains had to be taken to prevent theft. Some of these costs and complications can be avoided by directly measuring the flow of plant sap (which is



Study co-author and Master's student, Mxolisi Gumede, drills holes into a bamboo tree at Shooter's Hill farm prior to inserting hypodermic probes.



An old pineapple field planted with bamboo at Kowie farm in the Eastern Cape.

mainly water). The problem is, the technologies to do this were developed for dicotyledonous tree species. Would it work for bamboo, which is monocotyledonous?

“The data suggested that bamboo (a grass) was behaving in a similar manner to natural grassland, in that it is a conservative water user during winter.”

Dicotyledonous and monocotyledonous plants – the two main groups of flowering plants (incidentally, most bamboos flower once in their lifetime) – have several distinct features that aid in telling them apart. These include the way sap-carrying vascular bundles (xylem) are arranged in the stem. With dicots, the bundles form the sapwood around the centre heartwood of the stem. With monocots, which have hollow stems, the bundles are scattered near the stem’s outside edge.

The team measured inner and outer diameters of beema and balcooa stems to determine average wall thicknesses for different stem diameters. Next, they used precision equipment to slice out tiny stem cross-sections for viewing under light and electron scanning microscopes.

With a better understanding of the structure and positioning of bamboo vascular bundles, including the depths at which these

are found, the team was ready to try measuring sap flow. They used two techniques: heat pulse velocity and stem steady state.

For the heat pulse technique – which was used only in KwaZulu-Natal where stem walls were sufficiently thick – sets of hypodermic needles were inserted into stems to depths precisely determined during the measuring and microscope work. Each set included an electric heater needle and two needles wired to thermocouple probes up- and down-stream of the heater.

The heater needle was fired every 60 seconds, warming the sap. The difference between the voltage at the two thermocouples over time was recorded, with the heat acting as a tracer for sap flow.

The steady state technique involved strapping insulated collars around stems. These contained a continuous heat source and sensors before and after the source. The sensors recorded conductive heat losses.

Data from both techniques was logged and transmitted to the team’s Pietermaritzburg offices where it was used to calculate sap velocity and from this to determine transpiration volumes for the KwaZulu-Natal and Eastern Cape bamboo. Heat pulse velocity and stem steady state techniques used on beema and balcooa in KwaZulu-Natal over three summer months gave similar results, so an average of the two methods was used.

Balcooa, a giant bamboo, was found to use twice as much water as beema, with summer being the thirstiest time – coinciding with higher rainfall and temperature figures. Beema water-use during what was a wet summer in KwaZulu-Natal averaged 2.0 ± 3.2 mm a day – about twice as much as the dry winter use of 1.0 ± 1.6 a day. For balcooa, a range of 3.8 ± 6.0 mm a day was recorded in summer and 2.0 ± 2.8 mm a day in the winter.

The result bears out the findings of the microscope work – that balcooa has nearly twice as many vascular bundles as beema. Seasonal climatic conditions were found to have a considerable influence on bamboo transpiration in KwaZulu-Natal.

“This data also suggested that bamboo (a grass) was behaving in a similar manner to natural grassland, in that it is a conservative water user during winter. The annual water use of balcooa and beema was 746 and 510mm, respectively,” the report said.

By contrast, in the Eastern Cape, maximum daily evapotranspiration rates for balcooa averaged only 3 mm a day in the summer. Annual total evaporation was only 446 mm and 567 mm in 2019 and 2020, respectively – a period when the Eastern Cape suffered severe drought.

By way of comparison and to understand bamboo water-use in the context of changing land use, the team monitored eucalyptus and black wattle in KwaZulu-Natal. Natural grassland was included in the study too. It provided baseline or reference figures, used to estimate crop factors. These are things like crop height and surface roughness, reflection, ground cover and root characteristics, which result in different crops having different evapotranspiration levels.



A bamboo stem at Shooter's Hill farm with probes inserted to measure sap flow using the heat pulse velocity technique.

An automatic weather station installed at Shooter's Hill helped with measuring these factors. It also gave the researchers hourly and daily meteorological data which they used to interpret the effects of environmental changes on sap flow.

From January 2019 to December 2019, the heat pulse velocity technique recorded the highest water-use (1301.2 mm) in eucalyptus, followed by black wattle trees, with 911.4 mm. In the summer, also using direct techniques, peak eucalyptus water-use was found to be about 8 mm – “significantly higher than the daily bamboo water use (2–3.3 mm)”. The average winter figure was about 3 mm. The maximum daily summer transpiration for black wattle was 5 mm and in winter, 3.5 mm.

Bringing together the automatic weather station and other data, and evapotranspiration figures for the reference crop, the researchers derived a crop coefficient for the bamboo in the study. A crop coefficient is a constant value which agronomists plug into formulas (such as the Penman-Monteith equation) to estimate the water-use of a particular crop in often widely differing growing conditions.

Once they had derived crop coefficients, the authors were able to estimate bamboo water-use across the country. They concluded that bamboo, particularly beema, was a “conservative water user” relative to natural vegetation, while balcooa could be declared a stream flow reduction activity in only 32 quinaryes.

A little clarity here...

To aid research and planning, South Africa's catchment areas are subdivided into a five-level hierarchy, from primary at the largest scale, down to quinary at a very local level. In total, the country

has 5 838 quinaryes. The legislation deems an activity stream flow-reducing if its effect on runoff exceeds 10%.

The 32 quinaryes are found in northern parts of the Northern Cape and North West, as well as the particularly arid parts of Limpopo. These are quinaryes where rainfall ranges from 146 mm to 488 mm, making the commercial cultivation of bamboo a non-starter in any case. “Therefore, the commercial production of these two clumping bamboo species would be expected to have a minimal impact on stream flow,” the report said, “...(it) is unlikely to be declared a potential stream flow reduction activity by the Department of Water and Sanitation.”

The report called for further research on more mature bamboo including other species. “Since bamboo appears to be a conservative water user, research on the most suitable planting areas for the expansion of the industry should be undertaken to prevent failed investments in the bamboo industry,” the authors said.



The project team collected data from a number of heat pulse velocity probes at Shooter's Hill.

To download the report, *Quantification of the evapotranspiration and streamflow reduction caused by bamboo species on water resources in South Africa* (WRC Report No. TT 875/22) visit: <https://bit.ly/3AGusrE>

WATER CONSERVATION

Savvy showers helping SA's top nature reserve save water

A project to reduce the water consumption of the Kruger National Park's tourists is paying dividends, writes Petro Kotzé.

Petro Kotzé



The Kruger National Park is one of South Africa's premier protected areas and provides thousands of people with the opportunity to enjoy the internationally renowned wilderness. A visit to Kruger might be the closest many will get to experiencing untamed lands but, in the process of catering to tourists, a heavy imprint is made on the conservation area.

"Conservation very often involves trade-offs," says SANParks Senior Scientist, Dr Izak Smit. "This is even more so when considering social-ecological systems where both nature and people, and their interaction with each other, are considered." Tourists visiting parks do have some environmental impact, including the developmental footprint of infrastructure, the

carbon footprint of travelling to and within parks and water usage and waste generation whilst in parks, yet at the same time, Smit says, tourists fund conservation. Today, around 80% of SANParks' revenue is generated through income derived from tourism, which cross-subsidises SANParks's conservation efforts.

Over and above the financial injection, through visiting the parks, tourists often become passionate ambassadors for conservation in society. As such, careful consideration should be given to how to mitigate the impacts, whilst enhancing the benefits, Smit says. "The goal is to work towards sustainability, creating social-ecological systems that are ecologically resilient and intact, financially viable and socially relevant."

One more step towards this goal was recently taken when a research project pinpointed a way for water to be used more efficiently in rest camp showers, one of the largest human water uses in the park. The project entailed the implementation of a novel technology combined with educational information. It provided management with new insights into the people that visit Kruger, their showering habits and how to reduce the volume of water used in the process.

Though the lessons and technology can be applied anywhere, it resonates loudly in Kruger, where many visitors might not realise that they use the same rivers as the wildlife that they admire.

The water users in Kruger

In fact, though the park also has artificial waterholes fed from boreholes to provide water for wildlife, people also share this resource with the plants and wildlife. Water for staff and visitors are necessary to wash linen, water the gardens and for direct use in homes and chalets, to wash up, flush and shower, says Smit.

For most of the largest camps such as Olifants, Letaba, Shingwedzi, Crocodile Bridge and Berg-en-Dal, water is abstracted from the rivers that run through the park, says Dr Eddie Riddell, SANParks Manager: Aquatic Biodiversity Management. Some smaller camps like Punda Maria, Pafuri, Orpen and Shimowini rely on boreholes. Those, like Satara, located far from a perennial river receive water via pipelines from another (the Olifants River, in the case of Satara).

All water uses in the rest camps are governed by individual Water Use Licenses issued by the Department of Water and Sanitation.

The water for Skukuza, Kruger's largest rest camp, is abstracted from the Sabie River that runs right past the camp and is often visited by wildlife in clear view of thousands of tourists on the other side of the fence.

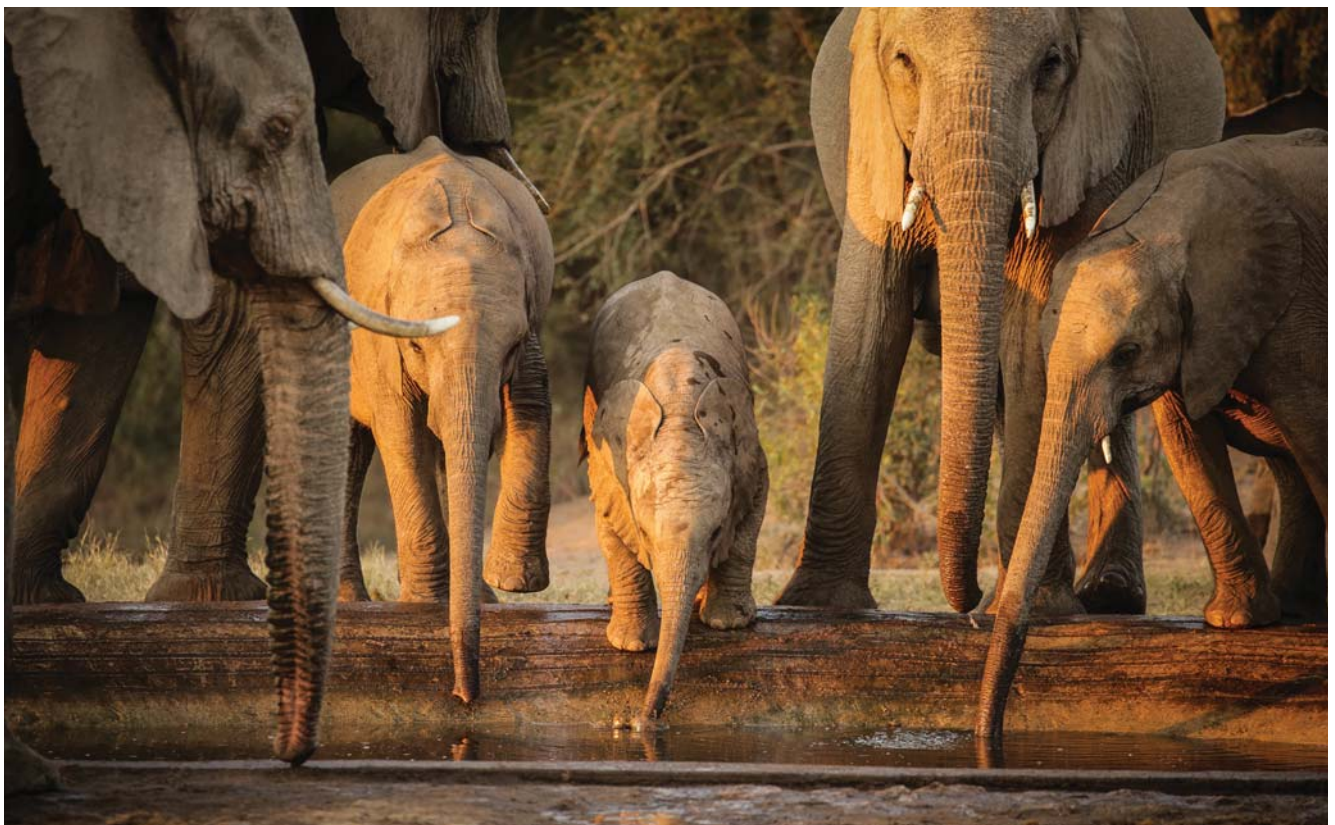
The water is purified to South African standards after it is abstracted and, after it has been distributed and used, is treated in a series of maturation ponds and artificially constructed wetlands before being released back into the river, also according to the required standards, Riddell says.

SANParks management has already implemented a range of initiatives to keep water use in rest camps to a minimum. Most of Kruger's gardens have been changed to be more water-wise, with irrigation restricted to early mornings and later afternoons when evaporative loss is minimal, Smit says. In addition, closed circuit-greywater systems are integrated into the design of new developments like the Skukuza Safari Lodge.

Low-flow showerheads have also been fitted in the rest camps, but showering remains a major component of water use, not only in SANParks, but in tourist accommodation globally as well as in private households.

Watching water go down the drain

The topic came to the attention of Prof Nico de Bruyn from the Mammal Research Institute at the University of Pretoria, one day while on a visit to the Kalahari. His friend mentioned that he had just waited for seven or eight minutes for the water in the shower to heat up and that, all that time, the water simply washed down the drain before he got in.



Petro Kotzé

In addition to water for people, Kruger also maintains artificial waterholes for wildlife.

Petro Kotzé



Water for the Skukusa rest camp is abstracted from the Sabie River that runs past the camp.

Petro Kotzé



Did you know, if you shower one minute less in Kruger, you save water for two impalas for a day.

Back home, the friends, all involved in research and sticklers for solving problems, tinkered with ideas to stop shower water from being wasted before it reached the right temperature. Initial ideas included technologies to catch the water and reintegrate it into the system but, these became too complex. Eventually, we realised that we can create a circulation loop in the water system, de Bruyn says. In their final design, an electronically controlled mixer recirculates water and releases it from the showerhead only once the water is warm enough. It is the first commercially available product that solves the problem without the need for its own heating system or elaborate plumbing reconfiguration. It eliminates water wastage by simply installing the mixer unit between the hot water source and showerhead.

"It's very simple," de Bruyn says. The technology entails two components. The first is the controller unit, which looks like a remote. The second is the mixer unit, "where the real magic happens". The product includes a timer that terminates the shower after a pre-defined time, although it can be immediately restarted. "We felt it's important to not just physically save water, but also to change the behaviour of the user over time", de Bruyn says. The hope is that they become cognisant of the time they spend in the shower at home, and then also practice water use awareness when they shower elsewhere.

The technology is called the Triton Xerophyte. It's a nod to Triton Showers in the United Kingdom, which they partnered with to develop the product and, a group of plant species that use very little water. Fittingly, the efficiency of the device could be tested in the Skukuza Rest Camp.

Testing shower devices

The experimental trial was conducted over nine months in 2020 and 2021 to include both summer and winter seasons. Ten chalets were included in the study, and at the end, a total of 2 467 shower sessions were recorded.

Five of the chalets were fitted with the Triton Xerophyte mixer units and posters explaining how to use them. Additionally, one of these chalets also had extra water-saving information graphics included. One infographic, placed in the bathroom, converted volumes of water typically used for a range of everyday activities such as showering, toilet flushing and filling the washing basin into ecological metrics. For example, visitors were told that one minute of showering equals drinking water for two impalas for a day. The principle behind this infographic was to express the water usage in metrics that visitors to a national park are likely to care about, instead of the rather impersonal, but more familiar, volume metric.

The second infographic, placed at the washing basin in the kitchen, introduced visitors to the source of water used in the chalet, namely the Sabie River that all the chalets overlook. This infographic provided information about the biodiversity and human livelihoods dependent on the river. The idea was to reconnect visitors to the resource they are dependent on. The infographics were also placed in two more chalets that did not have the shower mixer units fitted.

The Triton Xerophytes were pre-set for three-minute showers at a temperature of 38°C and a flow rate of four litres per minute, though visitors could easily change all settings if they preferred. Daily ambient temperatures were also measured throughout the study at a nearby automated weather station.

Smit says the results help them better understand various behavioural aspects regarding showering patterns in Kruger that were previously unknown. "These lessons can help us plan going forward," he says

Lesson one: park visitors are water wise

The average time of a shower in the chalets without any interventions was four-and-a-half minutes, using an average volume of 25 litres. "Very encouragingly, the data revealed that the average volume of water used and the time spent in showers in the park are considerably lower than showering volumes and times available for other parts of South Africa and internationally," Smit says.

Study findings vary, but in the lower range, a typical shower in a suburban area in South Africa has been pegged at 59.1 litres. A study in the USA measured 59 litres per shower. An average shower time of seven minutes was found to be common in Brazilian apartments, and, over nine minutes at a South African university.

The lower volume of water used per shower in Skukuza can be partly attributed to the low-flow shower heads that were already in use, but that would not explain the significantly shorter shower times. "This may be indicative that the typical visitor to

the park is already cognisant of their water usage and mindful of saving the resource," Smit says.

Lesson 2: using information and technology in combination work best

In the trial chalets with infographics only, showers were 27 seconds shorter (a 10% reduction) than the 'normal' chalets. Showers in the chalets fitted with the Triton Xerophytes were 50 seconds shorter (an 18.3% reduction) and in the chalets with both infographics and water unit mixers combined, showers were 63 seconds shorter (a 23.4% reduction). Since the flow rate is also better regulated in showers with Triton Xerophytes installed, the average volume of water saved per showering event was around 30%.

We learned that this type of intervention [providing additional information to motivate behavioural change] works better when used in combination with water-saving technology, Smit says. "Through the research process, we generated new ideas on how one can further increase the impact of behavioural change."

Lesson 3: more water can be saved when and where it's cold

Showers became longer, and used more water, as temperatures dropped, though much less so in the chalets where the Triton Xerophyte were fitted. Rather, the water-saving margin between the 'normal' chalets and those with trial shower units increased as temperatures decreased. At temperatures lower than 5°C, savings of 16 litres (about a 50% reduction) in comparison to control showers were achieved. "The savings were actually surprising even to us," de Bruyn says. "It was extraordinary."

"We learned that showering volume was higher, and the time a shower tap was running was considerably longer, during colder rather than warmer conditions in the absence of the Triton Xerophyte, but where the technology was installed, the water usage was less dependent on the ambient temperature," Smit says. This result provides important insight into which parks may be best suited for this type of technology intervention. Their value, Smit says, will be highest in parks with very cold winter evenings and mornings, when visitors typically take their showers, and where water is scarce such as the Kalahari and Karoo national parks.

Scaling up the benefits

Over and above the volume of water that can be saved, which reduces the impact of water abstraction on aquatic ecosystems, there are also knock-on financial and environmental savings. These include the cost and impact of water purification, distribution and treatment after use. Another critical saving is the energy saved by heating smaller volumes of water to the required temperature.

The researchers figured that taking the average shower volume of 17.3 litres in mind, when both the technology and infographic interventions are implemented, in comparison to the average shower volume of 25.5 litres without any intervention, the park could have saved 3.28 million litres of water and 72 000 kWh

in the 2019/20 financial year when just over 400 000 overnight visitors stayed in Kruger (if each overnight visitor showered once per day and no water was lost through leaks).

Initially, however, such savings will not come cheap. Each Triton Xerophyte unit retails at R9 985. It is unlikely that SANParks will be able to invest on a large scale in this type of technology," Smit says. However, he adds that corporate sponsorship may be a possibility to explore in order to operationalise these and/or other technology to reduce water usage in some of our national parks. "This will not only result in water saving within the parks, but may also have an educational role to play, hopefully resulting in pro-water saving behaviour of tourists when they return to their homes."

In this way, our protected areas can act as catalysts for change in the broader society. The study results point out that this is also one of the responsibilities of our national parks. However, the message is also clear that safeguarding the precious water resources of our protected areas is as much the responsibility of SANParks and those that share the catchments, as the tourists that visit from afar.



Petro Kotzé

Tourists and staff are the main human water users in the Kruger National Park.

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WOMEN IN SANITATION

Celebrating South Africa's women in sanitation – working hard to provide dignity to all

A recently held virtual seminar, hosted jointly by the Water Research Commission (WRC), the South African Sanitation Technology Enterprise Programme (SASTEP), and the University of KwaZulu-Natal (UZKN), focused on the experiences of women in the sanitation innovation field. Matthew Hattingh reports.

Worldwide, big cities traditionally rely on centralised wastewater works and labyrinthine sewers to meet their citizens' toilet-time needs. This big-ticket infrastructure provides for flush-toilets, long prized as the 'gold standard' in sanitation. The trouble is that cities are growing and the pipes cannot keep pace. More to the point, municipalities often lack the cash and the capacity to put them in or to keep them maintained.

In the case of Durban, city finances have been stretched by a COVID-induced economic downturn, last year's July riots and the floods earlier this year (which also swamped treatment plants). To this catalogue of woe must be added water scarcity and the likelihood that climate change will make matters worse.

Prof Cathy Sutherland, an urban geographer at the University of KwaZulu-Natal, suggests: if the city is to honour citizens' constitutional right to basic sanitation, it must start to do things differently.

Sutherland was leading a workshop, hosted by the WRC, on 'Changing the Sanitation Landscape: Narratives of Women in Sanitation Innovation'. And as she and other speakers told the online gathering, 'differently' will require a lot more off-grid or non-sewered sanitation solutions. It should also involve women much more in decision-making, give them a fairer deal in the sanitation workplace, and provide services mindful of their needs.

Drawing on work, field-testing new technology through the university's Water, Sanitation & Hygiene (WASH) R&D Centre, and her research on social transformation, Sutherland presented the webinar with a way of "conceptualising city-wide inclusive sanitation".

The delegates, who all link in what she calls the "sanitation innovation chain", included researchers, engineers, a businesswoman, a municipal official, a community worker, and

the WRC's CEO. These women share a professional or personal interest in making toilets safe, clean and dignified for others.

The workshop explored their work, detailing difficulties and opportunities they face. The delegates grappled with "gendered relations" between men and women, access to power and workplace dynamics. They shared personal stories and revealed home truths about sanitation in South Africa.



Prof Cathy Sutherland

REFILWE LESUFI



As a child, Refilwe Lesufi vividly remembers going to the toilet at her grandmother's place in rural Limpopo. "You were expected to use a small room which makes you feel claustrophobic and you feel like there might be snakes and other things hiding there."

Those were fretful visits for Lesufi, "privileged" to have grown up in a township home with a flushing toilet. "I realised then there were significant differences in levels of service," she says. Now, many years later, with children of her own and a career as a civil engineer (including leadership roles in her profession), Lesufi recalls that moment of understanding as the start of her "story with sanitation".

Encouraged by her parents and teachers, she did higher-grade maths and science at school, which opened the doors to the University of the Witwatersrand. An Eskom bursary paid her way, with the parastatal also providing her first job. Other jobs followed over the years, including a spell with a firm of consulting engineers, working on the design of municipal water and sewerage infrastructure.

In 2011 she started her own firm, Prana Consulting. It was an opportunity to get into business while realising a passion for "providing services for communities that were unserved and underserved".

Prana did work for the Accelerated and Shared Growth Initiative for SA (AsgiSA) programme. It took Bryanston-based Lesufi to the Eastern Cape, Limpopo and KwaZulu-Natal where she assessed school infrastructure. "I realised there was a dire need for proper, basic level infrastructure, sanitation being one of them," she says. "It was so sad. The pit latrines we were seeing were not properly designed. It was as if they were an after-thought that the schools themselves had to put in. There was no engineering... which made them unsafe."

A 2018 visit to the Reinvented Toilet Expo in Beijing, introduced Lesufi to alternative toilet technology. Here were lavatories that worked without connections to municipal sewers. It was a "lightbulb moment" seeing solutions to the problems she had encountered at the AsgiSA schools.

From 2020 Lesufi has been involved in testing non-sewered flushing toilet technology. It treats wastewater on site, using it

for flushing or irrigation. With the technology proven suitable for local conditions, attention turned to local manufacture, the aim being to drive down costs and make it more affordable, while creating jobs.

Turning to sanitation and gender, Lesufi says women have in the past been excluded from the industry. Men design and construct sanitation products and infrastructure, yet "cannot fully understand the nuances of a woman's needs".

A lack of financial investment by the state and corporates makes the sector a tough place to do business for women, but they need to be there. "As women we bring different values to the table and if we are allowed the opportunity to participate in decision-making it would take the sanitation sector far," she says.

RUTH COTTINGHAM



Ruth Cottingham's glass is neither half empty nor half full. Instead, it contains a small cake of dried and treated faeces. We are referring to a picture she shared with the webinar of herself, smiling as she lifts a wine glass.

"When I meet someone for the first time and they ask me what I do for a living," she says, "I have to decide how to answer that question. Sometimes I will just say I am an engineer, or I am involved in water and sanitation. But if the person looks particularly brave or interested I tell them the whole truth, which is that I go to work every day... and I test toilets. I love my work." An associate with Durban-based Khanyisa Projects, she tests technologies that aim to offer off-grid alternatives as acceptable to users as any conventional system.

Cottingham grew up in a number of places, notably southern Spain, and life in this drought-prone region gave her an early appreciation of water scarcity. An interest in toilets came later. She studied chemical engineering in Britain and went into the water sector, joining a large consulting firm, working on the design and construction of a number of large, centralised wastewater treatment plants.

Cottingham realised she wanted to deal more directly with environmental issues. Her young life had given her a taste for cultural diversity. Which brings her (by way of a stint in Mozambique) to South Africa – home for the past 10 years.

She is inspired by the “huge variety” of people she works with, especially the users of the toilets themselves, people she had no direct dealings with earlier in her career. “Diversity of perspective makes us do better work,” she says.

Cottingham finds her employers supportive and flexible – something she really valued when her son was little. It’s crucial that women be given space to balance the demands of work and family, so that they aren’t lost from the sector, she says. Like the other speakers, Cottingham touched on the hardships women face with sanitation, especially in informal settlements, adding to the burden of caring for children, the elderly and disabled. “When you need a toilet, it’s not always available.”

She sees the provision of decent sanitation as a social justice issue, crucial to giving people a better chance in life. On solving the global sanitation crisis, she says that alongside developing new technologies, focus is needed on keeping systems running. At many schools in South Africa, she notes, newly installed toilets quickly fall into a state of disrepair. “We need to find better ways of managing operation and maintenance of communal sanitation facilities. Developing good off-grid solutions is only half the challenge.”

LUNGI ZUMA



Chemical engineer Lungi Zuma is delighted more women are entering the sanitation sector. This, and increasing diversity in age and race are contributing to innovation. It’s also creating opportunities in the market for businesswomen, says Zuma, a chemical engineer with the eThekweni municipality’s water and sanitation unit.

“I would love to see women taking more of that space and making money from the sector and not being shy about that,” she says, “we need many more Refilwe’s in this sector.” Zuma is responsible for coordinating eThekweni’s sanitation research work with partners including the WRC, the University of KwaZulu-Natal and the Bill and Melinda Gates Foundation. She tells of the satisfaction the work gives her, “making a positive impact in people’s daily life and bringing about dignity”.

Since 2014, when she began work as a water and sanitation engineer, Zuma has witnessed a shift in the profession from an overwhelming focus on “numbers and technical solutions”,

to “appreciating and recognising there is a social part to the provision of sanitation”. Here she credits the team at WASH. In the development of her own career, Zuma paid tribute to a previous boss, Teddy Gounden. Not only was Gounden supportive, putting her name forward for projects and events, but watching him at work taught Zuma a thing or two about how to “implement innovations within a very rigid and bureaucratic institution like a municipality.”

NOKUTHULA KUBHEKA



When Pietermaritzburg civil engineering technologist Nokuthula Kubheka first started travelling widely for work, it was the novelty of new places that energised her. These days, helping other women in sanitation provides the biggest satisfaction.

Employed by consultancy Partners in Development, Kubheka’s work includes coordinating and leading field teams on sanitation research projects and training school janitors. “The majority of people doing this job are women and no-one recognises or supports them,” she says. Understanding the difficulties women like this face and including them in decision-making is vital to motivating them and for the success of projects.

She appreciates her boss David Still’s no-nonsense approach. “He is a leader and he gets his hands dirty. Gender seems not to exist for him. Male or female, we all get our hands dirty and he makes us jump from ridiculous heights, after him of course.”

Kubheka, who cut a natty figure at the webinar, points out to delegates a glamorous picture of herself in her opening slide – peroxide hair-do, bright lipstick and a floaty top, sitting at a trendy street café – and contrasts it with another pic, this time she’s wearing blue overalls and operating a Pitvaq pit latrine emptying machine.

“I do get my hands dirty,” she says, speaking of her pride in her work. But she acknowledges that on bad days she questions her career choices. Sanitations, she says, is a male-dominated field. But she is resolute and points out that women are slowly finding their voice and “challenging men in addressing sanitation and social issues in their communities”.

NOMANDLA NQANULA



That progress is being made to provide safe and dignified sanitation is apparent from Nomandla Nqanula's presentation. Equally clear is the mountain of work ahead if the lives of millions are to improve, particularly women living on the margins of our cities.

Nqanula is an "Enviro-Champ". A resident of Durban's Quarry Road West informal settlement, she has been trained to keep tabs on leaky taps and to report sanitation problems, uncollected waste and other faults to the municipality. She is also part of efforts to improve the condition of community ablution blocks (CABs) in her area.

Quarry Road West, sandwiched between the M19 highway and the banks of Palmiet River (a tributary of the Umgeni), was hard hit by the April floods. "Since the floods, we cannot clean up the waste in the riverbed in Quarry Road. As there are no functioning toilets, people are using the riverbed to go to the toilet," she says, "This makes our work very difficult as the sewage is mixed with the solid waste."

The municipality's introduction of CABs some years ago has been widely welcomed. But keeping a total of 1200 CABs in a fit state is a stretch. They may be called "restrooms", says Nqanula, but for the women who use them the experience is anything but restful.

"The CABs do not always work so we have to share the working CABs with men. You feel very uncomfortable while you are inside with them." Men frequently fail to knock – "so you have to watch out for yourself" – while others smoke inside.

She says women risk diarrhoea as well as urinary tract infections from long waits in toilet queues.

Sometimes there are no bins for sanitary pads at the CABs. This "leaves you with no confidence and everyone likes to look at you when you come out of the toilet, especially men". Desperate for privacy, some wait till after dark, but doing so brings its own troubles. "A woman we know went to the CAB at night and she was attacked. Luckily she screamed and fought back." Nevertheless, Nqanula sees opportunities for change and welcomes the support of engaging in innovative sanitation projects.

JENNIFER MOLWANTWA



Jennifer Molwantwa, as of April the first black woman chief executive officer in the WRC's 50-year history, spoke about the role others have played in fostering her career. She called on women to identify and nurture talent in others.

"Be intentional about it. Don't just hope it's going to happen. That is the main challenge for our country. We are hoping there will be a pool of excellent women leaders coming from somewhere when we are not doing the work," she says.

The country faced a "leadership challenge" in achieving gender parity in the boardroom and workplace and action was needed. The WRC, she says, is stepping up – making it a point to increase the number of women in research.

Women leaders have a role to make space for others, she says. "History will judge us if we don't make sure women are nurtured and taken onto the centre stage."

"Women are slowly finding their voice and challenging men in addressing sanitation and social issues in their communities."

STERKFONTein DAM – AN INTERESTING COG IN A MUCH BIGGER SCHEME

Nils Rowther/Flickr



Sterkfontein Dam statistics

Type	Earthfill
Height above lowest foundation	93 m
Gross capacity of reservoir	2 656 million m ³
Crest length	3 060 m
Volume content	19 million m ³
Type of spillway	None
Capacity of outlet works	220 m ³ /s

Sources: SANCOLD, Water Wheel archives

The Sterkfontein Dam is located on the Nuwejaarspruit, a tributary of the Wilge River, part of the Vaal River catchment. The dam is situated near Harrismith, in the Free State, and is the largest earth dam in South Africa. The dam, completed in 1977, forms part of the Tugela-Vaal transfer scheme. The embankment is a typical earthfill design 3 060 m long with an impervious core sloping upstream. The dam wall has a height of 93 m (raised from the original 68 m in 1983) and gross capacity of 2 656 million m³. Due to its small catchment area with negligible natural inflow the dam required no spillway, which made it unique. Interestingly, the dam wall contains 17 million m³ of fill (at the time of construction it was the biggest earthmoving job the Department of Water and Sanitation had ever undertaken). Interestingly, the storage capacity of the Sterkfontein Dam is virtually the same as that of Vaal Dam, while its water surface area is only 20% of that of Vaal Dam. The evaporation losses from Sterkfontein Dam are accordingly far lower than those from Vaal Dam. Water is therefore kept in reserve in the more efficient Sterkfontein Dam and only released once Vaal Dam is at its minimum operating level thus saving appreciable evaporative losses.

- To read more about the Tugela-Vaal transfer scheme, Visit, <https://bit.ly/3wx4dBn>



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