THE WATER WHEEL

JANUARY/FEBRUARY 2025 Volume 24 No 1

GROUNDWATER SOURCES

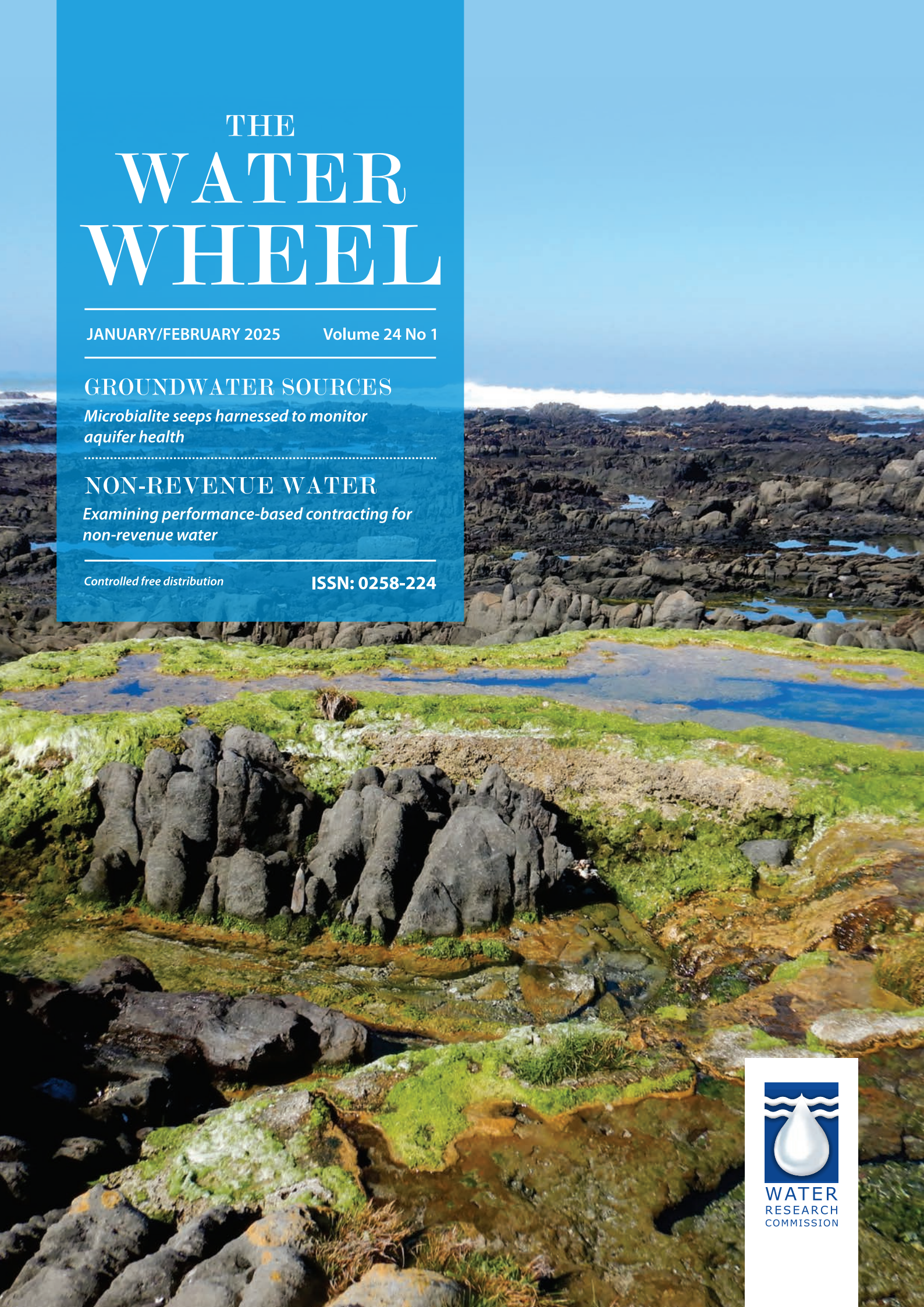
Microbialite seeps harnessed to monitor aquifer health

NON-REVENUE WATER

Examining performance-based contracting for non-revenue water

Controlled free distribution

ISSN: 0258-224



WATER RESEARCH COMMISSION

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.

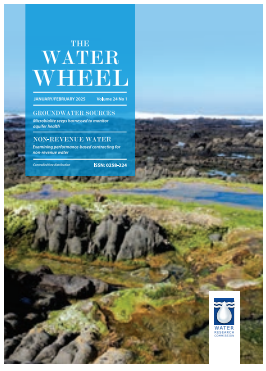
Editorial Committee:
Prof Sylvester Mpandeli (Chair), Ms Manjusha Sunil, Mr Bonani Madikizela, Dr Mamohloding Tlhagale and Dr Sudhir Pillay.

Editorial offices:
Water Research Commission, Private Bag X03, Gezina, 0031, Republic of South Africa.
Tel (012) 761 9300.
WRC Internet address:
http://www.wrc.org.za
Follow us on X:
@WaterWheelmag
Editor: Lani van Vuuren,
E-mail: laniv@wrc.org.za;
Layout: Anja van der Merwe,
E-mail: anjavdm@wrc.org.za

Contents

A project funded by the Water Research Commission investigated whether coastal microbialite seeps could be used to monitor local aquifer resources. See article on page 10.

Cover image by Gavin Rishworth



NEWS

Call for private-public sector collaboration to address sanitation challenges

Deputy Minister of Water and Sanitation, David Mahlobo, has called for enhanced collaboration between government, the private sector and civil society and for technological innovation to be employed to help address sanitation challenges as experienced in parts of the country.

He was speaking during a commemoration event for World Toilet Day on 19 November, hosted by the Water Research Commission. The minister noted that, although significant progress had been made to provide safe sanitation to all households since 1994, more work still needed to be done.

"Through the provision and the efforts of government and key stakeholders, the percentage of households with access to improved sanitation …grew from 61.7% to 84.1%," noted Mahlobo. "Despite the notable work, we admit as government that we need to keep our sleeves rolled up to ensure that all citizens of this country get to experience the pleasure of dignified sanitation facilities."

The minister further called for the investment of sanitation infrastructure and technological improvements in order to address sanitation challenges. "We need significant investments in modern sanitation infrastructure and creative, forward-thinking solutions. Together, we can drive the change required to overcome the challenges in the sanitation sector."

Mahlobo acknowledged the innovative projects being undertaken by the WRC aimed at finding alternative sanitation solutions. These so-called next generation sanitation technologies, which are both water-efficient and energy-neutral, are driven by the South African Sanitation Technology Enterprise Programme, with funding by the Bill & Melinda Gates Foundation.

In another initiative, the Department of Water and Sanitation has developed the National Faecal Sludge Management Strategy. The strategy is aimed at providing guidance to the sector on safe management of faecal sludge to enhance operation and maintenance of on-site sanitation systems, prevent groundwater contamination, safeguard public health, and protect the environment from pollution throughout the sanitation service chain.

Africa's first platform launched for vocational excellence in water management

The Energy and Water Sector Education and Training Authority (EWSETA), along with partners, has launched the Platform of Vocational Excellence (PoVE) in Water Management – the first initiative of its kind in Africa.

"South Africa faces an ageing workforce in the water sector, and bridging the gap between veteran professionals' institutional knowledge and the vocational training of young entrants remains crucial. PoVE is a critical initiative to advance sustainable water management in our country," noted Robyn Vilakazi, EWSETA Skills Delivery and Quality Assurance Executive.

Pieter Hoekstra, European Union representative and the Centre for Innovative Water Craftmanship Water Programme Manager, highlighted the initiative's broader significance. "This is not just about training water professionals – it's about shifting mindsets and encouraging responsible water use at all levels of society. From plumbers to civil engineers, everyone needs the knowledge to manage water resources effectively."

BACK TO TOP

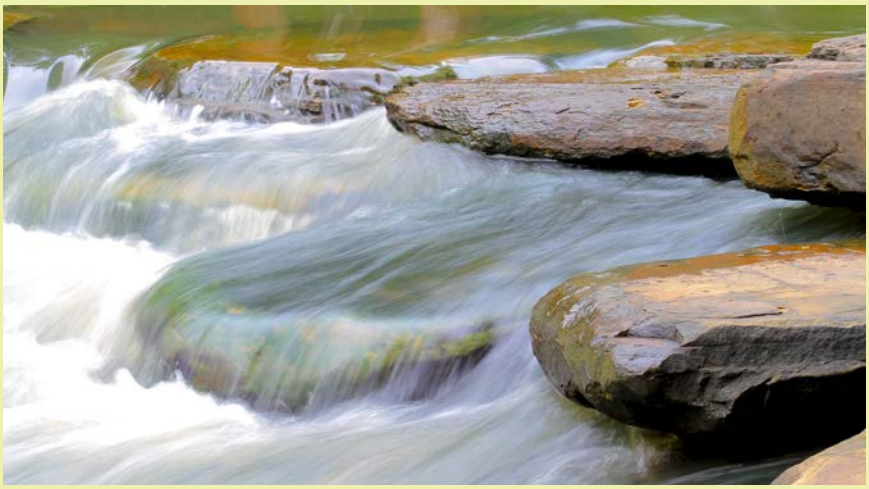
Initiative launched to advance environmental research and sustainability

The picturesque northern Drakensberg area formed the backdrop to the launch of the Expanded Freshwater and Terrestrial Observation Network (EFTEON) on 12 November 2024.

Funded by the Department of Science, Technology and Innovation (DSTI) and implemented by the South African Environmental Observation Network (SAEON), EFTEON represents a transformative step in how the country collects, analyses and applies environmental data. Addressing the launch, DSTI Acting Director-General, Gugulethu Zwane, said EFTEON is a commitment to understanding and preserving ecosystems for future generations: "This initiative demonstrates South Africa's dedication to the United Nations Sustainable Development Goals, particularly those addressing biodiversity, climate resilience, and water management. It also reflects our national strategy to blend scientific innovation with societal needs."

The platform is specifically designed to monitor critical ecosystems, integrating sophisticated tools, such as remote sensing, automated sensors and artificial intelligence-powered data analytics. By providing real-time, high-quality data, EFTEON will contribute to addressing societal grand challenges such as climate change, biodiversity loss, land use change and pollution.

EFTEON is one of 13 research infrastructures established under the South African Research Infrastructure Roadmap, a strategic initiative launched in 2016 by the DSTI. The roadmap aims to strengthen the public research system by building infrastructure that support cutting-edge scientific inquiry.



Diary

Water reuse
16-20 March
The 14th IWA International Conference on Water reclamation and Reuse will take place in Cape Town under the theme 'Overcoming the barriers for reuse of water'. For more information,
visit: https://iwareuse2025.com/

Aquifer recharge
28 April – 2 May
The 12th International Symposium on Managed Aquifer Recharge will take place in Stellenbosch under the theme 'From theory to implementation and operation'. For more information,
visit: https://ismar12.org.za/

Irrigation
13-15 May
The symposium of the South African National Committee on Irrigation and Drainage (SANCID) will take place in Bloemfontein. For more information,
visit: https://www.sancid.org/

Large dams
15-23 May
The 28th Congress and 93rd Annual Meeting of the International Commission on Large Dams will be held in Chengdu, China. For more information,
visit: https://www.icold-cigb.org/

Municipal engineering
29-31 October
The 88th IMESA conference will take place in East London under the theme 'Sustainable Engineering Solutions'. The call for abstracts is open until 10 April 2025. The main themes for the conference include buildings, structures and housing; ecological, environmental and social; electrical and electronic; financial, legal and regulatory; transport, roads and stormwater, as well as water and sanitation. For more information,
visit: https://conference.imesa.org.za/call-for-papers/

BACK TO TOP

GLOBAL

One of the tiniest frogs 'ever' discovered in Brazil

A frog smaller than a pencil eraser has hopped into the record books as one of the smallest vertebrates known to science. Researchers formally described the species in late October 2024 after encountering it in the Atlantic Forest in southeastern Brazil's São Paulo state.

At a length of 6.95 mm, ***Brachycephalus dacnis*** has given scientists a new appreciation of just how small vertebrates can get. The only known frog smaller than this, found in February 2024 in northeastern Brazil, beats it by just 0.5 mm but struggles with balance.

Frogs in the tiny ***Brachycephalus*** genus are notorious for their clumsy landings, often tumbling over or falling on their heads after jumping, as their vestibular systems were compromised in their evolution to be small. But the ***B. dacnis*** retained its inner ear structure, allowing it to hear and leap quite proficiently. Researchers found that it can jump an impressive 32 times its own size, with surprising grace.

"The size makes this frog very special," Edelcio Muscat, one of the researchers who described ***B. dacnis*** and a coordinator at Projeto Dacnis, a conservation NGO working in the Atlantic Forest. "The miniaturisation process hasn't affected any of its organs or its skeleton."

Brazil is home to the world's largest number of amphibian species, most of them in the Atlantic Forest, a biodiversity hotspot encompassing Brazil's largest cities, São Paulo and Rio de Janeiro, with dozens of species described every year. Just 13% of the original Atlantic Forest remains.

"The discovery of this species reveals how much we've lost without even realising it," noted Adrian Garda, a herpetologist at the Federal University of Rio Grande do Norte, not involved in the study. "Right before our eyes, such a peculiar and extremely miniaturised vertebrate existed. What might we have lost over the past 40 to 80 years of industrialisation?"

Source: Mongabay.com

Machine learning predicts highest-risk groundwater sites

An interdisciplinary team of researchers has developed a machine learning framework that uses limited water quality samples to predict which inorganic pollutants are likely to be present in a groundwater supply.

The new tool allows regulators and public health authorities to prioritise specific aquifers for water quality testing. While the proof-of-concept work focused on Arizona and North Carolina, in the US, it could be applied to fill critical gaps in groundwater quality in any region.

"Monitoring water quality is time-consuming and expensive, and the more pollutants you test for, the more time-consuming and expensive it is," says Yaroslava Yingling, co-corresponding author of a paper describing the work and Professor of Materials Science and Engineering at North Carolina State University. "As a result, there is interest in identifying which groundwater supplies should be prioritised for testing, maximising limited monitoring resources. We know that naturally occurring pollutants, such as arsenic of lead, tend to occur in conjunction with other specific elements due to geological and environmental factors. This posed an important data question: with limited water quality data for a groundwater supply, could we predict the presence and concentrations of other pollutants?"

To address this challenge, the researchers drew on a huge data set, encompassing more than 140 years of water quality monitoring data. This data was set to 'train' a machine learning model to predict which elements would be presented based on the available water quality data.

A key finding of the study is that the model suggests that pollutants are exceeding drinking water standards in more groundwater sources than previously documented. While actual data from the field indicated that up to 80% of sampled locations were within safe limits, the machine learning framework predicts that only 15% to 55% of the sites may truly be risk-free.

• To view the original article, Visit: https://pubs.acs.org/doi/10.1021/acs.est.4c05203

BACK TO TOP

Researchers identify previously unknown compound in drinking water

A team of researchers from the United States and Switzerland have reported the discovery of a previously unknown compound in chloraminated drinking water.

Inorganic chloramines are commonly used to disinfect drinking water to safeguard public health from diseases such as cholera and typhoid fever.

The researchers have now identified chloronitramide anion, chemically expressed as Cl-N-NO^2 – as a product of inorganic chloramine decomposition. While its toxicity is not presently known, its prevalence and similarity to other toxic compounds is concerning and warrants further study to assess its public health risk. Simply identifying the compound has been a challenge and breakthrough.

Julian Fairey, an associate professor of civil engineering at the University of Arkansas, was the first co-author on the paper published in Science. Fairey noted that researchers have known about the compound for decades but have been unable to identify it. "It is a very stable chemical with a low molecular weight. It is a very difficult chemical to find. The hardest part was identifying it and proving it was the structure we were saying it was."

This included being able to synthesise the compound in his lab, which had never been done before. Samples were sent for analysis to his colleague and co-first author on the paper, Juliana Laszakovits, a postdoctoral researcher at ETH Zurich.

Inevitably, there are questions about the health risks posed by this newly identified compound, which could not be previously evaluated in any toxicity studies. Identifying this compound is an important step in that process. Whether chloronitramide anion will be linked to any cancers or has other adverse health risks will be assessed in future work by academics and regulatory agencies. At the very least, toxicity studies can now be completed on this compound thanks to this discovery.

• To view the original article, Visit: https://www.science.org/doi/10.1126/science.adk6749

Hottest decade recorded to date

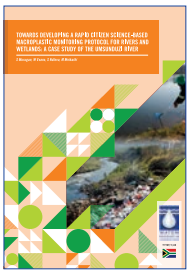
The World Meteorological Organization (WMO) has declared the years 2015-2024 the hottest on record, with 2024 being the hottest of them all.

The January to September global mean surface air temperature was 1.54°C (with a margin of uncertainty of about 13°C) above the pre-industrial average, boosted by a warming El Niño event, according to an analyses of six international datasets by WMO. "Climate catastrophe is hammering health, widening inequalities, harming sustainable development and rocking the foundations of peace. The vulnerable are hardest hit," said UN Secretary-General Antònio Guterres.

"It is essential to recognise that every fraction of a degree of warming matters. Whether it is at a level below or above 1.5°C of warming, every additional increment of global warming increases climate extremes, impacts and risks," added Celeste Saulo, WMO Secretary-General. "The record-breaking rainfall and flooding, rapidly intensifying tropical cyclones, deadly heat, relentless drought and raging wildfires that we have seen in different parts of the world (last) year are unfortunately our new reality and a foretaste of our future. We urgently need to reduce greenhouse gas emissions and strengthen our monitoring and understanding of our changing climate. We need to step up support for climate change adaptation through climate information services and early warnings for all," she added.

BACK TO TOP

NEW WRC REPORTS



Towards developing a rapid citizen science-based microplastic monitoring protocol for rivers and wetlands: A case study of the Umsunduzi River

Macroplastic pollution in rivers and wetlands is a growing environmental issue that has significant impacts on wildlife, water quality, and human health. Riverine plastic monitoring is crucial for determining the extent and impact of plastic pollution in rivers and for developing effective strategies for plastic waste reduction and management. The data obtained from monitoring can also inform public awareness and education campaigns, as well as policy and legislative actions to reduce plastic pollution. Aquatic plastic monitoring can be achieved through various methods, including manual surveys, citizen science initiatives, and remote sensing techniques, but none have been formalised for a South African context yet. This study conducted an analytical review of current unautomated macroplastic monitoring approaches, protocols and recommendations locally and globally; developed a typology for profiling macroplastic in the uMsunduzi River (Pietermaritzburg); and developed a citizen science-based macroplastic monitoring protocol for rivers.

WRC report no. TT 939/1/24 and TT 939/2/24 (sampling protocol)

Link: https://bit.ly/4f3kmBU(volume 1), https://bit.ly/4ifc4d7 (volume 2)

Policy brief: Promoting the adaptive capacity of rural communities to climate change through holistic catchment management: A case study of groundwater dependent communities in two catchments

South Africa's water reticulation services backlogs spells gloom for rural communities who are served mainly by municipalities that lack the revenue base and capacity to service the water needs of these communities due to their spatial incongruity. This leads to a significant dependence on groundwater, which is increasingly susceptible to climatic and non-climatic changes. A stakeholder-oriented catchment management approach of groundwater in rural communities is thus proffered.

Link: https://bit.ly/4fMcSEF

Position paper: Stopping the superbugs: Surveillance through wastewater systems

The rise of so-called 'superbugs' — pathogens resistant to multiple antibiotics—threatens to undermine modern medicine, making common infections and routine surgeries potentially fatal. Addressing the antimicrobial resistance (AMR) challenge requires innovative, scalable, and cost-effective solutions that can complement current traditional infectious disease management approaches. Wastewater-based surveillance (WBS) is an innovative public health tool that offers a proactive, scalable approach to infectious disease management, providing a critical layer of intelligence to complement traditional detection, reporting, and treatment systems. By leveraging this tool, public health systems can enhance their capacity to combat AMR threats, protecting both public health and antibiotic efficacy.

Link: https://bit.ly/3OD8g7N

Further evidence on the debate to shake off the South African water pricing system – Implementation and assessment of a dynamic water pricing model in South Africa

The overall objective of the research was to offer a critical evaluation of the current water pricing system in South Africa with a move towards improving its overall design to be more flexible and responsive to current economic and social circumstance. This was done under the primary premise that the current pricing system might be inconducive to the changing global and national developments impacting on water as a resource. In economic theory, the price of a good shows the benefit consumers derive from said good and the cost of providing the good. Inefficient pricing systems can result in the poor allocation of the resource, i.e. allocative inefficiency, where the pricing system does not provide the good to where it is needed the most.

WRC report no. 3137/1/24

Link: https://bit.ly/3Vk5W9J

Supporting the enabling environment for public sector uptake of water and sanitation innovations – final evaluation and recommendations

Public water and sanitation institutions have been able to demonstrate emerging innovations. However, the larger scale uptake of these innovations has proven challenging. The public procurement framework is often attributed as one of the main challenges with the wider uptake of innovations. The WRC commissioned a research study to explore the challenges with the existing public procurement and the impact that this has on the procurement of water and sanitation innovations. The findings let to a number of recommendations in this regard, as well as a practitioner's guide.

WRC report no. TT 941/24 (main report) and SP 174/24 (guide)

Link: https://bit.ly/4ib0yiZ (report) and https://bit.ly/3ZALLa3(guide)

A demonstration of treatment technologies for direct potable reuse

South Africa is a water-scarce country, with an average annual rainfall of less than 500 mm per year. The country faces increasing water stress due to prolonged droughts, climate change, and population growth. One solution to address water scarcity and stress is to reuse wastewater, particularly for non-potable uses such as irrigation, industrial processes and toilet flushing. However, the reuse of wastewater for drinking purposes, known as 'direct potable

BACK TO TOP

reuse' (DPR), is still relatively new in South Africa and faces technical, economic, and social barriers. The main expectation from this study was research for the future implementation of direct reuse as a sustainable potable water source in South Africa, with full public support for the technology, operational, maintenance and monitoring effectiveness, and the final water quality. The research was conducted at the Final Effluent Reuse Demonstration Plant (FERDP) at uMngeni-uThukela Water's Darvill Wastewater Treatment Works (WWTW) located in Pietermaritzburg, South Africa. This plant was recently constructed as part of a project to upgrade the Darvill WWTW.
WRC report no. TT 942/24
Link: https://bit.ly/4gj3d8z

Evaluating the removal of contaminants of emerging concern in drinking water and wastewater treatment systems

This project was part of a collaborative WRC-funded project that explored the integration of effect-based methods (EBMs) and chemical analysis to assess the efficiency of contaminants of emerging concern (CEC) removal in drinking water and wastewater treatment plants. Combining EBMs with chemical analysis offers a more holistic evaluation of water quality, helping to identify potential health risks and optimise treatment processes for cleaner, safer water. This report only focuses on the use of chemical analysis to characterise the CECs in source water, and their removal in drinking water and wastewater treatment systems. Additionally, this study also characterises the impacts of wastewater discharge on surface waters and determining the potential impacts of such discharges.
WRC report no. 3166/1/24
Link: https://bit.ly/4gaH24R

To download any of these reports
click on the web link provided, email:
hendrickm@wrc.org.za or visit: www.wrc.org.za

BACK TO TOP

GROUNDWATER SOURCES

Microbialite seeps harnessed to monitor aquifer health

A project funded by the Water Research Commission (WRC) investigated whether coastal microbialite seeps could be used to monitor local aquifer resources. Article by Sue Matthews.

Gavin Rishworth

Mineral precipitation and/or sediment trapping by communities of cyanobacteria and algae at the coastal seeps promotes the formation of Supratidal Spring-fed Living Microbialite Ecosystems, or SSLiME.

Over the past decade, researchers in the Eastern Cape have been studying microbialite ecosystems associated with freshwater seeps along the province's south coast. Initially, when the first few sites were identified in 2012 on the outskirts of Gqeberha (formerly Port Elizabeth), they were referred to as 'living stromatolites' in accordance with the first report of such structures along the South African coast in 2003, near Kei River mouth. Derived from the Greek words for 'layer' (***stroma***) and 'rock' (***lithos***), the term stromatolite is used for layered sedimentary structures that are formed by microbial organisms and that first appeared in the fossil record almost 3.5 billion years ago. Microbialite is a more all-encompassing term that includes non-layered forms.

Where calcium-rich groundwater is discharged as seeps and springs onto the highest zone of the south coast's rocky shores, mineral precipitation and/or sediment trapping by communities of cyanobacteria and algae promotes the formation of microbialites. The research team have dubbed these Supratidal Spring-fed Living Microbialite Ecosystems, or SSLiME – an appropriate acronym given their appearance.

Recently, the research team completed a WRC-funded project to explore the connectivity between the seeps and groundwater. Project leader Dr Gavin Rishworth, a senior lecturer in the Zoology Department at Nelson Mandela University (NMU), explains that the research was largely the work of Carla Dodd and Tristin O'Connell for their respective PhD and MSc theses,

BACK TO TOP

but other scientists from NMU, the South African Environmental Observation Network (SAEON) and the Council for Geoscience made contributions too, as reflected in the list of authors on the final report.

Titled 'Coastal microbialite seeps as accessible monitoring locations of local aquifer resources' (**WRC report no. 3161/1/24**), the report suggests that SSLiME may be useful as indicators of groundwater quality and quantity. In other words, they could potentially act as a proverbial canary in the coal mine in response to pollution and over-abstraction of coastal aquifers.

This is particularly relevant because a drought between 2015 and 2023 meant that many homeowners, businesses and public facilities in Gqeberha installed boreholes to supplement their water supply, while the Nelson Mandela Bay Municipality implemented a massive groundwater development programme – conceptualised in 2010 during a previous drought – that has come online over the past two years. What's more, the small settlements along the largely rural southern coast of the municipal area rely on septic tanks for sewage treatment, so contamination of groundwater with pathogens and nutrients is highly likely, at least in the immediate vicinity.

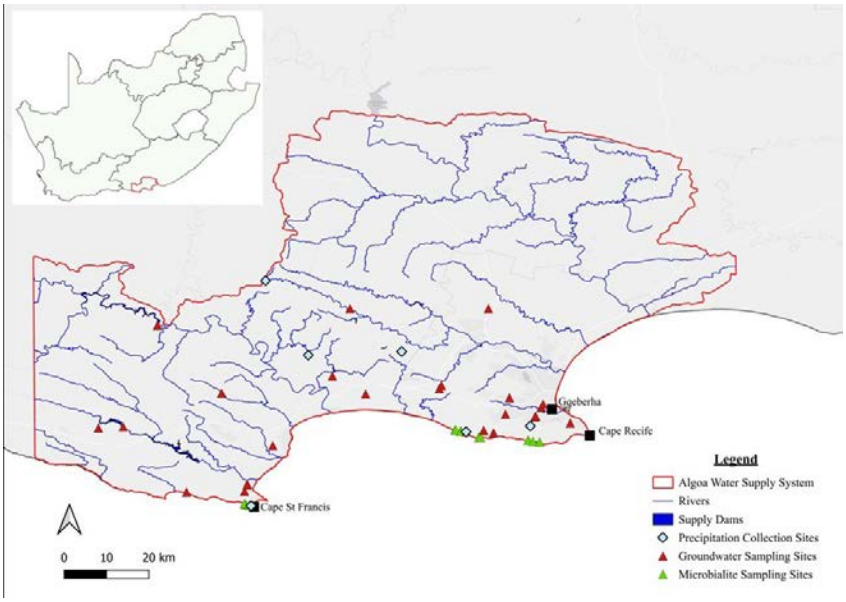
The groundwater resources of Gqeberha consist of the primary Algoa Group Aquifer, where water moves through porous calcareous sands, and the secondary Table Mountain Group (TMG) Aquifer below it, where water is stored in fractures, joints and faults in the hard quartzitic sandstones. While septic tanks lie close to the surface, abstraction boreholes generally target the deeper TMG Aquifer for its high-quality water, which is typically soft and acidic, with low levels of nutrients, calcium carbonate and total dissolved solids.

Given that the primary aquifer is porous and is underlain by hard rock, one would expect the coastal seeps to be fed by groundwater originating from relatively recent rainfall that has infiltrated the soil and then percolated through the primary aquifer to discharge at the coast. The presence of calcium carbonate formations within the SSLiME, with cyanobacteria and algae sustained by nutrient-rich water, would support this conceptual pathway. However, the TMG quartzitic sandstones are exposed along stretches of coast to the west of both Cape Recife and Cape St Francis, where the SSLiME are concentrated, and TMG-fed springs are believed to occur here. The primary aquifer can also be recharged by the TMG Aquifer through faults and fractures at the contact zone, making the source of coastal seep water uncertain.

In an effort to unravel this conundrum and understand the linkages between rainfall, groundwater and discharge via the coastal seeps, the project team compared stable isotope ratios of hydrogen and oxygen in water samples collected both inland and at the coast. Six rainfall stations were set up, each equipped with a dip-in precipitation totaliser as well as a duplicate totaliser, which was protected from rain but partially filled with 100 ml of 'standard' water with known isotopic composition. Once per month, samples were collected from both of the totalisers and the standard water was replaced, allowing the effect of evaporation on isotope ratios to be assessed. Groundwater samples were collected from 27 boreholes and 18 springs and seeps in a once-off sampling campaign conducted over the last two months of 2022, with the coastal seeps sampled again in March 2023 for a seasonal comparison.

Analysis of the samples revealed differences in isotope ratios of coastal groundwater discharge and inland groundwater, but an overlap in isotopic signatures indicated some hydrological connectivity between the catchment and coastal aquifers, or a common recharge area. This means that the SSLiME may well receive groundwater from both the primary aquifer and the TMG Aquifer.

Findings from another component of the project would seem to support this conclusion. A year-long study was conducted on a 40 km stretch of coastline between Cape Recife and Maitland



A map of the Algoa Water Supply System area showing locations of monthly precipitation collection sites, groundwater sampling sites and microbialite sampling sites.

BACK TO TOP

Beach to quantify the amount of groundwater discharging to the coast through the Gqeberha SSLiME. Five main sites were selected with four monitoring points at each, where flow rates were measured on a monthly basis using simple capture-cup or tracer-instrument methods depending on whether the flow was concentrated or diffuse. Assessing the results against South African Weather Service data on rainfall measured at the city's airport for the year of the study and the preceding year revealed that the relationship between rainfall and discharge was highly variable. However, there appeared to be a monthly or seasonal lag between rainfall and discharge, as well as a more consistent baseflow that the research team hypothesise may be contributed by the TMG Aquifer.

Apart from these flow measurements, a once-off estimate of flow rate according to five categories was made at all the other SSLiME locations identified within the 40 km stretch of coastline. Of the 1 533 freshwater seeps, 1 208 (78%) were recorded as having microbialite deposits. Using both the flow estimates and the monthly flow measurements from the 20 study sites, groundwater flowing through the Gqeberha SSLiME was calculated to total some 4 Ml/day.

In addition, water samples for nutrient analyses were collected from both the inflow and outflow of the 20 SSLiME study sites in four seasonal sampling campaigns. For inflowing water, the study sites at Seaview – the largest village along Gqeberha's south coast – had the highest dissolved inorganic nitrogen (DIN) load over the year, followed by those at the smaller Schoenmakerskop village. The highest dissolved inorganic phosphorus (DIP) load was at the eastern extent of Schoenmakerskop, known as Sappershoek. Comparing the inflow and outflow concentrations, the SSLiME systems seemed to be more effective at attenuating DIN than DIP.

The findings suggest that human occupation – with concomitant disposal of sewage and greywater laden with food waste and detergents, as well as fertiliser use in gardens – is responsible for elevated nutrient concentrations. The largest contributor to the DIN content was nitrate, followed by ammonia, which gives a clue as to what may be happening, although this is not addressed in the report. In septic tank treatment systems, most nitrogen in the effluent exiting the tank is in the form of ammonium, but this is converted through nitrification in the drain field to nitrate. If the septic tank is too full of sludge, sewage and greywater flows out of the tank before it has been properly digested by anaerobic bacteria, resulting in clogging of the drain field. This will inhibit nitrification, as will compaction of the drain field or extended saturation that results in anoxic conditions. Both nitrate and ammonium may contaminate groundwater, but nitrate is known to be especially mobile. Septic tanks are not very efficient at removing phosphorus, but it readily adsorbs onto soil particle surfaces once in the drain field. However, calcareous soils provide fewer opportunities for phosphorus removal and are therefore more vulnerable to phosphorus migration in groundwater.

Now that the WRC-funded project has been completed, the research team has embarked on a long-term SSLiME monitoring programme based on a protocol described in the final report.

"A year of monitoring is not enough to draw any well-founded interpretations – at least a decade would be ideal to understand what's really going on here," says Rishworth. "Most of our research to date has been short-term student projects looking at one component or another, or tying together various pieces of the puzzle, but we realised it's now time to bring together all of that research towards an intentional monitoring vision, without a specific hypothesis-driven research question. Knowing that there's likely to be increased groundwater abstraction and other pressures on the groundwater system in the region, having a robust long-term dataset will be important to be able to monitor change."

The monitoring programme will continue the rainfall stable isotope work with a view to generating a reliable local meteoric water line (LMWL) aligned to the standards of the Global Network of Isotopes in Precipitation (GNIP), but will otherwise focus on the SSLiME themselves, as groundwater-dependent ecosystems. This will include monitoring of stable isotopes, hydrochemistry (major ions), physicochemistry (nutrients, pH, temperature, electrical conductivity, etc) and flow rates of seepage water, as well as SSLiME status (accretion, erosion, bioturbation) and distribution counts, possibly making use of lidar or drone imagery.

Certainly, groundwater-dependent ecosystems form an important part of the monitoring programme for the City of Cape Town's TMG Aquifer Scheme at the Steenbras Wellfield, high in the Hottentots Holland mountains. Here there are two aquifers in the TMG – the upper Nardouw and the deeper Peninsula Aquifers – and both are targeted, explains Dylan Blake

Gavin Rishworth

An underwater view of SSLiME in a rock pool.

Gavin Rishworth

The research team at the Schoemakerskop study site.

BACK TO TOP

of Umvoto, the earth sciences consultancy appointed under engineering firm Zutari to undertake groundwater studies and wellfield development for the City.

"There are numerous wetlands, seeps and springs associated with the Nardouw Aquifer at surface within the wellfield area, and where abstraction occurs there is a potential drawdown risk to these groundwater-dependent ecosystems. The Peninsula Aquifer is less of an issue because it's deeply confined in the wellfield area, with the boreholes only tapping into it 700 to 800 m underground, and its groundwater-dependent ecosystems are all in the high mountain recharge zone areas. So it's unlikely that drawdown in the very deep boreholes in the Steenbras Wellfield will impact those, but an extensive monitoring network for both aquifers has been set up to make sure that is the case."

Each ecological monitoring site includes a stream channel and the seep or wetland associated with groundwater discharge, and a wide range of parameters are monitored. Surface to depth monitoring of soil moisture and water levels helps in understanding how the ecosystem is linked to the aquifer, and can identify red flags before serious impacts occur.

"Soil moisture probes are used near the surface along with shallow piezometers at 2–3 m depth, and then for the Nardouw Aquifer we have monitoring boreholes at 50 m depth and 150–300 m depth, whereas for the Peninsula Aquifer the monitoring boreholes are at 100–200 m depth in the mountainous recharge areas and at 700–1 000 m depth within the wellfield areas. The various Nardouw and Peninsula Aquifer boreholes used for abstraction are also closely monitored in terms of groundwater levels and abstraction volumes," says Blake. "The first red flag would be non-pumped groundwater levels in the production boreholes declining over time, followed by long-term groundwater level declines in the monitoring boreholes. The City is busy developing Thresholds of Potential Concern for the various groundwater-dependent ecosystems using a monitoring and modelling approach, so that wellfield operational decisions can be taken long before any impacts become evident in the ecosystems."

Dr Ricky Murray of Groundwater Africa, who has been appointed by the Nelson Mandela Bay Municipality to conduct monitoring and auditing of their recently developed wellfields, agrees that groundwater levels are the most important parameter to monitor. He adds that this monitoring is relatively easy to do, and understanding the results is far more straightforward than trying to interpret ecosystem changes that might be due to other factors.

"What I stipulated in my recommendations, which have been incorporated into the water use licenses for the wellfields, is to limit drawdown so that it doesn't go below sea level," he says. "It's fine if this happens for short periods of time, if an emergency supply of water is needed, but the principle is that you don't want to change the hydraulic gradient – you want groundwater to flow as it has done over the millennia from land to sea. The general hydraulic gradient won't be affected if it is reversed in a small area around the production borehole for a short while, but it's critical to ensure that water levels in the monitoring boreholes are not drawn down below sea level, because they represent the regional hydraulic gradient."

He adds that at the Bushy Park Wellfield, which is situated close to the southern coast where the SSLiME occur, there is a risk that over-pumping of the production boreholes could induce saline intrusion into the aquifer if the hydraulic gradient is reversed. A monitoring borehole has therefore been installed between the wellfield and the coast, and this will give a clear indication of the effect of abstraction from the wellfield in relation to the broader area.

"The monitoring programme here does not include monitoring of groundwater-dependent ecosystems, but there's very close monitoring of groundwater levels. The municipality has a state-of-the-art SCADA system that is continuously capturing electronic data, and the staff keep a watchful eye on it all. Besides electronic cut-off switches that prevent borehole water levels being drawn down below stipulated depths, hourly water level, abstraction and water quality data are stored so that the performance and status of the wellfields and aquifers can be reviewed on an annual basis, as required by the water use licenses. In addition, since data sets of hourly readings would simply become too cumbersome after 20 to 50 years, daily data are stored for future assessments of the effects of long-term groundwater abstraction."

Murray and Blake both point out that private groundwater use in Gqeberha is more of a concern, because it is not being adequately monitored. The municipality's Water & Sanitation Services By-Law stipulates that the use of water obtained from a source other than the water supply system is not permitted without the prior consent of the Executive Director, and in November 2024 the borehole registration form was updated to include details on borehole usage (domestic, commercial or industrial), yield, depth, borehole construction and other information. Anything more than small-scale use classified under Schedule 1 of the National Water Act would also require a water use licence, which would include a range of monitoring conditions and a schedule for submitting reports to the regional office of the Department of Water and Sanitation (DWS). However, compliance is believed to be low, and DWS lacks the capacity to perform the regulatory function effectively.

For the moment, private use of groundwater has likely declined dramatically, because the drought has ended and water levels in the dams supplying Gqeberha have recovered. Nevertheless, the NMU researchers will continue in their quest to improve understanding of the relationship between groundwater and coastal seeps, with their fascinating SSLiME.

"We know that early modern humans would have used this coastline for its rich food resources, but they would have needed readily accessible freshwater sources too, and the seeps likely acted as stepping stones in this regard," says Rishworth. "So they have value not just as monitors of our modern groundwater aquifer resources, but also as a unique cultural heritage asset for South Africa as a whole."

• To access the report, ***Coastal microbialite seeps accessible monitoring locations of local aquifer resources*** (**WRC report no. 3161/1/24**), visit: https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/3161%20final.pdf

BACK TO TOP

WATER REVENUE

Symposium highlights the complexities of the water payment conundrum

Water revenue models in many of our municipalities are broken. The experiences of Durban and Cape Town, while very different, help us understand why… and point to possible fixes. Matthew Hattingh reports.

Almost Tuscan, a tower looms above double doors, windows framed by tall columns, filling a wall from floor to ceiling. Gables break the lines on a tiled roof, with eaves kicking up at their ends. Is that a bit of Bali sneaking into the design mix?

They're a familiar sight on the fringes of our cities and towns, on hillsides in the former homelands: big flashy houses, often worth millions and sometimes built beside modest, even crude dwellings. Simon Scruton, deputy head of the eThekwini metro's water and sanitation unit, calls them "Mzinyathi mansions" – a reference to an area inland of Inanda, north-west of central Durban, where the countryside is fast giving way to the city.

Understanding why funds for the delivery of services in eThekwini are so stretched might start with these grandiose homes. Indeed, their location in places like Mzinyathi go to the heart of a multibillion-rand problem facing most municipalities in South Africa: how do we get the well-off to make a fair contribution to the cost of providing common services? Scruton was speaking at a 12 November webinar which sought to better understand why many of our countrymen (excluding the poor) don't pay for water – and what might be done to change this.

The webinar was hosted by the University of KwaZulu-Natal's

BACK TO TOP

Water, Sanitation and Hygiene (WASH) Research & Development Centre. Jay Bhagwan, Water Research Commission (WRC) senior research manager for water use and waste management, welcomed guests with some context. He said failure to pay for services made 80% of the country's municipalities "technically bankrupt" and he traced this back to the mass rollout of free basic services, notably water, in the noughties.

Extending basic services to people neglected in the apartheid era was vital, but some who could afford to pay for water believed they needn't. "The horses have run away from the cart," said Bhagwan. In eThekwini revenue from the sale of water fell short of the cost of providing it. Unchecked, he warned the under-recovery risked "catastrophe". He added that the WRC had initiated several studies into poor payment, that also sought to understand how poor governance and lack of leadership made matters worse and looked at water theft and vandalism of infrastructure.

The Mzinyathi Mansions were built on communally held, Ingonyama Trust or traditional authority land, which represents 43% of the eThekwini municipal area. eThekwini, established in 2000, expanded the Durban Metropolitan Area by 68% to include satellite towns, farming land, peri-urban and rural homesteads. This land falls under the custodianship of the King and traditional councils. But the municipality had to provide services, the nub of the problem.

To bill for water, the municipality needs an official record, including surveys and demarcation of communal land. But the traditional councils allocate land with their own system and record-keeping. Municipal and traditional systems don't connect, except when people apply for services and have meters installed. Complicating matters, the meters sometimes failed, or land was further subdivided.

"Your normal billing processes of having registered, national addresses… in the billing system, having a domicile, etc, that goes out the window," said Scruton. Which helps explain these mansions "worth many, many millions of Rand" in rural and peri-urban eThekwini. The owners are attracted to traditional authority areas not least "because there's no payment for services across the board". "It really is threatening the viability of the municipality." He said that non-revenue water stood at 54% for the 2023/24 financial year.

Scruton recalled how in the early 2000s the municipality rolled out infrastructure, "like there was no tomorrow", including to poorly serviced Ingonyama Trust areas. "We got into the very high 90s in terms of (the percentage of households) having access to a water supply system," said Scruton. But eThekwini became a "victim of its own success". With more people moving to traditional authority areas and "wholesale tampering", instead of all the homes in a particular system getting their allowance at the allotted time, water was diverted, benefiting fewer homes for longer. The system broke down. "So people… in those areas [are] dissatisfied with the level of service, which in turn has a knock-on, back onto the payment rate."

Scruton and his colleagues saw that traditional engineering solutions – "carrot and stick… and often more stick than carrot" – would not work in these areas if applied in isolation. He doubted installing smart meters would end tampering. Technical solutions should be buttressed by social acceptance or be "doomed to failure".

He was upbeat, however, about a turnaround strategy to "arrest the decline and put us into an upward spiral". This aligned with a National Treasury plan to knock the country's 278 municipalities into shape by paying out certain grant funding provided they met performance targets.

So far, the unit had met initial targets, Scruton said. The focus had been on reforming its operation as a whole, including making the billing and metering chain better, improving customer experience and satisfaction, and enhancing leadership and knowledge management. They also aim to bring support services, like human resources, information technology, fleet management, supply chain management and finance, back into the unit. These were centralised some 15 years ago with a "debilitating effect on our business". Restoring them should make it more agile and responsive to customers, said Scruton.

"In 2016 there had been 1 500 registered boreholes and wells in Cape Town. By April 2019, the figure had soared to 26 000, with many more unregistered boreholes likely."

Scruton regards customer trust and satisfaction as vital to raising payment levels, referring to the rollout of an eThekwini smartphone app (with more than 100 000 downloads) that keeps consumers in the loop about repairs and problems. Prof Cathy Sutherland, of the WASH R&D Centre gave an overview of studies her centre and other colleagues were doing on payment for services. Picking up on Scruton's commentary on households in the Ingonyama Trust, she said land tenure arrangements were "shaping citizens' relationship with the state and perceptions of whether they should or should not be paying for water".

Anxious not to stereotype, she said their research – which spanned literature, legal and policy reviews, plus surveys of 105 households in case study sites and 500 households across eThekwini – revealed that 45% of residents do not pay for water services. This was particularly true of traditional authority areas. In low-cost housing projects and townships, payment levels were better, with affordability and reliability of services, big concerns.

Meanwhile, the city's revenue-centred model for funding water provision meant it treated consumers in the suburbs (careful to pay lest they be cut off) as the proverbial golden goose, deepening inequality. Overall, the ability of citizens to pay for water was declining, lowering the quality of the service metro-wide, and discouraging others from paying or prompting non-payment as a "mundane protest".

Not only was non-revenue water high in the municipality (the ratio of water not paid for by consumers, stolen or lost to leaks versus sold), average consumption was "very high" – up to 298-litres per person, daily, compared to the international average of 173-litres. eThekwini mayor Cyril Xaba on 10 October announced "curtailment plans" to cut consumption by 8.4%. But Sutherland noted the measures Xaba mentioned were "quite traditional" – metering; disconnection of illegal connections; line pressure reduction; and a drive to staunch leaks. The importance of paying wasn't mentioned.

"We have kind of hit the perfect storm," she warned, "We've got a (revenue-based) model … that cannot really sustainably meet the constitutional rights of citizens and support the mandates of the local state and ensure the adequate and just provision of services. We've got a circle of provision failure where citizens cannot afford to pay for services, so they don't contribute to revenue, so they get less quality services." Without revenue, the municipality can't maintain or improve services, leading to poor service delivery.

"And so that cycle continues… [ending up] in low quality service delivery for the poor, increasing the costs for those who can pay and no real clear benchmark for who can and cannot afford water, and how that should be decided." This increases municipal debt, and costs society as a whole.

Sutherland said their research indicated a need to "build social compacts between the state and citizens" and she felt the water and sanitation unit's turnaround strategy sought that. She said all people surveyed in eThekwini supported the provision of free basic water to the poor.

"The trick is," Scruton said, "to identify those consumers who are really indigent so that the municipality could continue with a "certain (affordable) amount of cross-subsidisation." Sutherland agreed that identifying who should pay could be tricky and called for more "localised, nuanced solutions" and hybrid governance, involving partnerships between traditional leaders and municipalities to "reframe citizen responsibility". This was a big ask for a municipality seeking universal systems that can be centralised, but the complexity of eThekwini, with its 4.2-million people, demanded this.

Sutherland spoke of the added difficulties of a changing climate. Metro infrastructure was still recovering from the April 2022 floods, reminding us that new and existing infrastructure must be beefed up to cope with climate shocks, with implications for municipal finances.

According to a study by the WASH R&D Centre, up to 45% of eThekwini residents do not pay for water services.

BACK TO TOP

Sam Cox/Flickr

eThekwini mayor Cyril Xaba has announced "curtailment plans" to cut consumption by 8.4% through metering; disconnection of illegal connections; line pressure reduction; and a drive to staunch leaks.

Elsewhere similar challenges emerged. Cape Town continued to learn from its Day Zero drought.

Dr Nicholas Simpson, chief research officer at the University of Cape Town's African Climate and Development Initiative, told the webinar how water and sanitation charges had previously been a mainstay of City of Cape Town finances, representing about R2-billion or 14% of the money it raised itself. But this changed during the drought, from 2015 to 2020 as dams supplying the city came perilously close to running dry.

Increasingly stringent rationing culminated in a quota of 50-litres per person per day. This, an aggressive communication campaign and other measures, had the intended consequence of throttling use, with consumption in the metro more than halved. A "large swath" of Capetonians found ways to go off grid – including boreholes, rainwater harvesting and desalination schemes.

Simpson said in 2016 there had been 1 500 registered boreholes and wells in the city. By April 2019, the figure had soared to 26 000, with many more unregistered boreholes likely. Many with the means carried on consuming water at levels they had always enjoyed.

The unintended consequences: sales tanked, so did city finances. Cape Town, like eThekwini and other municipalities, had long levied tariffs based on consumption. It sought to recover the cost of operating its water systems from sales (while cross-subsidising the provision of cheap or free water to the poor). Meanwhile, the system needed to be maintained with little scope to trim system costs. Bhagwan explained: "You can't fire everyone because there's no revenue, because you have a drought."

And there was a real likelihood it might happen again. "The entire revenue model of the city is built upon the assumption that demand for those services, for water, would remain constant, or at least predictable over time, which for a policy world, makes good sense, but… we now live in a climate change world," said Simpson. To put its finances on a sounder footing, Cape Town rejigged its tariff structures. Its 2018/19 budget reduced the number of steps in the tariffs, for a higher cost recovery at lower levels of consumption. "In addition, the city agreed upon the introduction of a fixed service charge for electricity and water and sanitation services, independent of consumption levels which they had lost."

Simpson said the fixed service charges were intended to recover the cost of maintaining the service and its infrastructure. Meanwhile, the city had wrestled with governance of access to water. In the past dams were at the centre of water supply; now a hybrid of technologies was able to provide water at levels from household to big business. Simpson felt Day Zero had provided lessons Cape Town could draw on given the distinct possibility another dire drought may hit in the next 10 years, including recognition that investment in ecosystem services, things like clearing alien and invasive species from catchment areas, was "one of the cheapest and best options for biodiversity to… release more water into the system".

"So quite a win there for biodiversity and water access."

BACK TO TOP

NON-REVENUE WATER

Examining performance-based contracting for non-revenue water

Nick Graham, Sophiya Gabier, Lelethu Bodlani and Victoria Johnson report on a potential solution to solve non-revenue water, involving the private sector.

The non-revenue water (NRW) situation in South Africa is dire. The 2023 No Drop Report found that the national NRW figure is 47%, up from 41% in 2018 and 37% in 2012. This means that almost half of the water that is extracted, treated and distributed is never paid for, and the situation is getting worse. The negative financial implications for municipalities are obvious and some of this wasted expenditure could be repurposed to pay private contractors to help address the NRW issues.

Performance-based contracts (PBCs), where the private sector takes risk in implementing NRW interventions in exchange for a portion of the savings, have been implemented successfully internationally and twice in South Africa. PBCs have multiple advantages and appear to be a win-win for both the municipalities and the private sector, but have not been applied at scale in South Africa, despite the growing NRW problem. Research funded by the Water Research Commission sought to answer the question: 'Why not?', and to propose a framework for successful implementation of these forms of contract in a South African context.

Causes of high NRW

There are two broad categories of NRW: technical losses (leaks) and commercial losses (inaccurate metering and billing, and illegal connections). The No Drop Report indicates that the bulk of the problem (70% of NRW) is in technical losses in the water networks. Apparent losses (meter inaccuracies and illegal connections) make up only 18% of NRW, while unbilled connections make up 12%.

BACK TO TOP

Non-revenue water is an indication of inefficient water-supply networks and failing infrastructure, which in turn are symptoms of inadequate management of the systems. The Municipal Infrastructure Grant Framework in the Division of Revenue Act 2023, states that: "Where non-revenue water is in excess of 30% and not decreasing from year to year, the municipality shall be determined to be failing to manage its water supply". According to an analysis of the 2021/22 audited municipal financial statements, this would include 70 out of the 113 Water Services Authorities that reported NRW figures (62%).

Reasons for the high level of technical loss include historically poor maintenance and lack of adequate asset replacement leading to old, leaking infrastructure. To delve deeper, the reasons underlying poor asset management are fundamentally about poor management of the network, a lack of adequate funding or both, and the interaction between these two issues. Losses in excess of 30% of system input volume are likely to be attributable to some extent to a shortage of skills or capacity.

Reasons for commercial losses include insufficient funding to replace faulty meters, insufficient staff capacity / funding for meter reading, political resistance to installing meters, political / community resistance to removing illegal connections and poor billing systems.

Reasons why PBCs are not being implemented

The two main reasons why PBCs have not scaled in South Africa are: 1) that the risks to the private sector have been too high, leading to a lack of interest; and 2) that municipalities lack the skills and experience to design and implement these contracts. PBCs, by design, are intended to transfer performance and financial risk to the private contractor. However, there are several other non-performance risks that may be faced by potential contractors:

- Local political risks – including disruption by the 'construction mafia', community protest or community resistance to the contractor's presence in certain areas.
- Council political risk – that a Council will renege on the contract, or, given the long-term nature of the contract, a subsequent Council will challenge or reject the contract entered into by the previous Council.
- Payment risk – disputes over the remuneration calculation, delayed payment, or total non-payment of agreed amounts.
- Partnership risk – lack of cooperation by municipal officials to gain access to the network, to control impact on the network by third parties, or to collect billed revenue after metering and billing interventions.
- Data quality risk – if data quality regarding the baseline water consumption or the technical details of the network are poor, then this adds to the standard performance risk hat contractors must take.

PBCs are a new form of contract that have only been tested twice to address NRW in South Africa. As such, it may be unfamiliar to municipal officials, who may be reluctant to try this approach, or not know how to design such a contract. Reluctance to enter into a PBC is often linked to the bureaucratic inertia created by the regulatory environment. While a legal

High technical water losses are most likely due to historically poor maintenance and lack of adequate asset replacement leading to old, leaking infrastructure.

review found that there are no legal or regulatory prohibitions on PBCs, some forms of PBCs will trigger Section 33 of the Municipal Finance Management Act, the requirements of the Public-Private Partnership Regulations, or alternatively, the Municipal Asset Transfer Regulations.

PBCs can be designed to avoid these regulatory processes, but this negates some of the advantages of the risk transfer. Municipalities need to match their appetite for regulatory burden with the advantages of greater risk transfer. A lack of experience in these types of contracts can be addressed through external specialist technical support and tools, such as the ones currently being developed by the Water Partnerships Office.

Implications for the applicability of PBCs for NRW in South Africa

The reason for implementing a PBC is so that a private party can address NRW issues that a municipality is unable to address. However, the major underlying reasons for NRW, namely a lack of capacity and lack of money, are also likely to limit the applicability of NRW PBCs. Capacity is an issue because some technical and contract management capacity is needed to scope, engage with, and manage the contractor. Conversely, those municipalities that are well capacitated and can manage their network adequately may not need a PBC. PBCs will usually cost more than if a municipality undertook the same work itself because of the risk and profit that needs to be priced into these contracts. A lack of money is an issue because money is still needed to set up the contract and pay the contractor. While the savings achieved by a PBC are meant to cover the costs of the intervention, there are some up-front costs required, and the municipality still needs to have cashflow to pay the contractor when the incentive payments become due. Municipalities with severe financial issues may not be able to honour PBC contracts.

The implication of these dynamics is that PBCs are most appropriate where there is some, but insufficient internal technical capacity, low internal incentives for NRW reduction and the cost of NRW to the municipality is high, but where the municipality has sufficient financial liquidity and contract management capacity to honour these contracts. The number of municipalities in which these conditions are all true may be limited.

Preconditions for the implementation of PBCs

There are several preconditions that need to be in place to address the abovementioned risks to make PBCs attractive to the private sector and cheaper for the municipality:

- Correct diagnosis: The nature of the NRW problem needs to be correctly understood to specify the correct intervention.
- Credible baseline: Meter records, preferably of minimum night flow, are required to set a baseline against which to pay the contractor.
- Ring-fenced district metered area: The areas in which interventions are planned need to be discreet from other zones and all pipelines supplying the area must be metered.
- Political support: Council support will increase confidence that the contract will be honoured and assist with community engagement.
- Institutional support: Senior management needs to motivate the contract to the Council and to gain adequate and unrestricted access to the network.
- Community support: Benefits to the community need to be communicated to ensure support and develop longer-term assistance with NRW reduction.
- Municipal technical capacity: A minimum level of technical capacity is required to engage with the contractor and to manage the contract.
- Responsibility and accountability: Officials need to be designated as being responsible for the contract and accountable for its success.
- Adequate funding: Funding is required for project setup, fixed fee items and incentive payments when these are due.
- Commercial attractiveness: Preliminary work is required to calculate the potential savings and return on investment to ensure commercial attractiveness.

Conclusion

PBCs have been successful both locally and internationally and offer strong potential to address the rampant NRW in South African municipalities. However, there are reasons why PBCs have not been adopted at scale, which largely relate to municipal technical capacity and the complex and difficult context in which municipalities operate. PBCs should not be seen as an external 'quick fix' to a technical problem or a clever way to finance the fixing of leaks in old pipes. Rather, they are an initial mechanism for intervening in a failing municipal water system. They are one part of a larger, longer-term solution that needs to be found for the lack of adequate technical capacity and resources in municipal water services departments. Municipalities need to be supported to meet all the preconditions to address all the potential risks and to maximise the chances of success.

To access the report, ***Performance-based contracting for non-revenue water and its relevance in the South African context*** (**WRC report no. 3143/1/24**), Visit: https://bit.ly/3VflqdF

BACK TO TOP

WATER SOURCE

Water factories: The intrinsic value of a critical resource in water-scarce cities

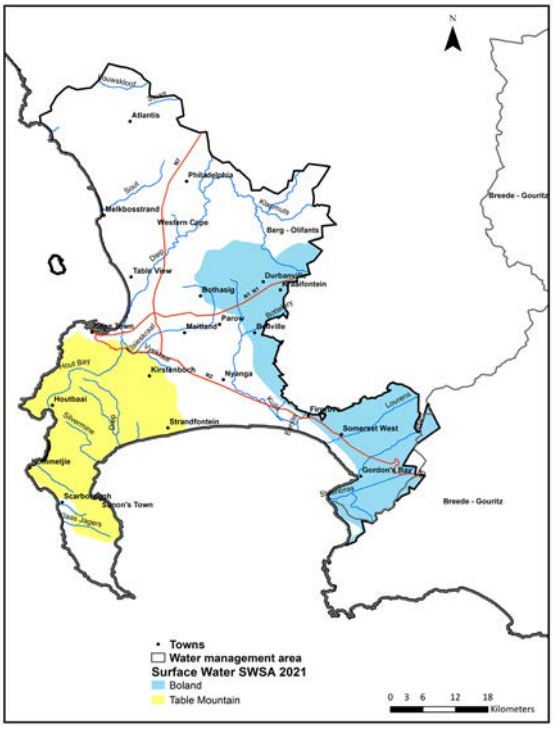
Earl Graham, Chantel Petersen, Lindie Smith-Adao, Ilse Kotzee, Michelle Audouin, Linda Rulumeni and Sarah Davies report on a current project to safeguard South Africa's strategic water source areas.

Water resources are becoming increasingly limited due to a changing climate and increasing population, causing a worldwide decline in water quality, equity and availability. Many water custodians and resource managers recognise the need to improve and provide clean water and sanitation to achieve one of the 17 Sustainable Development Goals by 2030.

Surface water – Strategic water source areas (SW-SWSA's) represent only 10% of the country's land surface area of South Africa, Lesotho and Eswatini but generate 50 % of the region's surface water runoff. Groundwater- strategic water source areas (GW-SWSA's) represent 9% of the land surface in South Africa and generate up to 42% of the baseflow in their areas, performing an important role in the dry season through maintaining surface water flows. Most SWSAs occur in mountain catchments, such as Table Mountain National Park, but others occur as groundwater, such as the Cape Flats Aquifer (see map on this page).

SWSAs provide many benefits to society, including water for domestic (e.g. drinking and cleaning), industrial (e.g. cooling at power stations) and agricultural (e.g. irrigation) purposes. Surface water SWSAs supply water that supports at least half of the population and economic activities that generate more than 64% of Gross Value Add (GVA) and provide water – directly or indirectly – for 70% of irrigated agriculture. The SWSAs are at risk of water pollution and over-exploitation due to an understatement of their importance. For example, only 18 % of these SWSAs surface water areas are formally protected. Pressures and threats on SWSAs are often difficult to fully quantify due to urban sprawl, unplanned or uncontrolled development, industrialisation and agriculture/private land ownership.

Strategic water source areas, especially groundwater areas, do not always follow governmental boundaries and can occur across national, local and private boundaries, presenting challenges in managing and protecting these areas. An innovative project to assist metropolitans and local municipalities in improving the management and protection



Strategic Water Source Areas for surface water (a) and groundwater (b) in the City of Cape Town.

of their SWSAs, thereby supporting the development and the livelihoods of future generations of city dwellers, is the 'Implementation of South Africa's Strategic Water Source Areas (SWSAs): Towards Effective Governance and Protection', which is led by the Council for Industrial and Scientific Research (CSIR) with the support of the Water Research Commission (WRC). Here, 'protection' includes targeted intervention, management and formal protection. The three-year WRC project (April 2022 – March 2025) identified two municipalities as case studies: the City of Cape Town and Wizenberg Municipality. At a local

BACK TO TOP

level, municipal implementation of strategies to maintain and enhance SWSAs is a critical gap that needs to be addressed.

This project developed a user-friendly framework guideline document (publication date to be confirmed) that can assist local municipalities in understanding and determining some of the critical needs surrounding SWSAs, which will, in turn, empower decision-makers and local custodians on how best to manage, protect, and monitor and spatially delineate priority areas for such efforts. The framework will comprise five stages: a situation assessment, a visioning process, the development of strategies, the identification of possible projects and linked activities, and a monitoring and evaluation stage. The guide identifies critical risks to SWSAs (i.e. both for surface water and groundwater) while providing generic strategies around five themes (Figure 2) linked to place-based management recommendations and monitoring indicators to mitigate these risks.

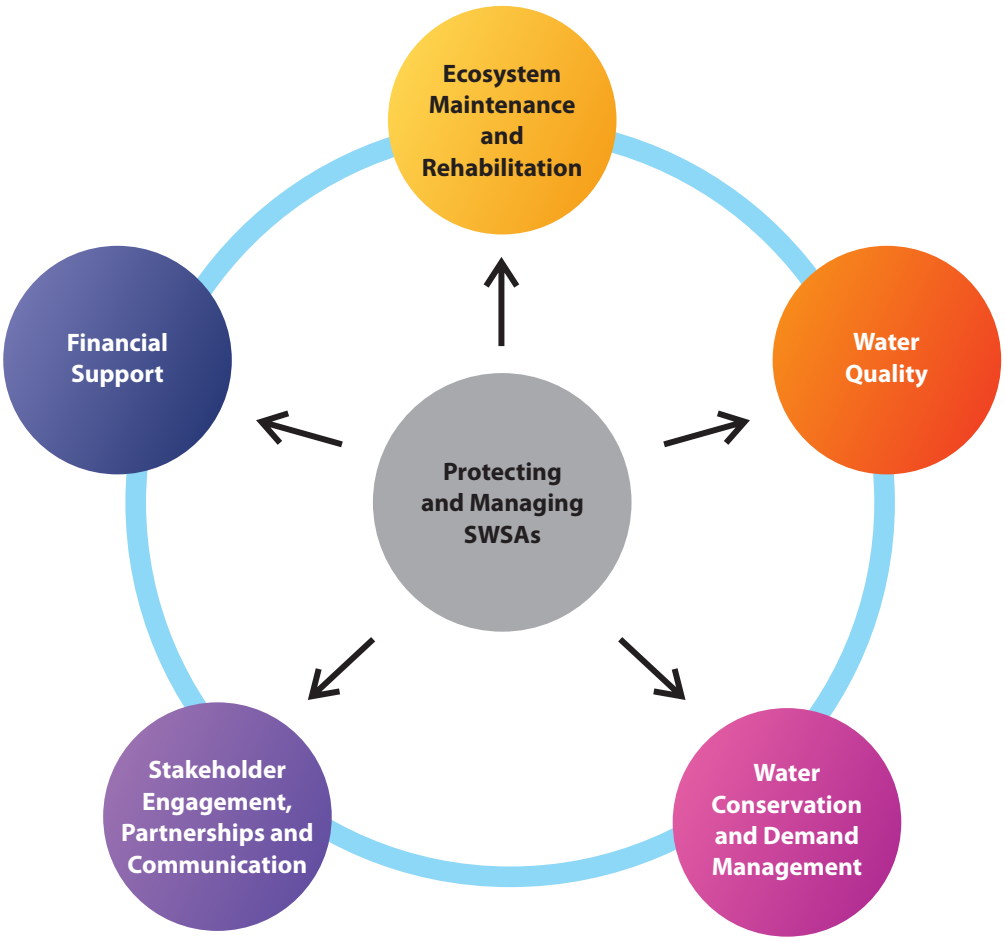
Developing a spatial understanding of key priorities and management needs

- The spatial mapping of priority areas for surface water and groundwater links the management guidelines developed in the framework to the ground-localised actions (Figure 3). This spatial framework would serve to achieve the following:
- Understanding the role of and threats to SWSAs
- Identify key national spatial datasets
- Understand the links between threats, management guidelines, and the strategies and projects identified for SWSAs within local government.
- Improve the management and protection of SWSAs within and between municipal areas.

The project team delineated the spatial framework based on the most significant threats to each SWSA management area. The site-specific projects within those management areas were further reviewed to delineate priority areas and develop site-specific guidelines, allowing for achievable deliverables within measurable timelines. The spatial framework successfully indicated key pressures to SWSAs, with the most frequent pressures being urban development, the spread of invasive alien species and pollution from urban and agricultural runoff. If replicated and enforced, the identified frameworks can significantly assist municipalities in determining budget requirements and ensure that more projects reach their end phase. The spatial framework is intended to inform decision-making around desired land use activities, mitigation actions, biodiversity offsetting, and inform planning. These outputs can also be used for strategic input into municipal Integrated Development Planning (IDP) and Spatial Development Frameworks (SDFs).

The benefits of using the municipalities case study approach are:

- The existing high-level plans, strategies, and monitoring guidelines will be used, along with the developed



Main themes of the proposed strategies for local government protection and management of SWSAs.

BACK TO TOP




City of Cape Town

Rivers earmarked for rehabilitation activities in the City of Cape Town, Liveable Urban Waterways (LUW) Project include (top left and right): Keyers River, Spaanschemat, (bottom left and right) Prinskasteel and Westlake River, among others.

framework, to inform best practices regarding the effective governance of its SWSAs.

- The project will identify gaps and/or advances in its current plans, strategies and frameworks, aiding the success and efficacy of water governance.
- The overarching project intends to create uniformity and potentially inform a standardised approach to effectively managing SWSAs, ensuring that local water custodians speak the same language and thus effectively mitigate, protect, and enhance water resources. This key outcome will ensure that the municipality's approaches to water governance remain relevant and that the municipality participates/informs and remains at the forefront of such a change.

References:

- DWAF (Department of Water Affairs and Forestry), 1996. South African Water Quality Guidelines (Second Edition). Volume 7: Aquatic Ecosystems. Pretoria, South Africa.
- Le Maitre, D.C., Seyler, H., Holland, M., Smith-Adao, L.B., Nel, J.L., Maherry, A. and Witthüser, K., 2018. Identification, Delineation and Importance of the Strategic Water Source Areas of South Africa, Lesotho and Swaziland for Surface Water and Groundwater Enhancement. Water Research Commission (WRC) Report No. TT 754/1/18. WRC, Pretoria, South Africa.
- Lötter, M.C. and Le Maitre, D., 2021. Fine-scale delineation of Strategic Water Source Areas for Surface Water in South Africa using Empirical Bayesian Kriging Regression Prediction: Technical report. Prepared for the South African National Biodiversity Institute (SANBI), Pretoria.
- Stats SA (Statistics South Africa), South African National Biodiversity Institute and Department of Forestry, Fisheries and the Environment (2023) Natural Capital Series 3: Accounts for Strategic Water Source Areas, 1990 to 2020. Discussion document D0401.3, Stats SA (Statistics South Africa), Pretoria, South Africa.
- United Nations,2015. The 17 Goals [Online]. Available: https://sdgs.un.org/goals [Accessed 07 May 2024].

BACK TO TOP

OPINION

The water challenge: building water security together

Water Research Commission senior research manager, Dr Shafick Adams, unpacks the challenges currently faced by the South African water sector and offers some solutions towards achieving national water security.

In South Africa, the issue of water security has reached a critical juncture, exacerbated by climate change, population growth, rapid urbanisation, usage behaviours, and low infrastructure integrity, among others. The current strategy for addressing these water security challenges resembles a 'whack-a-mole' approach, where reactive problem-solving leads to the temporary resolution of one issue only for another to emerge.

This method is marked by fragmentation, resource inefficiency, and a focus on short-term fixes rather than sustainable, long-term solutions. Although the country has made some progress in tackling water insecurity for many, it is clear that we need alternative approaches, particularly adaptive systems approaches, to meet both current and future demands but also to tackle the root causes of many of our challenges. The water challenges that we are experiencing. Does it point to a failure to adapt fast enough in an integrated manner?

Many of the challenges requires us to deal and investigate the direct and contributing factors using a systems approach. A systems approach goes beyond examining and responding to individual components or news cycle issues; it focuses on the interconnectedness of a system's elements and how their interactions shape overall outcomes. By embracing this perspective, we can better understand the complexities of our water systems and design interventions that are not only effective but also equitable.

The Water Research Commission's (WRC) thematic research areas provide a framework for ensuring sustainable access to water

BACK TO TOP

across various sectors. It emphasises the importance of research, innovation, and collaboration – not only to secure water for today but also to protect it for future generations. However, a pressing question remains: ***Can South Africa rise to the challenge of building a water-secure future?*** The answer is yes, but we must recognise that our efforts have not kept pace with a changing climate and politico-techno-social-economic dynamics. We have been investing in increasing water supply, mainly using surface water resources, since the early 1970s-when we observed the shift from a wetter to drier period. Unfortunately, not for everyone, and many legacy issues remain.

Water availability is more than just the physical presence of water; it also encompasses water quality, operational reliability, storage capacity, distribution, competing demands, and human behaviour. At the operational level, infrastructure theft and vandalism further complicate service delivery. Poor water quality because of agricultural runoff, dysfunctional treatment plants, industrial discharges, and other pollutants continues to strain South Africa's water sources, posing health risks, increases treatment costs, and limiting safe usage.

While South Africa's water systems—such as aquifers, surface water systems, and desalination plants—provide crucial sources, increasing cross-sectoral demands are pushing these systems to their limits. This growing imbalance between demand and supply has left communities vulnerable to droughts, water outages, and even complete water shortages.

The challenges we face are compounded by ageing infrastructure, poor governance, and a lack of coordinated management. Infrastructure integrity is one of the major threats to water availability, with many systems operating well past their intended lifespans or just simply poorly maintained, leading to significant water and revenue losses. The global climate crisis adds further strain, with changing rainfall patterns, more frequent droughts and floods, and rising temperatures impacting both the quantity and quality of water.

Settlement patterns increase the vulnerability of people and infrastructure to disasters, such as flooding and landslides, related to intense rainfall events. A transformative systems approach is required. This must include innovative monitoring and modelling tools and adaptive management strategies that are essential for predicting and mitigating water-related risks.

Developing smart technologies for real-time water monitoring and early warning systems is not a luxury; it is an urgent necessity. However, the inter- and intra-institutional 'data politics' and will is hampering collection and sharing of data and information to achieve this. Knowing how a system behaves and our ability to predict allows for timely interventions. However, while technological innovation is critical, it must be complemented by appropriate governance provisions and societal behaviours. For instance, introducing in-home smart water devices that monitor consumption, detect leaks, and optimise water usage can empower households to conserve water, reduce costs, and contribute to sustainable resource management.

The transformation from incandescent lightbulbs to more energy efficient bulbs is a great example of interventions to reduce energy usage. The same shift is too slow in water. We have toilets that can flush with less than 2 litres but outscaling is not achieved; a typical toilet uses 9-13 litres currently. Just think about the industrial activity (jobs) that can be locally created by this. Maybe the government, with its 80 630 facilities, should become the first large adopter?

The WRC's call to bridge the gap between research and practice, by co-creating solutions with stakeholders and fostering cooperation, provides a pathway for addressing the complex and multifaceted nature of water scarcity. Greater collaboration across sectors is essential; we must engage academia, industry, government, and civil society to develop solutions that are context-specific and scalable. Innovation must extend beyond technological fixes. South Africa's water challenges are intertwined with issues of equity and social justice. Access to water remains uneven, with rural and low-income communities are disproportionately affected by water shortages.

Integrating and protecting natural ecosystems within water management strategies-through blue and green infrastructure and nature-based solutions offers a sustainable path forward. Strategic Water Source Areas (SWSAs), which are regions that produce high volumes of water relative to their size, play a critical role in securing the nation's water supply. Although SWSAs comprise only 8% of South Africa's land, they provide water for half the population, drive two-thirds of the country's economic activities, support 70% of irrigated agriculture, and supply over 90% of urban consumers through rivers and dams. By safeguarding these land areas, we can enhance water quality and reduce sediment build up in our dams, and bolster resilience to climate change. Protecting these regions through pollution control, land management, and continuous water quality monitoring will bolster resilience and help secure cleaner water for the future-a responsibility that extends beyond the water or environmental sectors.

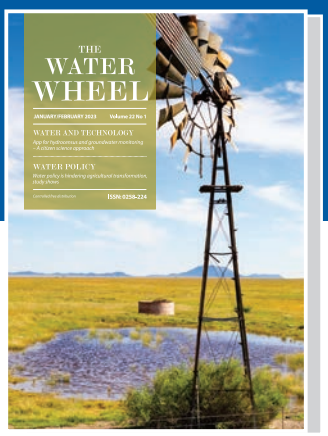
To re-emphasise, South Africa's water challenges are not only technical and climate change issues; it is fundamentally a governance issue. Effective governance is crucial for achieving water security. The lack of coordination between stakeholders and rigid institutional practices hinders the adoption of innovative solutions. Without a concerted effort to reform implementing institutions and practices, even the most advanced technologies and research breakthroughs will fall short. The reliance of many settlements on groundwater for their water supply is at significant risk, as only two municipalities in South Africa have in-house groundwater expertise-and no one has the appetite to change this.

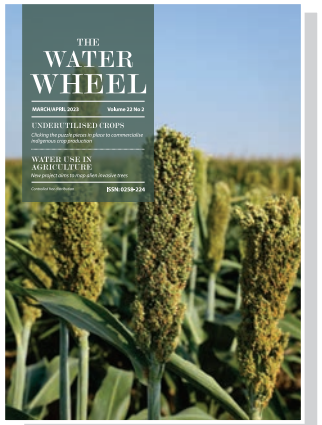
Achieving water security requires more than short-term fixes (like the growth in water tanker services); it demands a long-term commitment to innovation, collaboration, and adaptive management. Water is a finite resource, and the stakes could not be higher. If we cannot act, the consequences will be dire (e.g. economic stagnation, social unrest, and environmental degradation). However, if we embrace this challenge together, we can build a water-secure future that supports both human and ecological well-being. The time to act is now and not only tackle the symptoms but also the root causes of our challenges. We need a united, cross-sector effort that bridges political, economic, technical, and social divides to build a resilient, water-secure South Africa. This, in turn, will strengthen other interconnected and dependent areas such as energy, health, and food systems.

BACK TO TOP

THE WATER WHEEL

SUBSCRIPTION





Contact Details

Name: _____

Company: _____

Designation: _____

Tel: _____

Fax: _____

E-mail: _____

What would your like to read more about in the Water Wheel?

_____

_____

_____

_____

WATER RESEARCH COMMISSION

The Water Wheel

Tel: +27 (0) 12 761-9300
E-mail: laniv@wrc.org.za /www.wrc.org.za
Physical address: Lynnwood Bridge Office Park, Bloukrans Building, 4 Daventry Street, Lynnwood Manor
Postal address: Private Bag X03, Gezina, 0031

BACK TO TOP

DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

www.wrc.org.za

The Water Research Commission not only endeavours to ensure that its commissioned research remains real and relevant to the country's water scene, but that the knowledge generated from this research contributes positively to uplifting South African communities, reducing inequality and growing our economy while safeguarding our natural resources. The WRC supports sustainable development through research funding, knowledge creation and dissemination.

The knowledge generated by the WRC generates new products and services for economic development, it informs policy and decision making, it provides sustainable development solutions, it contributes to transformation and redress, it empowers communities and it leads various dialogues in the water and science sectors.

The WRC Vision is to have highly informed water decision-making through science and technology at all levels, in all stakeholder groups, in innovative water solutions through research and development for South Africa, Africa and the world.

FOLLOW US ON

WATER RESEARCH COMMISSION

THE POWER OF KNOWLEDGE TO THE PEOPLE