THE WATER WHEEL

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IRRIGATION WATER MANAGEMENT

From irrigation pioneer to global impact: the SAPWAT legacy lives on

HYDROGEOLOGY

Urban vadose zone: The hidden water cycle beneath our cities

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NEWS

South Africans show strong trust in scientists, but want greater transparency and public engagement

South Africans have a moderately high level of trust in scientists, according to a new study that examined public attitudes towards science and its role in society. The research ranked South Africa 23rd out of 68 countries participating in the international Trust in Science and Science-Related Populism (TISP) Many Labs Project.

The study found that scientists are widely regarded as competent, with respondents expressing confidence in their intelligence, qualifications and commitment to improving public well-being. More than 75% of respondents also identified the scientific method as the most reliable way to determine whether something is true or false.

Trustworthy scientists were described as evidence-driven, honest, well-qualified, accountable and effective communicators.

However, respondents expressed more moderate confidence in scientists' integrity and transparency, with some citing concerns about political influence, financial interests and tensions between science and religion.

Trust was highest among people aged 40 to 49, increased with age, and was slightly higher among men and urban residents. Education, income and political orientation had little influence on trust levels. Nearly 80% of respondents said scientists should communicate more with the public and play a greater role in policymaking.

The researchers conclude that strengthening trust will require greater openness, meaningful public engagement and ensuring that the benefits of science are shared more equitably across society.

To view the original study, visit: https://sajs.co.za/index.php/sajs/en/article/view/21970

New treatment plant to improve water supply in Hammanskraal

President Cyril Ramaphosa has officially unveiled the new Klipdrift 50-megalitre-per-day Package Water Treatment Plant in Hammanskraal, marking a major milestone in efforts to restore reliable access to safe drinking water for communities north of Pretoria.

The plant, commissioned during the Department of Water and Sanitation's Mandela Day programme, is expected to significantly improve water security in the area by supplying up to 50 million litres of treated water daily. Speaking at the launch, President Ramaphosa described the facility as a major achievement and an example of how collaboration between national, provincial and local government can deliver practical solutions to communities facing water shortages.

While welcoming the completion of the plant, the President stressed that the next priority is rehabilitating the local water reticulation network to ensure treated water reaches households as quickly as possible. The project forms part of government's broader efforts to expand access to clean drinking water and strengthen water infrastructure, particularly in underserved communities.

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China–South Africa strengthen collaboration on water issues

Ties between South Africa and China have been strengthened following a two-week visit by local water expert Prof Sylvester Mpandeli to several leading Chinese water and agricultural institutions.

Prof Mpandeli, Honorary Vice President of the International Commission on Irrigation and Drainage (ICID), Chairman of the South African National Committee on Irrigation and Drainage (SANCID) and Water Research Commission (WRC) water–energy–food nexus expert, was hosted by Tsinghua University in Beijing as a Distinguished Visiting Professor from 1 to 14 July 2026. The visit builds on almost a decade of collaboration between SANCID and Chinese institutions. In 2016, the Chinese National Committee on Irrigation and Drainage (CNCID) sponsored SANCID to organise capacity-building training on the African continent, when Prof Mpandeli was Chair of the African Regional Working Group of ICID.

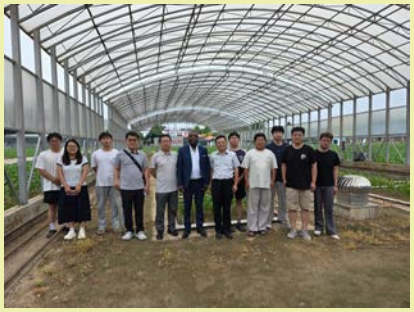
During his latest visit, Prof Mpandeli delivered public lectures and participated in engagements at several leading institutions, including Tsinghua University's Department of Hydraulics Engineering, the China Institute of Water Resources and Hydropower Research (IWHR), CNCID, Wuhan University and China Agricultural University. His presentations focused on issues central to sustainable water and food security, including agricultural water management, climate change adaptation, the Water–Energy–Food Nexus, smart irrigation technologies and water governance.

The engagements also opened the way for longer-term collaboration. Discussions with institutional leaders resulted in an agreement to explore partnerships between SANCID and five Chinese institutions over the next five years, creating opportunities for joint research, knowledge exchange, capacity building and innovation.

A highlight of the visit was Prof Mpandeli's tour of the Dujiangyan Irrigation System, a World Heritage irrigation site dating back more than 2 000 years. The visit provided an opportunity to learn how China preserves its historic irrigation infrastructure while ensuring that local communities continue to benefit from these systems. SANCID has itself received five World Heritage Irrigation Structures awards since 2024, making the Chinese experience particularly relevant as South Africa seeks to strengthen the sustainability of its own heritage irrigation sites.

Prof Mpandeli also visited irrigation schemes and smart technology initiatives, including the Binzhou Irrigation District in Shandong Province, as well as the Yellow River, where he observed the impacts of sedimentation and learned more about China's approaches to managing major irrigation systems.

According to Prof Mpandeli, the visit provides an important platform for South African and Chinese experts to deepen research and development cooperation and share solutions relevant to the Global South.



Honorary ICID Vice President, Prof Sylvester Mpandeli, met doctoral students at the China Institute of Water Resources and Hydropower Research Experimental Farm.

Prof Mpandeli at the Chinese National Committee on Irrigation and Drainage in Beijing, where he gave a public lecture.

Prof Mpandeli at the Department of Hydraulics Engineering at Tsinghua University.

Prof Mpandeli was also hosted by the China Institute of Water Resources and Hydropower Research.

Prof Mpandeli learning about the Yellow River.

Prof Mpandeli visited the Dujiangyan Irrigation system, a historical irrigation system dating back 2 000 years.

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GLOBAL

New UN report calls for urgent acceleration on water and sanitation, with Africa facing critical challenges

UN Photo/Evan Schneider

A decade after the adoption of Sustainable Development Goal 6 (SDG 6), a new United Nations SDG 6 Synthesis Report on Water and Sanitation 2026 shows that significant progress has been made globally, but warns that the pace of change remains far too slow to achieve universal access to water and sanitation by 2030.

The report highlights remarkable global achievements over the past ten years. More than 961 million people have gained access to safely managed drinking water, 1.2 billion now have safely managed sanitation services, and 1.6 billion have access to basic hygiene facilities. Water-use efficiency has also improved by almost 20%, while more countries are adopting integrated water resources management to balance the needs of people, economies and ecosystems.

However, the findings reveal that progress remains uneven, particularly across many low-income regions, including Africa. The report identifies significant gaps in water quality monitoring, noting that data coverage remains particularly limited in North Africa, while countries across the continent continue to face capacity, governance and financing constraints that hinder implementation. Only around 60 000 of the two million global water quality records analysed came from the world's lowest-income countries, underscoring the urgent need to strengthen monitoring systems across Africa.

The report also warns that achieving SDG 6 by 2030 will require an eightfold increase in the current rate of progress for safely managed drinking water and a sixfold increase for sanitation services. Without significantly greater investment, stronger institutions, enhanced partnerships and accelerated innovation, universal access will remain out of reach.

For Africa, where water security underpins public health, food production, economic growth and climate resilience, the report reinforces the importance of sustained investment in water science, infrastructure and governance. It calls for transformative action that places water at the centre of sustainable development and recognises it as a critical driver of the continent's future prosperity.

To view the report, visit: https://bit.ly/3UjJC2e

Invasive giant prawn spreads through protected areas in Brazil

The giant river prawn (***Macrobrachium rosenbergii***), introduced to Brazil in the 1970s for aquaculture, is becoming a growing threat to the country's coastal and estuarine ecosystems. So reports Mongabay.

A decade-long study by researchers from Brazil and Uruguay found that the invasive species has established breeding populations in sensitive habitats, including protected areas. Scientists confirmed the presence of egg-carrying females, showing the prawn is reproducing successfully in the wild. Its ability to tolerate a wide range of temperatures and salinity, combined with warming waters linked to climate change, is expected to accelerate its spread.

Researchers warn that the species competes with native prawns for food and habitat, disrupts aquatic food webs, and may introduce devastating diseases such as white spot syndrome. The findings highlight the urgent need for monitoring and stronger biosecurity measures to prevent further ecological damage and protect Brazil's rich estuarine biodiversity.

To view the original study, visit: https://link.springer.com/article/10.1007/s12237-026-01669-7

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Tiny plastics in drinking water may be making dangerous bacteria stronger

Nanoplastics are already a concern because people may ingest them directly, but new research points to another possible danger. These tiny plastic particles may also make harmful bacteria more difficult to control.

In a study published in ***Water Research***, Virginia Tech researcher Jingqiu Liao and an international team found that nanoplastics can interact with environmental microbes in ways that may create indirect risks to human health, especially through drinking water systems.

"It is important to better understand the adverse effects of nanoplastics on human health, and not just in humans but also in the environment, which indirectly influences human health," said Liao, assistant professor of civil and environmental engineering. "The nanoplastics can make the antimicrobial-resistant pathogens better survive, which could be harmful to the environment and would have public health implications."

The researchers reported that bacteria exposed to nanoplastics can become more resistant to disinfectants. That could create serious problems for water treatment facilities and distribution networks designed to keep drinking water safe.

"When the nanoplastics interact with the biofilm and the bacteria inside them, they can strengthen the biofilm and make it more resistant to any kind of measures that are going to keep the water clean," said Liao, who is also an affiliate with Fralin Life Sciences Institute's Global Change Centre.

The study found that exposure to nanoplastics increased the physical strength of the biofilm and made it more resistant to disinfectants. The authors conclude that "the increased mechanical strength of the biofilm and its resistance to the disinfectants highlight a potential challenge for water treatment and distribution systems, as nanoplastics may increase the formation of difficult-to-eradicate biofilms on the surface of some water treatment and distribution systems."

- To view the original study, visit: https://www.sciencedirect.com/science/article/abs/pii/S004313542501615X?via%3Dihub

The 'Asian water tower' is losing vast volumes of groundwater every year

Groundwater reserves beneath High Mountain Asia (HMA), often called the "Asian Water Tower", are shrinking at an alarming pace, according to a new satellite-based study.

The region provides water that supports farming, cities, and ecosystems across more than a dozen downstream countries, making it a critical resource for hundreds of millions of people. Researchers estimate that groundwater storage is declining by about 24.2 million megalitres each year.

The research was led by Prof Shudong Wang of the Aerospace Information Research Institute of the Chinese Academy of Sciences (AIRCAS). The team sought to overcome two major obstacles to understanding groundwater in the region: limited on-the-ground data and the extremely complex mountainous landscape. The findings have been published in ***Environmental Research Letters***.

To build a clearer picture of what is happening underground, the researchers created an artificial intelligence (AI) powered assessment model that combines observations from multiple satellites, Earth system modelling, and explainable AI. Using this approach, they reconstructed about 20 years of groundwater storage (GWS) changes across High Mountain Asia. The system also helped identify the main forces driving those changes and allowed the researchers to explore how groundwater risks could develop under future scenarios.

The results show that roughly two-thirds of HMA experienced declining groundwater storage between 2003 and 2020. The largest losses occurred in heavily populated downstream basins where irrigation demands are high, including the Ganges-Brahmaputra, Indus and Amu Darya basins. Some inland areas at higher elevations, however, experienced localized increases in groundwater storage.

- To view the original study, visit: https://iopscience.iop.org/article/10.1088/1748-9326/ae2e1b

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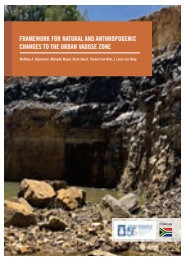
NEW WRC REPORTS



Framework for natural and anthropogenic changes to the urban vadose zone

This project builds on previous research and examines how natural processes and human activities affect the water cycle and the ground beneath our cities. The research team used case studies to investigate how urban development changes the physical and water-related properties of soil and rock. Urbanisation can affect both the flow and quality of water. One important issue is non-revenue water – treated water that is supplied to users but is lost, mainly through leaking pipes. Non-revenue water levels are high in many South African cities. These leaks can cause large amounts of water to enter the soil and increase the recharge of groundwater. Population growth and urbanisation can make these problems worse. The project also looks at different sources of groundwater contamination, including pollution from coal mining, fuel storage and fuel spills. Water leaking into the ground can also affect buildings and other land uses, such as cemeteries. In some cases, excessive water movement through the ground can weaken foundations, cause buildings to fail or contribute to the formation of sinkholes. Particular attention is given to unsaturated flow, which is the movement of water through soil and rock that is not completely filled with water. This is important because most urban development takes place in this zone, known as the vadose zone. Local changes in water movement can cause parts of this zone to become fully saturated, creating phreatic zones.

WRC report no. TT 954/1/26 and TT 954/2/26 (Case studies)
Link: https://bit.ly/3ST0lne (Volume 1) and https://bit.ly/4y07vKL (Volume 2)

Position paper: Pipe liner technology for bulk water pipeline rehabilitation – A strategic framework for South African water boards

South Africa's water sector faces a deepening infrastructure crisis. The country's water boards collectively manage tens of thousands of kilometres of bulk water transmission mains, rising mains and distribution pipelines, much of it ageing, operating beyond design life, and under increasing mechanical stress from load-shedding-driven pump cycling. Non-revenue water (NRW) losses cost the country an estimated R7.3 billion annually, with pipeline leakage a primary driver. This position paper draws on the findings of WRC Study C2024/2025-01617, a comprehensive investigation into pipe liner technology for bulk water pipeline rehabilitation, to set out a strategic framework for water boards. The paper argues that trenchless pipe liner technologies, including cured-in-place pipe (CIPP), spray-in-place pipe (SIPP) and close-fit sliplining, offer significant potential to reduce NRW, extend asset service life and lower lifecycle costs, but that their adoption in South Africa requires a structured approach to technology selection, independent testing, skills development and regulatory alignment.
Link: https://bit.ly/45KO6I5

Investigation into the use of South African Cape anchovy and West Coast round herring for direct human consumption for increased food and nutrition security

South Africa and other Southern African Development Community (SADC) countries face persistent challenges of food and nutrition insecurity, especially in their low-income populations, with about 20% to 40% of the population in the region experiencing severe food insecurity. Yet, South Africa has abundant and underutilised pelagic fish resources, in particular Cape anchovy (***Engraulis encrasicolus***) and red-eye round herring (***Etrumeus whiteheadi***), also known as West Coast round herring. In addition, these two species are currently primarily used for fishmeal and fish oil production rather than for direct human consumption. The argument being advanced in this report is that increasing the direct human utilisation of underutilised fish resources such as anchovy and West Coast round herring could positively contribute towards nutrition and protein food security in South Africa and in the SADC region as a whole.

WRC report no. 3267/1/26
Link: https://bit.ly/4iuHT47

Integrating geospatial, human and socio-economic approaches for profiling the agroecosystem nexus in uMsunduzi Floodplains: A guide for supporting the transformation of community farming practices

Wetlands play a critical role in maintaining the regional ecological balance, mitigating floods and droughts, providing habitats for diverse flora and fauna, and supporting human well-being through essential services, such as carbon sequestration and water purification. However, wetlands are constantly being degraded by human activities, so that some can no longer offer ecosystem services. Considering the importance of these ecosystems and their extensive degradation, numerous research efforts have been exerted towards understanding, identifying and addressing the factors that drive current change and degradation. However, fewer research efforts tend to be directed towards riverine or floodplain wetlands, especially in developing regions such as southern Africa. The focus of this project was to evaluate the integration of geospatial, human and socio-economic approaches for profiling the agroecosystem nexus in the floodplains of the uMsunduzi River, so as to guide efforts supporting the transformation of community activities.

WRC report no. 3265/1/26
Link: https://bit.ly/4zIWFuc

Resource accounting and irrigation requirements for the cultivation of Artemisia afra Jacq. Ex. Wild as a conservation strategy

Medicinal plants are known to play an important role in primary healthcare through traditional medicine, and they are sold in the informal markets and commercial sectors of South Africa. The ever-increasing demand from a growing global population who prefer healthcare and dietary supplements from natural

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sources has led to an expanding medicinal plant industry, thereby opening new opportunities. ***Artemisia afra Jacq. ex Willd***. is one of the medicinal plants that have traditionally been used to treat various ailments, with several studies mentioning its use to treat and/or manage upper respiratory infections and cancers. The continued wild harvesting of ***A. afra*** may increase harvesting pressure on its wild populations and will have a long-term impact on its natural ecosystem. This project sought to contribute to the conservation of ***A. afra*** by investigating remote sensing as a potential monitoring tool and by developing cultivation information, with a focus on water management.

WRC report no. 3264/1/26

Link: https://bit.ly/4gmW21U

SAPWAT change of custodianship and climate database upgrade

South Africa faces increasing climate variability, rapid population growth, and rising competition for limited water resources. Irrigated agriculture, the country's largest water user, is under pressure to improve efficiency, making accurate estimates of crop water requirements essential. For more than two decades, SAPWAT software has been the national standard for irrigation planning, widely used by farmers, advisors, researchers, and the government. However, the continued use of SAPWAT now faces critical challenges. The custodian can no longer sustain its maintenance and provide decision support. Consequently, the continued use of SAPWAT in new computer operating environments is infeasible without proper maintenance. The main objective of this project was to transfer custodianship of SAPWAT to the University of the Free State. Specific aims included capacitating researchers to provide support with respect to the use of SAPWAT software; and improving the applicability of SAPWAT through a new climate database to determine reference evapotranspiration for South Africa.

WRC report no. 3249/1/26

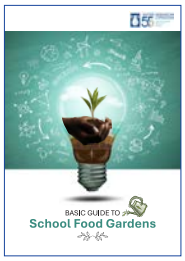
Link: https://bit.ly/4ci3MQh

Potential impacts of stratospheric aerosol geoengineering on water yield, crop yield, and rangeland productivity in Africa

Several socio-economic activities in Africa are fuelled by river basins, agricultural production and rangeland productivity. However, the productivity of these activities is increasingly threatened by climate change induced by greenhouse gases. International negotiations to reduce greenhouse gas emissions have been slow, while emissions themselves continue to rise. Stratospheric Aerosol Geoengineering (SAG), or Stratospheric Aerosol Injection (SAI), has been proposed as a quick and cost-effective method to mitigate the temperature rise related to climate change globally. However, the implementation of SAG is still controversial due to the associated political, environmental, and socioeconomic risks, which may not be evenly distributed across the globe. Among others, this study aimed to calibrate and evaluate hydrological, crop, and rangeland models over Africa; examine the potential impacts of climate change and SAG intervention on water yield over the river basins in Africa; investigate the potential impacts of climate change and SAG intervention on crop yield over the Africa; study the potential impacts of climate change and SAG intervention on rangeland productivity in Africa; and inform policy-makers on potential impacts of SAG on water resources, food security and rangeland in Africa.

WRC report no. 3198/1/26

Link: https://bit.ly/4qHLjm3



Basic guide to school food gardens

Hunger and stunted growth among children remain enormous challenges in South Africa, especially in rural areas. School food gardens are an important and practical solution and, along with feeding schemes, can help supplement children's diet by providing fresh, healthy vegetables. Studies also show that food gardens have the potential to improve children's diets beyond what they produce at school – children exposed to food gardens also tend to eat more vegetables at home. School food gardens also provide other benefits beyond busting hunger. By growing their own food, children learn, in a practical setting, where food comes from, how plants grow and why caring for the environment matters. Gardens support lessons in science, nutrition and life skills, while encouraging curiosity, teamwork and responsibility. Overall, school food gardens help improve nutrition, support learning, build skills and contribute to healthier, more resilient learners and communities across South Africa. This booklet provides some guidance when starting a school food garden. It is not comprehensive, but rather points to 'tips and tricks' that will make such a garden successful.

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

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

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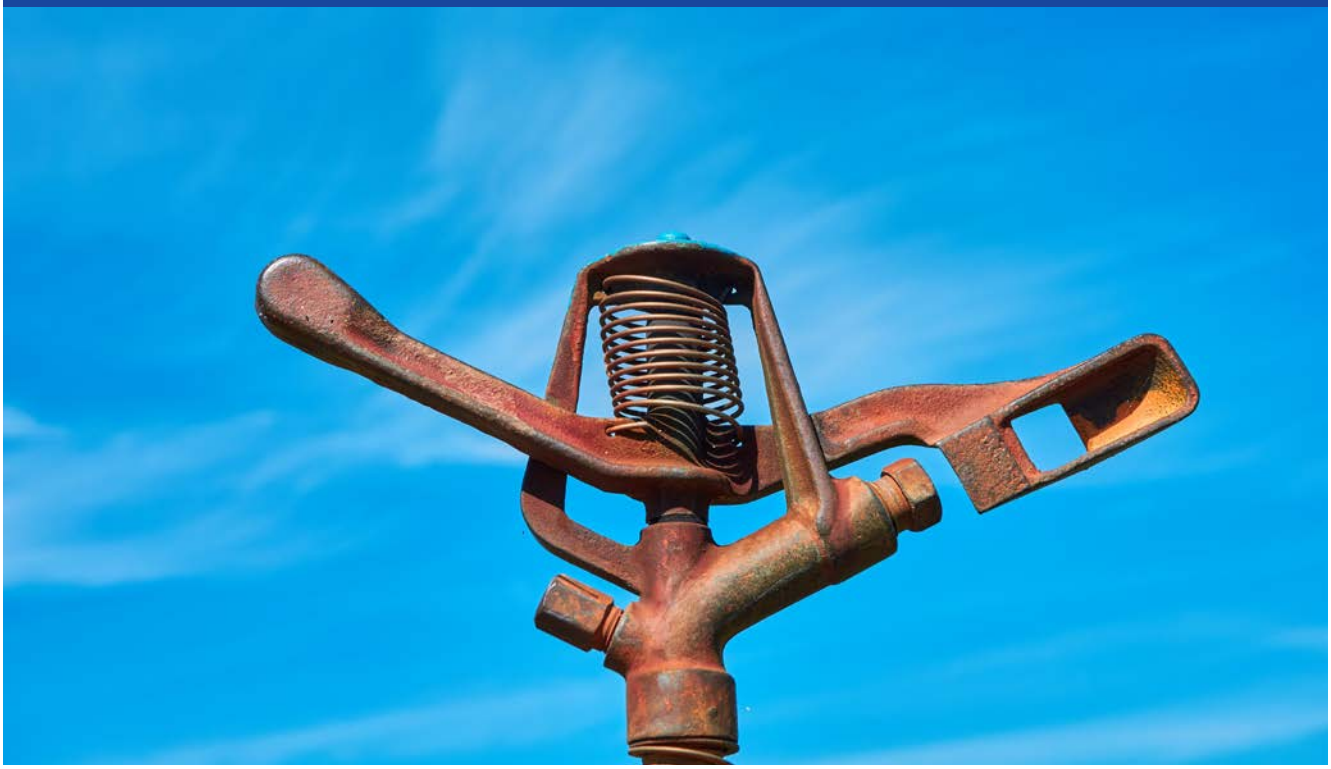
IRRIGATION WATER MANAGEMENT

From irrigation pioneer to global impact: the SAPWAT legacy lives on

Celebrated developer of SAPWAT, Dr Pieter van Heerden, remembers a lifetime of work as the renowned irrigation planning and management tool passes to a new home at the University of the Free State. Article by Petro Kotzé.



Behind most water allocation decisions in South Africa lies SAPWAT, a decision support tool developed by South Africa's own esteemed water expert, Dr Pieter van Heerden. For more than two decades, the South African Plant Water Model has been the national standard for irrigation planning, widely used by farmers, advisors, researchers, managers and the government. Dr van Heerden has been a custodian of the software since the early days of the tool's development, a choice that would define his internationally celebrated career and change the face of water allocation across many parts of the globe.

Close to his eightieth birthday, Dr van Heerden and his close collaborator, wife Gela, with the continuous support of the Water Research Commission (WRC), have now handed the baton over to the University of the Free State (UFS), ending a historic chapter and heralding the next, which will bring critical updates in line to the tool, with new climate variability and change, and operating environments.

Prof Sylvester Mpandeli, WRC Senior Research Manager and South African National Committee on Irrigation and Drainage (SANCID) Chairman, says SAPWAT is not just a technical model but part of South Africa's sustained response to its water-scarce status: as much a decision-support tool for water use and allocation in irrigation as it has been driven by the innovative people who made it happen, and who continue to use it to

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Today, SAPWAT's users span the globe, as the tool is used in most countries south of the Sahel, as well as around the Mediterranean, in Central Asia, India and the Americas.

conserve water efficiently and effectively. Chief among them is Dr van Heerden.

From the farm to the first line of code

Dr Pieter Schalk van Heerden was born on 24 November 1946 on a farm at Cradock. After passing first class in Matric, he completed his BSc in Agriculture (Sheep and Wool, Animal Physiology) at Stellenbosch University. This was followed by two Honours degrees – a first in Agricultural Extension at the University of Pretoria and a second in Agriculture (Agronomy) at UFS.

To meet the stipulations of his bursary, Dr van Heerden initially worked as an agricultural extension officer in Karasburg, Namibia (then South West Africa). After a period on the family farm, he then worked in Cradock, again as agricultural extension officer, advising some 300 farmers across roughly 27 000 hectares in the Cradock, Hofmeyr and Great Fish River valley irrigation areas, recommending cropping patterns, cultivars, irrigation water management, fertilisation, saline soil reclamation and pest control, all grounded in proven experimental results.

In 1988 he moved to the Department of Agriculture's head office as Management Advisor (irrigation), coordinating around 100 irrigation development projects nationally and publishing the department's first computer program for irrigation bed design. Between 1991 and 1999 he served as Deputy Director for Research, then Extension, in the national and Free State agricultural departments, acting as director for nine months, helping to integrate the Free State's provincial agriculture departments, and contributing to a new national irrigation policy.

In 1999 he joined prominent South African agricultural engineer and researcher Charles Crosby's independent irrigation consultancy, planning water requirements for farms and schemes nationwide. Crosby was already working on the first version of SAPWAT. Together, Crosby, affectionately known as the "Wise Old Man of Irrigation", and Dr van Heerden continued to develop the program into the definitive computer-based planning model for estimating crop irrigation water requirements in South Africa.
This journey was not without a few curveballs.

Placing water on a curve

In the early nineties, methods for determining water requirements were limited. The Green Book (named after author Dr George Green), South Africa's accepted standard since 1973, was based on models too rigid for newer, short-cycle irrigation methods, and its outputs were losing credibility. A pilot study funded by the WRC in 1996 set out to establish a decision-making procedure for estimating crop water requirements, with "built-in" databases removing the need to seek climate or crop data elsewhere. It led to the pilot program SAPWAT 1.0, released in 1999, which has since been continuously upgraded and eventually replaced by SAPWAT 4.

"The one big breakthrough at this stage was that the ET_0 values (the reference crop evapotranspiration values) were statistically placed on a curvilinear regression curve," Dr van Heerden says. "Thus, one could choose any planting date and always be on the curve, applicable worldwide to any weather station with at least monthly weather data. What gave me the biggest headache was making sure that the regression curve worked everywhere in the world. For most places it fitted nicely, but in the monsoon regions the curve shifts away from the normal, and along the Red Sea there are areas where the climate variation is too big for successful application of SAPWAT."

A further breakthrough came from the University of KwaZulu-Natal (specifically, Prof Roland Schulze of the Agricultural Engineering Department), which held daily weather data for South Africa's roughly 1 900 quaternary drainage regions: fifty years of data per region, fed into SAPWAT to calculate not just an average water requirement but a standard deviation, so users could work with the 70% or 90% probabilities irrigation developers need.

This meant that SAPWAT became more than a crop growth model, rather developing into a planning and management tool that relies on an extensive climate and crop database, is general enough to cover vegetables, field crops, annual and perennial crops, and pasture and tree crops, and can simulate wide-bed planting, intercropping, and different irrigation methods. It also draws on crop-specific research, including how long a crop takes to move through its growth stages, plotted onto its four-stage crop curve, and has been continuously upgraded over the years, mainly with WRC funding.

Lani van Vuuren

Dr Pieter van Heerden (right) with Prof Giel Viljoen (then of UFS) at the celebration of the WRC's 40th anniversary.

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Lani van Vuuren

Dr Pieter van Heerden (second from left) was awarded the SANCID Lifetime Achievement Award during the organisation's symposium in 2025. With him are the other award winners Prof Chris du Preez (Capacity Building and Research Development Award), Prof Sylvester Mpandeli (Leadership Award) and Prof Leon van Rensburg (Capacity Building and Research Development Award).

On the road with *Oom* Charles

In SAPWAT's early years, Dr van Heerden and "Oom Charles" (Charles Crosby) presented courses on irrigation areas across the country, bringing irrigators together with town and city water managers for day-long symposiums, preceded by tours of purification works, wetlands, and farms. "We loaded the whole lot of people together into one bus," Gela recalls, "established large farmers, men from water affairs and the mines, and small-scale farmers." At the start of the journey the atmosphere was very stiff, she recalls, because people were sitting together with others they were not usually in contact with, but by the end of the bus ride, the conversations flowed.

They genuinely tried to understand one another. Dr Van Heerden recalls one farmer who demonstrated his margins by drawing lines across a standing sack of wheat. Each cumulative line representing a cost factor, for example for fertiliser, seed, and weed control, until only a narrow line remained: "That is now my share," he said.

"In the end it really was far-reaching stuff," Gela says. "We built a matrix, a good one, and in the end ***Oom*** Charles took our model and held it up to the rest of South Africa." He knew, she says, what he had in Pieter.

Still, initial reactions to the tool were mixed. Some started using the tool immediately; others were reluctant, wary of ending up with less water than they believed they needed. "We know of people who went in among the farmers and said: look here, ***oom***, this thing doesn't lie, this is how much water you need," Dr van Heerden says. But SAPWAT's use gradually spread from designers to co-operatives, banks, valuers, and environmental impact practitioners.

International renown from small beginnings

The model was continuously updated over time. SAPWAT 3 was released in 2008, and an improved version, SAPWAT 4, was released in 2017. The tool has now been applied by countless users around the globe, including most countries south of the Sahel, as well as around the Mediterranean, in Central Asia,

Historically, SAPWAT users have reported water savings of between 33% and 50%.

India and the Americas. Since around 2000, SAPWAT has also underpinned South Africa's irrigation licensing system, and it is endorsed by the Department of Water and Sanitation (DWS) for issuing water use licences and quantifying optimal allocations for specific command areas.

"To get a water use licence, users have to be able to prove how much water they're going to need, and that's where SAPWAT is used," Dr van Heerden notes. "New applicants must show that the water requirement of their intended crops matches the total water use they're applying for."

As such, because it bridges the gap between official national policy and day-to-day scientific research, SAPWAT remains one of the WRC's greatest practical and academic success stories. SAPWAT documentation and software are among the most heavily utilised and sought-after outputs of the WRC, which enabled the free distribution of the software and its accompanying literature via its Knowledge Hub.

On ResearchGate, SAPWAT papers enjoy massive citation and download volumes, driven in part by local universities that use the program as a primary undergraduate teaching tool for agricultural modules. Additionally, researchers in sub-Saharan Africa frequently download SAPWAT documentation to study the impacts of climate change on crop yields, water footprints, and regional irrigation schemes.

Milestones amid personal difficulty

Not long after SAPWAT 3's release, Dr van Heerden began to develop macular degeneration. "At a certain stage I could no longer read normal print," he explains. Gela took the strain of the growing correspondence. It was against this backdrop that Dr van Heerden completed his doctorate, which he could apply for without first completing a Master's. Due to his outputs, publications, and contributions to the agricultural irrigation community, he was instead allowed to proceed directly to his PhD.

Gela recalls this work as her husband's greatest achievement. "The perseverance he has in spite of his limitation is astounding." He was awarded his PhD in Irrigation Management under Prof Sue Walker's supervision on 10 December 2015, the oldest person at that year's higher-degree graduation ceremony.

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We laughed so much, Gela remembers, when their neighbour, a ***tannie*** in her nineties at the time, congratulated Pieter, then pulled up short and asked, "But what are you going to do to keep your mind going now?" Dr Van Heerden was very far from done, keeping at it for another decade. Numerous local and international recognitions have marked the value of his work.

Well-deserved recognition

In 2011, the International Commission on Irrigation and Drainage (ICID) awarded South Africa a WatSave Award in the Technology category at the 21st International Congress on Irrigation and Drainage in Tehran, Iran, presented to SAPWAT's project managers, Dr van Heerden and Charles Crosby.

That year, the South African Irrigation Institute also recognised Dr van Heerden for his contribution to irrigation technology, and in 2013 he received a South African Society for Agricultural Extension (SASAE) silver medal for his special contribution to the promotion of agricultural extension.

Last year, SANCID also honoured him for his lifetime contribution to the sector. "For me, the most important [of all the accolades] is the ICID award, notes Dr van Heerden. "It means a tremendous amount to get that kind of recognition: to say, the work you did for irrigation isn't forgotten, and it reaches beyond the irrigation industry too. I'm proud of it."

Gela remembers the SANCID's lifetime achievement evening warmly. "When the presenter announced Dr Pieter van Heerden, the developer of…, the room answered in one voice, "SAPWAT!" before his CV could even be read," she recalls. She was recognised alongside him that evening. "It really was a great treat."

Handing over the baton

The van Heerdens describe the handover to UFS, under the custodianship of Prof Bennie Grové (Associate Professor in the Department of Agricultural Economics), as a relief. "Amen," Dr van Heerden says simply. "We can relax now, and we're very grateful that the university can give SAPWAT a permanent home."

The work is not done. Crop coefficients and growth periods need revising in light of new research and changing crop patterns, "in some cases quite different from what people have in their heads," Dr van Heerden says. SAPWAT's climate dataset does not cover the last 25 years of climate data, casting doubt on its water-use estimates, and it is unclear how far the model has kept pace with newer methods, such as the FAO 56 dual-crop coefficient approach.

Yet, the coming work is integral. "I can't see irrigation being able to carry on without SAPWAT, or without an updating of SAPWAT," Dr van Heerden says.

Prof Mpandeli explains that, for this next phase, the WRC deliberately sought an institution that would build on Dr van Heerden's work rather than start over: "We wanted to hand the tool and its development to an institution that would be able to add value on the work that Dr van Heerden has already done." UFS was the natural choice, both for its technical capacity and its connection to Dr van Heerden, who did his own PhD there. For now, until the WRC has finalised the Water Observatory system, UFS will be SAPWAT's de facto custodian.

Prof Mpandeli's vision for SAPWAT's next chapter has two parts: a practical tool for the water and agriculture sectors, and a teaching platform "used at both undergraduate and postgraduate level… because this is a national product contributing towards our national priorities and the Sustainable Development Goals (SDGs)." He is also pressing the DWS to formally adopt SAPWAT and has committed WRC resources to capacity building across the country.

A fond farewell

"I'd like to add a thank you," Dr van Heerden concludes. "Firstly, to the WRC, for all the years of support and funding of SAPWAT." Charles Crosby's contribution, he says, was immense. Dr Van Heerden describes him as an inspiration, motivator, mentor, leader and friend, he says, "who also put me through my paces." Dr Van Heerden also thanks all the people in the irrigation and plant production industries who contributed to SAPWAT's development.

Prof Mpandeli describes him as one of the sharpest minds he has worked with, and generous with what he knows: "He is one of the sharpest knives in the drawer. He's not afraid to share his knowledge, experience, and expertise. He has been there for the country, for the water and agriculture sector." Senior scientists of his calibre, Prof Mpandeli argues, deserve to be kept involved for as long as possible: "My belief is that he still has got a role in this country."

The van Heerdens are now both fully retired. Between them they have five children and eleven grandchildren, five in New Zealand and six in South Africa. "We really got to know wonderful people and saw wonderful places," Gela says. "It has made us rich in experience. It has been a beautiful, wonderful time."

SAPWAT enquiries can be directed to Prof Bennie Grové at groveb@ufs.ac.za

Main benefits of the SAPWAT tool

- Accurate water estimation: Uses the FAO-endorsed Penman-Monteith equation and long-term weather data to calculate precise crop water needs on a month-by-month basis.
- Extensive database: Includes decades of historical weather data and crop databases tailored for South African and international conditions.
- Improved water efficiency: Helps planners, farmers, and irrigation designers optimise water use, reducing resource waste, waterlogging, and soil salinity.
- Economic decision-making: Features enterprise budget modules that link water requirements directly to production costs and potential profits.
- Versatile Application: Works across various crop types, including field crops, vegetables, orchards, pastures, and small-scale rainwater harvesting modules.

ANTIMICROBIAL RESISTANCE

Wastewater: An unexpected highway for antibiotic resistance

Scientists have shown that extracellular DNA (exDNA) in wastewater and connecting river systems is an overlooked but important reservoir of mobile, high-risk resistance genes that influence how antimicrobial resistance persists and spreads. Jorisna Bonthuys reports.

South Africa has more than 950 municipal wastewater treatment plants, yet only 13% comply with the minimum water discharge standards. Moreover, while the country's older wastewater treatment plants can remove harmful chemicals and eliminate bacteria, they were not designed to remove exDNA – genetic material released from bacteria during the treatment process. Despite such shortcomings, these facilities remain vital tools for public health monitoring because of their diverse microbial communities, dynamic ecosystems and key role in the sanitation system.

A study led by researchers from the DSTI-NRF Research Chair in African Microbiome Innovation at Stellenbosch University (SU) investigated how antimicrobial-resistant genes (ARGs) behave in wastewater treatment plants and the rivers connected to them. The team focused on nine wastewater treatment plants of different sizes and with different treatment technologies in the City of Tshwane.

The findings were published in the journal ***Cell Reports*** in an article titled 'Persistence of high-risk antimicrobial resistance genes in extracellular DNA along an urban wastewater-river continuum'. The study revealed that wastewater and river systems are dynamic reservoirs of antimicrobial resistance (AMR), the ability of disease-causing microbes to withstand antimicrobial treatments.

AMR is already considered a major threat to health and development. South Africa, with its complex burden of infections and non-communicable diseases, has high rates of antibiotic resistance, which is a growing concern. The findings also indicate that exDNA is an overlooked yet important reservoir of genetic resistance that warrants greater attention from scientists, wastewater engineers, and public health officials.

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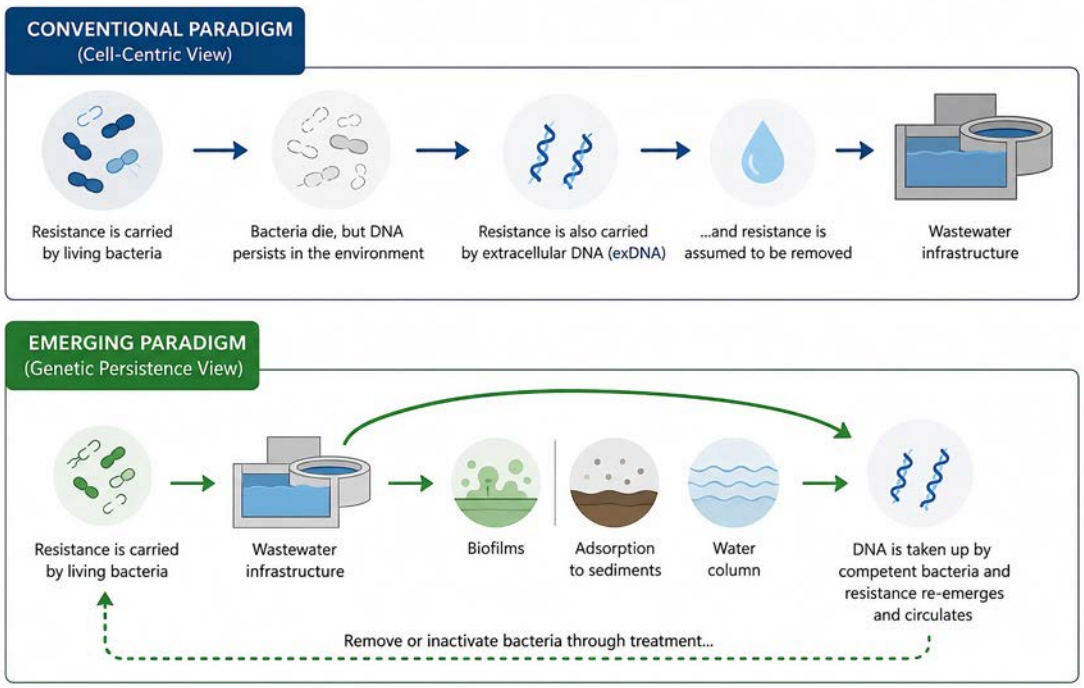

From a cell-centric to a genetic persistence view of antibiotic resistance, highlighting the role of extracellular DNA (exDNA) in the persistence and circulation of resistance genes in wastewater environments.

"The results underscore the need to understand how AMR spreads through ecosystems and into human populations," says Dr John Paul (JP) Makumbi. Makumbi, a medical microbiologist and the paper's first author, is conducting postdoctoral research on this topic at SU.

Novel research approach

Wastewater-based epidemiology – using sewage to monitor community-level health trends, much as it has been used to track polio – has been in use for many years, initially concentrated in the Global North but now well established in African settings, including a growing number of South African studies. Increasingly, these efforts also draw on the One Health approach, which recognises the interconnection between people, animals, plants and their shared environment. This approach will also be important in tackling rising AMR threats, Dr Makumbi believes.

Most AMR-related research examines resistance genes within living bacteria. This gap is especially clear in low- and middle-income countries, where the high cost of tools to study environmental AMR has limited research. Much less research has examined resistance genes that are free in the environment and not associated with living organisms. This study aims to fill that gap.

The researchers sampled key points in 2023. At each sampling site, they collected raw influent and treated effluent. They filtered the samples through fine membranes to remove intact bacterial cells, leaving only free-floating genetic material dissolved in the filtrate.

From this, exDNA was extracted, purified and sequenced using shotgun metagenomics, a technique that reads genetic sequences directly without requiring prior cultivation of any organism. The team screened the extracted genetic material for resistance genes and traced their likely taxonomic origins. The researchers then compared the effects of single-stage activated sludge processes (ASP-only) with combined ASP-biofilter systems on antimicrobial-resistant genes. ASP is a biological process for developing an activated mass of microorganisms capable of aerobically stabilising waste.

The treatment plants they focused on varied in scale and technology, serving catchment populations from a few thousand to over a million people. Four plants relied solely on the standard ASP process, the primary biological treatment method for municipal and industrial wastewater in South Africa, while five combined ASP with an additional biofilter stage.

What turned up in the sampling

As expected, resistance genes were more abundant in wastewater than in river water: raw influent carried 196 different resistance genes and effluent carried 187, compared with 84 upstream and 94 downstream in the rivers. Only six genes were unique to rivers, suggesting a shared resistome between treatment plants and the waterways they discharge into. The term resistome refers to the complete collection of antibiotic resistance genes and their precursors within a given microbial community.

The study also shows exDNA not only harbours high-risk antimicrobial resistance genes but also serves as an ecologically distinct AMR reservoir dominated by a few key groups. This free-floating genetic material is found outside cells in environments such as soil, aquatic ecosystems, and human tissues. The researchers found genetic material from two major bacterial groups, commonly known to exhibit high-risk resistance profiles. Both the ***Pseudomonadota*** and ***Bacteroidota*** groups are commonly associated with multidrug-resistant behaviour.

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JP Makumbi

Researchers collect water samples at a wastewater treatment facility in an urban centre in South Africa to investigate how antimicrobial resistance genes move through water systems

JP Makumbi

Researchers sampling downstream river water to assess the real-world impact of wastewater discharge on freshwater systems in a large city in South Africa.

Across all samples, the team identified 561 individual exDNA-associated resistance genes, representing 127 distinct genes and spanning 12 broad classes of antibiotics. Several of these are frontline weapons against serious infections; carbapenems and cephalosporins, in particular, are considered last-resort options when other antibiotics have failed.

"We found exDNA carrying resistant genes in the effluent," Dr Makumbi points out. "Sewage brings together microbes from many sources, including hospitals, abattoirs, homes and street runoff, thereby increasing opportunities for horizontal gene transfer and the emergence of novel resistance genes."

Even after conventional treatment killed bacteria carrying resistance genes, these genes persisted, floating free in the water and intact enough to be picked up by other living bacteria or viruses.

Upstream ecosystems are also key drivers of resistance gene spread in their own right, independent of any treatment plant's influence, the findings show. "This means that river systems function less like passive channels and more like hotspots where the cumulative signature of multiple pollution sources builds up," Dr Makumbi says.

Bacteria are notorious for sharing genes – and not only with each other while alive, Dr Makumbi explains: "They [bacteria] don't just share these genes from one live bacterial cell to another but can also pick up genes from DNA that has been released from a dying cell and then incorporate it into their own genome [the complete set of genetic instructions found in an organism]."

This process, known as horizontal gene transfer, allows organisms within or between species to acquire new traits – including antibiotic resistance – directly from their environment. "Bacteria naturally produce antibiotics, and the same bacteria also produce resistance genes that help them survive while killing their competition," Makumbi explains. That is the natural loop. The fact, however, remains that AMR is also a clinical problem we cannot avoid."

In wastewater treatment plants, this process [of sharing genes] is accelerated by overexposure to a toxic mix of untreated effluent from abattoirs, hospitals and industry, raw sewage and other pollutants. "Higher levels of ARGs in river samples likely result from the combined effects of these releases and the shared pool of resistance genes between treatment plants and river environments," Dr Makumbi notes. "This means a wastewater treatment plant can act as a superspreader of antimicrobial-resistant genes, shaping the genetic landscape of wastewater and freshwater environments."

The paper reports that multi-stage systems combining ASP with biofiltration did outperform ASP-only plants, reducing resistance genes across several antibiotic classes.

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An old pipeline facing new threats

The study's findings highlight the need to rethink wastewater treatment plant design and develop smarter strategies that specifically target exDNA removal.

""We should protect our wastewater treatment plants by pretreating effluent from high-risk sources such as abattoirs, hospitals and industry before it enters the system," Makumbi says. "The same logic applies to treating effluent before it reaches the environment. Everyone will benefit from less polluted water entering our rivers."

Historically, many wastewater treatment plants were built to remove pathogens and harmful chemicals — not to specifically target and destroy free-floating DNA.

Some plants in South Africa and elsewhere are beginning to adopt more advanced approaches, such as ultraviolet treatment, to reduce the load of resistance genes. But as Makumbi notes, "progress remains slow".

"We need to consider the full pipeline of resistance when tackling antimicrobial resistance," Makumbi says. "This means that we will need to incorporate techniques like shotgun metagenomics within our routine surveillance to see what is happening within our systems. It doesn't have to be in daily surveillance, but to have some integration of some of these techniques, for example, some long-term studies, especially through government agencies that may have the resources to do this."

Although combining ASP and biofiltration showed slightly better efficacy at lowering ARG abundance, the presence of high-risk ARG classes makes it clear that ongoing breakthroughs in treatment technology are vital.

Biological treatment alone, the study suggests, may not be enough to address exDNA persistence. Strategies that disrupt genetic material in the first place could further reduce the risk these genes pose once they're released.

The stakes extend well beyond academic interest in microbial ecology. Treated wastewater is increasingly reused for irrigation, industrial processes, and, in some regions, even for potable use – a trend likely to grow as water scarcity intensifies.

"In water-scarce countries, there is a move to ensure that effluent quality supports reuse for certain purposes as a water conservation effort," Dr Makumbi notes. "If exDNA carrying high-risk resistance genes passes largely unaffected through treatment, residual genes in treated effluent present a route for reintroducing them into the human population. We need to consider the full pipeline of [AMR] resistance and follow a One Health approach when tackling antimicrobial resistance."

Prof Thulani Makhalanyane, who holds the DSTI-NRF Research Chair in African Microbiome Innovation and leads the broader research programme on microbes at SU, frames the challenge in a regional and global context: "Future wars will in part be based on water security and AMR. This is especially true in Africa, where ageing infrastructure, poor management, and an inability to sufficiently integrate science into policymaking are compounding the problem. We hope that the findings from this study will add to the call for action to ensure water security."

Next steps

At this stage, the exact mechanisms by which ARGs survive and move within microbiomes and between ecosystems remain unclear. More work is also needed to quantify transformation rates in natural settings, evaluate wastewater treatment technologies that remove exDNA, and trace gene flow in wastewater treatment facilities and connected rivers.

With this in mind, Dr Makumbi will expand his research efforts to the Western Cape. He will be investigating antimicrobial resistance genes in exDNA along urban wastewater systems and rivers in the City of Cape Town and elsewhere.

"If we are to slow the advance of antimicrobial resistance, we must broaden our surveillance and mitigation strategies to account for the mobility of genetic material itself," Dr Makumbi says. "Incorporating exDNA surveillance into routine and long-term monitoring programmes will give a fuller picture of AMR risk and help evaluate treatment effectiveness.

"That means treating not only microbes but their DNA, rethinking wastewater infrastructure, and aligning environmental management with clinical stewardship. The persistence of high-risk antimicrobial resistance genes in exDNA along wastewater-river continuums is a warning, and the time to act is now," he concludes.

To view the original article, visit: https://www.sciencedirect.com/science/article/pii/S2211124726002068

More about antimicrobial resistance

- The World Health Organization (WHO) defines antimicrobial resistance (AMR) as instances when bacteria, viruses, fungi and parasites do not respond to antimicrobials.
- AMR is a major global health and development threat. Studies show that almost 5 million deaths per year can be linked to AMR – more than HIV/AIDS and malaria combined. It is projected that by 2050, the figure will rise to 10 million per year, at a cost of US$100 trillion to the global economy.
- The misuse and overuse of antibiotics, for example, taking them when they are not needed or taking the wrong type, remains one of the main drivers of AMR. Lack of adequate access to appropriate new and existing vaccines, diagnostics and medicines also contributes to the crisis.
- Most human deaths from antimicrobial resistance occur in sub-Saharan Africa.
- One in six laboratory-confirmed bacterial infections worldwide was resistant to antibiotics in 2023.
- Experts warn that antimicrobial resistance in farm animals, if unchecked, could lead to a pandemic.
- AMR affects all countries, regardless of income, and spreads across borders. People living in low-resource settings and vulnerable populations, such as the very young and very old, are especially impacted.
- Between 2018 and 2023, antibiotic resistance rose in over 40% of the pathogen-antibiotic combinations monitored, with an average annual increase of 5–15%.

Sources: WHO, The Lancet and Science

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GROUNDWATER

Better the devil you know: Durban aquifers come in for close scrutiny

Groundwater, despite its importance, hasn't received the attention it deserves. A new study focusing on contaminants of emerging concern is helping correct this. Matthew Hattingh reports.

"Stille waters, diepe grond. Onder draai die duiwel rond." The Afrikaans proverb refers to the mysteries and psychological depth sometimes lurking below the surface of shy or seemingly placid people. Alerting us that deep within, a secret, perhaps even tempestuous nature, may be roaming.

This familiar piece of wisdom could well apply to groundwater. Our subterranean stores, a vital supplement to our water supply, remain something of a mystery. Do we really know what aquifers contain? And are the contents as pure as some of us would like to think? Ought we to be more on guard, to protect the resource?

A recent Water Research Commission (WRC) funded study tested the waters of greater Durban, with particular attention to a relatively new, unregulated bedevilment, known as contaminants of emerging concern (CECs). These include pesticides, potions and lotions, drugs, legal and otherwise, and "lifestyle" compounds, like caffeine and nicotine.

Hydrogeologists Siphesihle Ndlovu and Molla Demlie are the authors of 'Study of the occurrence, distribution, and fate of contaminants of emerging concern in groundwater in the Greater Durban Region' (**WRC Project No. C2023/2024-01416**).

It presents an overview of the eThekwini metro region's groundwater and river systems, the climate and topography, and

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rock and soil formations that hold the groundwater.
The authors collected, analysed and compared samples drawn in different seasons from 54 boreholes and seven surface water sites. Over three years, they developed a broad picture of the state of groundwater in the region, encompassing rural, peri-urban, residential, informal settlements and industrial land.

Ndlovu and Demile, a University of KwaZulu-Natal doctoral fellow and professor respectively, believe their study is timely. CECs have long been an area of research worldwide, but the focus has been on surface water. More recently, attention has shifted to groundwater, and South Africa needs to catch up. Only a handful of studies have been completed on contamination of the country's groundwater, with sampling limited to a few boreholes. Yet, we are increasingly dependent on groundwater as a supplement or alternative to surface water stretched thin by a growing urban population. eThekwini is now using more groundwater than ever before.

In a ***Water Wheel*** interview, the authors of the study spoke of extensive private borehole use, with limited regulation, including north of the city in new developments such as Cornubia and Umhlanga Ridge. In the popular imagination, groundwater is thought to be protected, as it's buried beneath soil and rock. Depending on the hydrogeological setting, however, it can be "highly vulnerable to contamination".

The authors are keen to correct such misconceptions, providing "comprehensive evidence of the occurrence, distribution, and controlling processes of CECs in water". CECs are increasingly found in surface and groundwater, a headache water authorities and regulators need to come to grips with, especially because CECs are hard to pin down. Chemically, they can be complex, particularly in combination with other contaminants, and their sources can be diverse.

As far as CECs go, the study reminds us that "low-level mixtures of pharmaceuticals and other organics can have additive or synergistic harmful effects on aquatic organisms".

To gauge the threat in Durban, water samples were collected from groundwater and surface water. These included 35 private and community-owned boreholes, at schools, clubs, mosques and churches; two Department of Water and Sanitation regional monitoring boreholes; and 17 municipal landfill monitoring boreholes. This was done at the end of the dry season (August), the start of the wet season (after the first flush of rain), and at the end of the wet season (April).

The study focused on groundwater in the greater Durban area, where especially private borehole use is increasing.

Samples were painstakingly filtered and prepared with the help of two Master's candidates and two Honours graduates (part of the project's capacity-building component). Researchers at specialised laboratories then looked for CECs, major ions, trace elements, environmental isotopes, and microplastics. Major ions are electrically charged ions found dissolved in water and include calcium, magnesium, sodium, chloride, sulphate, and bicarbonate. These dictate the salinity of water and ionic balance (essential salts) – all crucial to water quality. Major ions and trace elements provide clues to the origins of groundwater. They indicate the soils and rock the water has passed through and suggest how quickly aquifers were recharging.

Chromatography was used to identify and measure major ions in the samples. Mass spectrometry helped analyse trace elements and isotopes. Isotopes are versions of a given element, with greater or fewer neutrons than the norm, and as a result, different masses. The ratios of isotopes change with different environmental processes. Lighter water molecules have weaker bonds and so evaporate more readily. Heavier water molecules condense more and so rain down sooner.

Although only a tiny portion of water molecules contain heavy oxygen and hydrogen isotopes, they have a unique atomic signature. This allowed the researchers to use isotopes to trace where groundwater came from and the processes it had undergone.

High-resolution mass spectrometry allowed the researchers to detect the tiny tell-tale differences in isotope concentrations. The results indicated all surface water and some groundwater samples had gone through evaporation.

Analysis revealed spikes in electrical conductivity and levels of chlorides and nitrates at the start of the wet season. Elevated nitrate levels are associated with fertilisers and human or animal waste, while increased chloride may also indicate wastewater, sewage, or other human activities. This suggested a first flush into aquifers of CECs accumulated in the dry season, in the soil and rock above the water table and on hard urban surfaces. Subsequent rains were observed to recharge aquifers, diluting contaminants.

Concentrations of nitrates and sulphates in populated areas south-west of Pinetown and Phoenix "strongly suggest sewage leakage and surface runoff as possible active contamination sources of groundwater". Isotopic evidence confirmed "surface waters can enter the aquifer quickly, bypassing the natural filtration capacity (of the soil and rock above), increasing the likelihood of CECs reaching the water table", the study found. "The aquifer is most vulnerable during the start of the wet season, where the mobilisation of pollutant loads creates a surge in contamination potential."

Plumes of salty water occurring with sewage indicators in urban areas served as a "strong proxy" for the presence of CECs,

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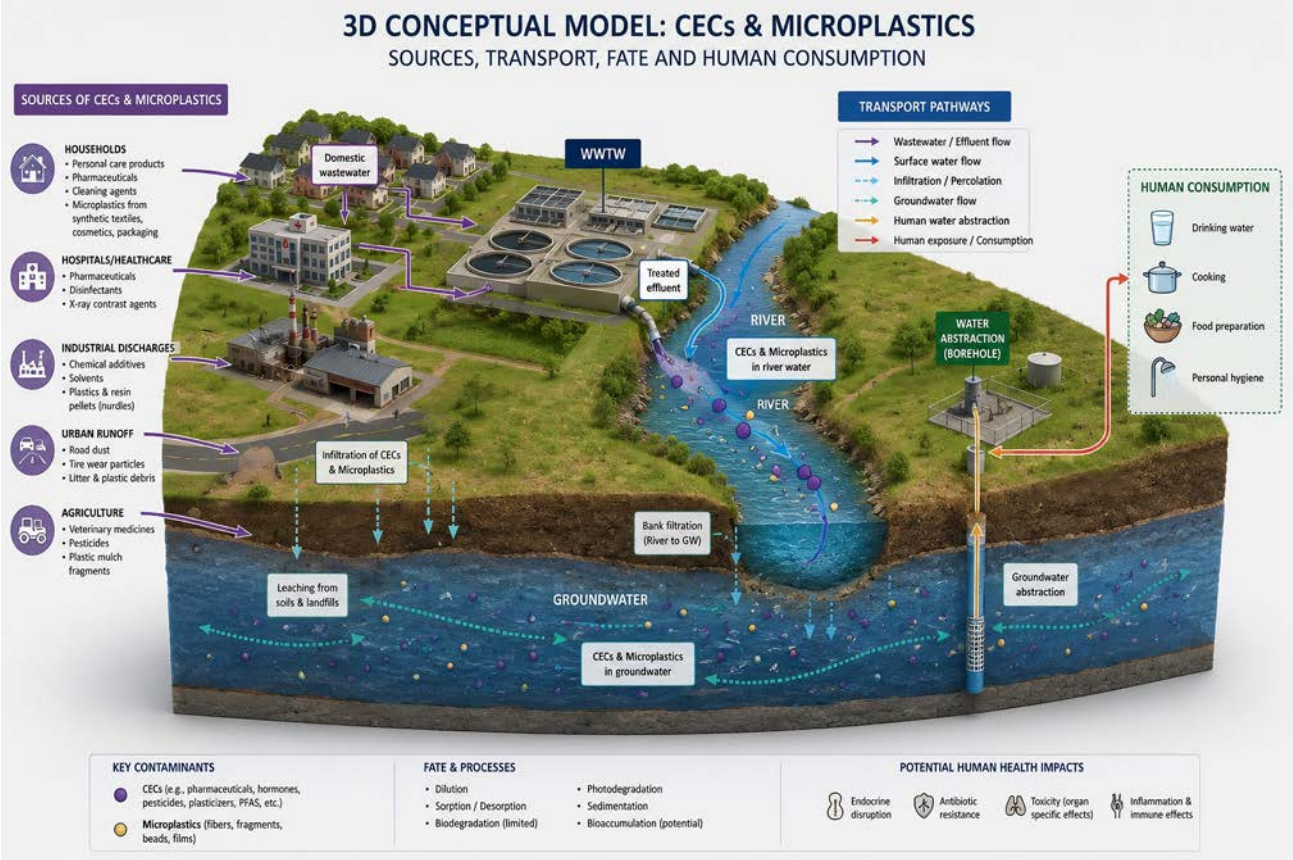
Photo supplied



How CECs and microplastics find their way into groundwater.

suggesting these contaminants "co-migrate with conventional pollutants".

The search for CECs involved targeted analysis of 17 selected contaminants, and non-targeted analysis, which took a drag-net approach. The 17 CECs included anti-inflammatories, like the ubiquitous ibuprofen; the antiepileptic carbamazepine; antibiotics like tetracycline; and lifestyle and industrial compounds like caffeine and bisphenol A (used in plastics goods and can linings).

Contaminant detection was found to be strongly seasonal, with water quality deteriorating as pollutants concentrated during low rainfall. In total, 207, 138 and 121 CECs were detected across all the sample sites during the end of the dry season, start of the wet, and end of the wet season, respectively.

Seven broad classes of CEC were detected: pharmaceuticals and personal care products (PPCPs); pesticides, herbicides and biocides; industrial chemicals and plasticizers; surfactants and polymers; fatty acids and amides; dyes and pigments; and microplastics.

Topping the list of CECs in Durban's groundwater were PPCPs, especially in urban and industrial areas like Pinetown and the South Durban Basin, where a cornucopia of ***muthi*** was detected. These included non-steroidal anti-inflammatory drugs; antibiotics; antidepressants; antidiabetics; anthelmintics; antiepileptic and anticonvulsants; antifungals; antipsychotics; antihistamines; anxiolytic and sedatives; cardiovascular drugs; and hormones and steroids.

The presence of antibiotics heightened growing concerns that these may raise antimicrobial resistance in aquatic food chains, "ultimately affecting the human population". Many PPCPs, or their remnants, pass through the body, enter the sewers, and reach wastewater treatment works, where processes have proved ineffective at removing some of them. They also ended up in municipal landfill sites, fortifying a noxious soup of nasties leaching into the groundwater. Older and decommissioned sites tended to be leakier than newer sites.

Groundwater samples from boreholes near landfills and rivers contained the highest contaminant levels. The lowest numbers of CECs were in samples from standalone boreholes used for drinking water. "Overall, the contaminant profile in landfill monitoring boreholes was characterised by high detection frequencies of analgesics, hormones and specific antibiotics, confirming landfills as point sources of PPCPs residues," the study reported.

Industrial chemicals and plasticizers (used to make plastics malleable, including triethyl phosphate and phthalates) were concentrated around landfills and manufacturing hubs, especially in Pinetown, Isipingo and Mobeni. Triethyl phosphate (a flame retardant and plasticizer) is slow to break down in the environment, lingering in aquatic and soil systems. It dissolves easily in water, so once released into the environment is transported with surface water or groundwater. It can then affect wider areas.

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Phthalates are used in plastics and cosmetics. Like several other CECs detected in the study, they are endocrine disruptors – compounds that interfere with natural hormones in living organisms. They can throw body temperature, blood sugar, and fluid levels out of whack and fiddle with fertility. Pesticides and herbicides were detected in more diffuse patterns, most likely associated with farming and residential gardens. Surfactants, found in soaps and detergents and used in industry, were "pervasive… and served as sensitive proxies for greywater ingress and untreated sewage".

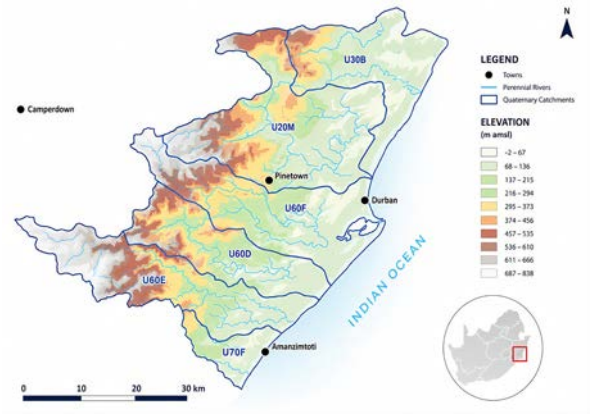
The study dedicated a chapter to microplastics, tiny pieces of plastic polymers, including tyre dust, shards and scrapings from carrier bags and packaging, and filaments from synthetic textiles. Filaments were found in all the groundwater and surface water sampled – especially in the wet season and in samples collected around townships, informal settlements and industrial areas.

Fibres were the most common microplastic shape detected, followed by fragments, films, and foams. Because fibres tend to be longer and skinnier than irregular shaped fragments, once liberated in the laundry they are good at slipping through the pores of aquifer material and more likely to survive the journey intact.

Ndlovu and Demlie were surprised by the volume and variety of microplastic they found in groundwater samples, having anticipated the soil above would do a better job trapping it. That said, the microplastic fragments were typically smaller than those found in surface waste, suggesting bigger fragments were being checked.

Examined under an electron microscope and with X-ray spectrometry, the microplastic samples revealed surfaces cracked and scratched from being bumped about and broken while travelling down rivers and through soil. The roughened surfaces of the fragments might "serve as hosts and habitats for other contaminants, such as heavy metals and microorganisms", making microplastics not only contaminants, but carriers.

For this study, 54 groundwater and 7 surface water samples were collected in three seasons across the greater Durban region. Groundwater levels, onsite physico-chemical parameters, borehole construction and location information were documented during the fieldwork. All samples were analysed for major ions and trace elements, environmental isotopes, microplastics, and CECs.



The study focused on the greater Durban area.

The authors felt that water authorities and the public were rightly anxious about the increasing presence in drinking water of microplastics – and other CECs. They warned that Durban's freshwater resources were being progressively transformed, "with significant implications for ecosystem integrity and human health".

The data demonstrated how certain contaminants could serve as tracers, helping to identify the source of pollution. The presence of carbamazepine and artificial sweeteners in groundwater, for example, pointed to wastewater ingress because of these contaminants' persistent usage and environmental stability. Saccharin and bisphenol A were associated with landfill-affected groundwater, although these compounds can originate from other sources.

The authors called for integrated water resource management and upgrades to waste and wastewater infrastructure and methodologies to raise treatment standards.
Greater scrutiny of industrial waste and wastewater was needed too. And water quality monitoring must be improved.

WRC research manager for the study, Dr Yazeed van Wyk, said the study's significance lies in showing where these contaminants occur, how they move through groundwater systems and the implications for future groundwater monitoring and management.

"The findings provide an important scientific basis for developing more proactive approaches to groundwater protection in South Africa."

But monitoring and mitigation measures won't happen on their own. Policy and regulations must first be rejigged and expanded to include targeted CECs. More research was needed too, including on how contaminants are transported through the ground; on groundwater in different hydrogeological settings in the country and beyond.

"This study must not stop here. It has to go into how this affects people," said Demlie, calling for multidisciplinary research on the health implications of CECs. The authors hope their study will lay the groundwork for this. On it rests not only the future of our groundwater, but perhaps of us all.

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ONE HEALTH

Rivers at risk: Rethinking surveillance to prevent waterborne zoonotic outbreaks

A recent Water Research Commission (WRC) funded study suggests that the next zoonotic disease outbreak in the Eastern Cape is likely to be associated with a river that has offered clear indicators of increasing health risks, probably for months in advance. Article by Jorisna Bonthuys.

A study conducted by researchers at Rhodes University's Institute for Water Research identifies rivers as active ecological reservoirs and transmission routes for waterborne zoonoses outbreaks rather than being passive conduits of contamination.

Funded by the WRC, the study, titled 'An integrated approach to timely detection and prevention of waterborne zoonoses outbreaks in selected municipalities of the Eastern Cape, South Africa', was led by Dr Chika Felicitas Nnadozie. She heads up the Centre for Environmental Water Quality at the university.

Dr Nnadozie and her co-authors addressed a central question: Is it possible to detect outbreaks of waterborne zoonoses before clinical cases emerge? Their findings indicate that early detection is indeed feasible, provided that the water sector, health authorities, veterinary services and environmental regulators collaborate and proactively monitor river systems.

The study focused on the Amathole District Municipality and the Nelson Mandela Bay Metropolitan area in the Eastern Cape. The province is highly vulnerable to waterborne zoonoses due to livestock-human-water interactions, climate variability and inadequate service delivery, particularly in water and sanitation.

Against this backdrop, the researchers set out with four aims: identify the rivers and pathways most likely to carry zoonotic disease between animals and humans; determine whether river surfaces – aquatic plants, rocks, even microplastic litter – actively

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cultivate these pathogens; pinpoint when outbreak risk peaks seasonally; and use this information to design interventions that interrupt transmission rather than document it after the fact.

They employed metagenomic sequencing (a laboratory method used to study all the genetic material recovered from a mixed sample of organisms), spatial risk mapping, community surveys, and stakeholder workshops to identify critical rivers and exposure pathways, integrating environmental and social data to develop a practical framework for early detection and prevention.

The findings reinforce the idea that biofilms on both biotic and abiotic substrates serve as persistent ecological refuges that sustain pathogen populations between outbreaks.

The link between water and infectious diseases

Waterborne zoonoses are infectious diseases caused by zoonotic pathogens, including bacteria, viruses, protozoa, and parasitic helminths (worms), transmitted from animals to humans, and vice versa, through contaminated water.

Globally, most emerging infectious diseases are zoonotic, and many are waterborne. Zoonotic diseases account for nearly 60% of new infectious threats, and affect low- and middle-income countries the most. Damaged ecosystems, shifting land use and closer human-animal contact fuel their spread.

Freshwater pathogens thrive in a remarkable variety of habitats, drifting freely through the water or clustering together on living and non-living surfaces. This ability to attach to surfaces and form biofilms is central to pathogen persistence in aquatic ecosystems, as it enables microorganisms to withstand environmental stressors, exploit localised nutrient sources, and evade hydrological flushing.

Aquatic plants (macrophytes) and rocks have long served as stable, ecologically integrated havens for pathogens, but microplastics now add a new, human-made platform that could intensify these dangers thanks to their durability, movement through water, and strong attraction to resistant and harmful microbes.

Study overview and objectives

South Africa has a long history of waterborne disease outbreaks and of zoonotic disease risks associated with interactions among humans, livestock, wildlife, and the environment.

Recent outbreaks include Rift Valley fever, African swine fever, avian influenza, and foot-and-mouth disease, which underscored systemic vulnerabilities in biosecurity and public health (un) preparedness across the human-animal-environment interface.

Water-related zoonotic pathogens such as ***Cryptosporidium*** spp., ***Giardia*** spp., and ***Leptospira*** spp. have also been documented at human-animal-environment interfaces in South Africa, highlighting the importance of environmental surveillance and integrated One Health approaches to disease prevention and management.

Wastewater effluent, livestock and wildlife faecal contamination and poor sanitation are key factors influencing pathogen persistence and transmission. Waterborne disease risks are exacerbated by fragmented governance arrangements, competing land-use priorities, and insufficient enforcement of water quality standards. Additional pressures include rising animal disease outbreaks and systemic gaps in disease surveillance. Droughts and floods caused by climate change also make it harder to access safe water and often force people and animals to share water sources, increasing the risk of pollution and disease.

Recent studies indicate that waterborne pathogens, including those that can spread from animals to people, are common in South African rivers, home water storage and wastewater systems. This is a major public health concern, especially in rural and nearby urban areas with poor sanitation and reliance on rivers, Nnadozie points out.

For the Eastern Cape, where ageing sanitation infrastructure, free-grazing livestock and seasonal climate extremes converge, that risk has particular urgency. "In many communities, rivers provide domestic water, irrigation, spiritual spaces and livestock watering," Dr Nnadozie says. "These rivers also collect human, livestock, and wildlife waste, wastewater effluent, and runoff, becoming transmission points for pathogens moving from animals to people."

Unpacking the results

The team used geographic information system (GIS) layering of hydrology, precipitation/drought patterns, flood occurrence, proximity to wastewater treatment works, livestock density, agricultural land use and population concentration.

During 2023 and 2024, they collected 78 environmental samples from the Kat and Swartkops rivers – not just water, but biofilms scraped from rocks, macrophytes and plastic debris in the river. Each sample went through DNA extraction and metagenomic sequencing to generate a detailed genetic snapshot of the bacterial communities living in and on a river.

The researchers analysed microbes on various substrates to assess pathogen distribution and persistence. They evaluated seasonal patterns through repeated sampling and statistical analysis. The researchers also conducted structured household questionnaires (181 respondents), focus groups, and stakeholder workshops across Kat, Swartkops and other catchments to document river-use behaviours, exposure pathways, reporting practices and institutional coordination.

The results demonstrate that macrophytes hosted the most diverse and abundant biofilm communities, often exceeding those found in water samples. Rock biofilms and macrophytes supported ***Leptospira*** and other genera associated with direct contact and ingestion.

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Wastewater effluent, livestock and wildlife faecal contamination and poor sanitation are key factors influencing pathogen persistence and transmission.

Additionally, plastics and other hard surfaces concentrated ***Legionella*** and provided colonisable microhabitats, demonstrating a 'microplastisphere' effect.

The findings reinforce the idea that biofilms on both biotic and abiotic substrates serve as persistent ecological refuges that sustain pathogen populations between outbreaks.

The results show that both natural and artificial substrates serve as reservoirs for zoonotic bacterial pathogens. Furthermore, the pronounced winter increase in genera such as ***Legionella***, ***Mycobacterium***, and ***Leptospira*** suggests that colder conditions may elevate exposure risk, particularly for aerosol- and water-associated transmission pathways.

Novel risk map generated

Each layer of information gained during this study was integrated onto a five-point risk scale and combined into composite catchment risk maps of the province. This mapping exercise enabled them to classify rivers by vulnerability to waterborne zoonotic pollution.

The risk map shows that the Eastern Cape is mostly characterised by low to moderate risk levels. These reclassified layers form the basis for identifying areas of heightened potential for contamination and prioritising rivers within the province.

Approximately 89% of the province's area falls within low- or moderate-risk categories. However, the remaining 11%, concentrated in specific, identifiable zones, accounts for the majority of the risk. According to Dr Nnadozie, the five risk-level zones they identified are characterised by dense human settlement, intensive river use, and inadequate wastewater infrastructure.

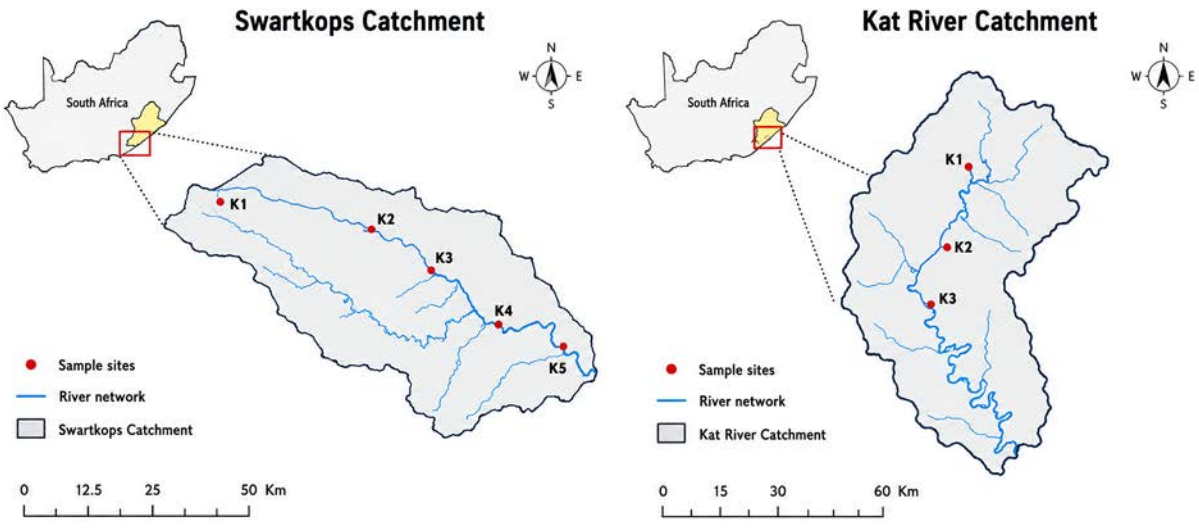
The spatial distribution of risk levels identified reveals geographical variation in vulnerability to waterborne zoonotic diseases across the province.

High-risk areas are clustered near Uitenhage, Hankey, Kirkwood and Humansdorp, the central coastal belt near King William's Town and pockets of the north-eastern interior. Very high-risk zones are most prominent around Gqeberha and KuGompo City (East London), as well as along the north-eastern coastal corridor near Butterworth, Bizana, Lusikisiki, and Port St Johns.

Human behaviour matters – not just proximity to high-risk rivers

The study demonstrates that exposure risk is structured less by people's proximity to rivers than by how people and animals interact with these rivers. While most activities involved low-risk contact, ingestion-related pathways associated with fishing, ritual practices, and domestic water use posed a significantly higher risk of outbreaks.

Exposure depends on how communities actually interact with contaminated water – and here the team turned to social science, surveying people living near the Kat and Swartkops rivers about their daily use of these waterways.



The two main study areas, showing the sampling sites.

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Respondents reported 18 distinct river-related activities. The most common, by far, were low-risk: walking along the banks, observing nature, simply enjoying the landscape. Fishing and ritual water use – including baptism and traditional cleansing practices – were reported less frequently, but these activities involve direct ingestion or intensive contact, thereby carrying a much higher risk of transmission.

Recommendations and next steps

Overall, the findings suggest that waterborne zoonoses outbreaks in the Eastern Cape are not just microbiological issues but also reflect failures in how surveillance, governance and community engagement work together. Dr Nnadozie says the results demonstrate that "waterborne zoonoses outbreaks are predictable outcomes of ecological, behavioural, infrastructural and governance failures, rather than random events".

"Rivers do more than carry waterborne pathogens; they also influence how these pathogens spread and affect their environment," she says. "We know zoonotic pathogens have environmental, hydrological and human drivers. The findings show there is a high likelihood that many waterways may be silently contributing to a high infection rate in the general human population through multiple routes of exposure."

The findings about risk zones have important implications for surveillance budget planning, Dr Nnadozie believes. Province-wide blanket monitoring is unnecessary; instead, targeted interventions are feasible.

Institutionally, the study found that fragmented surveillance and weak reporting systems exclude communities from early warning processes, eroding trust and undermining prevention.

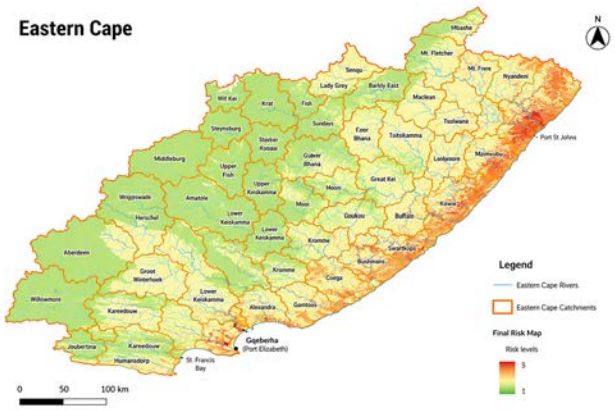
The research positions environmental surveillance indicators, particularly pathogen genetic signals in water, as early warning tools that support timely and targeted public health interventions.

The study identifies clear priorities for follow-up, including longitudinal monitoring to validate seasonal predictors and refine lead times for early warning.

The researchers set out eight key recommendations. They urge that surveillance for waterborne zoonoses be guided by risk, zeroing in on the catchments flagged as high or very high risk, while keeping a lighter watch elsewhere. Environmental monitoring should reach beyond the river's surface to probe the hidden world of biofilm-laden plants, rocks, and plastics where pathogens linger.

Early warning systems must be tuned to the seasonal spike in waterborne diseases each winter. Prevention should home in on places where people are most likely to ingest contaminated water, such as fishing spots, ritual water-use areas, and domestic collection points, rather than relying on broad river-health campaigns. Wastewater treatment upgrades should be seen not just as infrastructure projects but as vital public health measures.

Formal One Health governance should also unite the water, health, veterinary, and environmental sectors under shared goals and budgets, moving beyond reliance on informal cooperation.



Zoonotic contamination potential zones for river systems in the Eastern Cape. The map illustrates spatial variations in zoonotic contamination risk affecting river systems across inland, coastal and north-eastern regions of province, categorised into five risk levels (1 = very low risk to 5 = very high risk.)

In addition, community voices need to be woven into the system through real reporting channels and visible feedback, helping to restore the trust that focus groups found lacking. Finally, future research should sharpen the thresholds that prompt action, test the framework, and identify ways to adapt it in other provinces facing the same tangled risks.

The researchers recommend establishing an operational pilot of integrated One Health surveillance and response in selected high-risk catchments to test governance arrangements, data systems and trigger mechanisms.

Dr Nnadozie believes South Africa could benefit from a surveillance system that "routinely monitors these priority rivers, moving away from being purely reactive to outbreaks".

"An early warning system will provide us with an opportunity to anticipate that these diseases will come into the population and try to prevent it even before it appears," she says. "In terms of what should then be prioritised in terms of surveillance, I would say we should actually not only look at the water column, but look at those substrates as well. In high-risk areas, we need to fix the wastewater treatment points, improve that infrastructure, and maybe incorporate community-based surveillance.

"Wastewater failures and livestock waste inputs continue to be treated as infrastructure or environmental issues rather than as precursors of public health emergencies, allowing preventable risks to escalate into crises."

Both prevention and preparedness are essential, and effective surveillance can facilitate timely responses.

"Outbreaks are not merely microbial, microbiological events, but socioecological failures," Dr Nnadozie concludes. "Rivers are functioning as active transmission interfaces, not passive environments. This means that we have to actively manage the reservoir environments if we want to manage zoonotic diseases."

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HYDROGEOLOGY

Urban vadose zone: The hidden water cycle beneath our cities

The hidden world beneath our cities is constantly reshaped by urban development, influencing groundwater recharge, contaminant movement and infrastructure stability. Recent Water Research Commission (WRC) funded research reveals why understanding the urban vadose zone may be one of the most important steps towards securing South Africa's groundwater future.
Article by Dr Yazeed van Wyk

Every year, South African municipalities lose billions of litres of treated drinking water through leaking infrastructure. These losses place enormous pressure on already strained municipal finances, reducing the revenue available for maintaining ageing infrastructure and investing in water services. Yet from a hydrogeological perspective, the story does not end once that water escapes a pipeline. It becomes part of the urban subsurface, infiltrating soils and fractured rock, mixing with natural recharge and interacting with the geology beneath our cities. In doing so, it may raise groundwater levels, mobilise contaminants, weaken foundations or even contribute to sinkhole formation. What begins as an infrastructure problem ultimately becomes a groundwater problem.

Few components of the water cycle are as overlooked as the vadose zone. Situated between the land surface and the groundwater table, this unsaturated layer is where every drop of rain destined to become groundwater must first travel. Although unfamiliar outside specialist circles, the vadose zone is increasingly recognised as playing a fundamental role in protecting water resources, maintaining resilient infrastructure and sustaining the ecosystem services upon which society depends. It is here that water is stored, redistributed and, in many cases, naturally filtered before reaching an aquifer. It is also where anthropogenic activities leave their first and often most enduring imprint on the subsurface.

As pressures on land and water resources continue to

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grow, understanding the urban subsurface has become an international research priority. Urbanisation, climate variability, changing land use and contaminants of emerging concern all interact within the vadose zone, influencing how water moves through the ground and ultimately determining the quality and quantity of groundwater available for future use.

Recognising the importance of these processes, the WRC funded the recently completed study titled ***Framework for natural and anthropogenic changes to the urban vadose zone*** (**WRC report no. TT 954/1/25**). The study demonstrates that urban development does far more than replace natural landscapes with roads and buildings. In doing so, it fundamentally reorganises the movement of water beneath the surface, altering recharge pathways, contaminant transport and the interactions between engineered infrastructure and the natural subsurface environment.

Perhaps the most important insight emerging from the research is that cities do not simply consume water. They reshape the urban water cycle itself.

The common perception is that urbanisation reduces groundwater recharge because concrete and asphalt seal the land surface. While this is partly true, the reality is considerably more complex. As cities expand, natural recharge processes are increasingly supplemented and reshaped by anthropogenic recharge generated through leaking infrastructure, stormwater systems and other engineered pathways. Roads redirect runoff, stormwater systems concentrate infiltration, leaking water mains create unintended artificial recharge and ageing sewer networks introduce entirely new contaminant pathways. Quarries, excavations, basements, buried services and irrigated green spaces further modify the movement of water beneath our cities. Rather than simply reducing groundwater recharge, urban development redistributes where, when and how recharge occurs, fundamentally rewriting the urban water cycle.

This shift in perspective has important implications for groundwater management. Traditionally, hydrogeological investigations have focused on the aquifer itself in terms of how much groundwater is available, where it occurs and whether it can sustain future abstraction. These remain essential questions. However, a growing body of research shows that the quality and quantity of groundwater are determined long before water reaches the water table. The journey through the vadose zone influences how much recharge ultimately reaches an aquifer, how quickly contaminants move through the subsurface and how resilient groundwater resources remain under increasing environmental pressure.

Leaking municipal infrastructure provides one of the clearest examples of this hidden water cycle. For municipal engineers, a leaking water main represents wasted treated water and lost revenue. For hydrogeologists, however, it represents an unintended recharge experiment. Water that was intended to remain within the distribution network instead moves through soil, weathered rock and fractured geological formations. Where sewer networks leak, the concern extends even further. Nutrients, pathogens, pharmaceutical residues and other contaminants may migrate through the vadose zone towards groundwater. Depending on the local geology and the presence of preferential flow pathways, these contaminants may be retained, transformed or transported over considerable distances before eventually reaching an aquifer.

For a country that is placing increasing emphasis on groundwater as a strategic component of long-term water security, these findings carry an important message. The recently announced National Water Action Plan includes proposals to expand groundwater development through the drilling of additional boreholes to serve approximately 250 000 households over the next two years. While this represents an important investment in water security, groundwater development cannot simply be measured by the number of boreholes drilled. Just as South Africa recognises the importance of protecting its Strategic Water Source Areas for surface water, safeguarding groundwater recharge areas is equally important for ensuring the long-term sustainability of our aquifers. Protecting groundwater therefore begins long before water reaches the aquifer. It begins with understanding the processes occurring within the vadose zone.

Fortunately, the scientific knowledge required to address these challenges already exists. Hydrogeologists, engineering geologists, water-quality scientists, geotechnical engineers and municipal engineers have developed the expertise and technical know-how needed to investigate groundwater recharge, contaminant transport and subsurface flow. The challenge is seldom a lack of scientific understanding. More often, it lies in bringing these different disciplines together when planning, maintaining and expanding urban infrastructure.

Cities are complex systems, and so too is the ground beneath them. Roads, pipelines, stormwater systems, buildings and groundwater are often planned and managed separately, despite interacting continuously below the surface. Recognising these connections allows problems to be anticipated before they become costly failures, including groundwater contamination, infrastructure damage and rising groundwater levels.

Much of what happens beneath our cities remains invisible. Water may migrate through fractures for years before its effects become apparent. Contaminants may move unnoticed through the subsurface long before they are detected in a monitoring borehole. Yet these hidden processes are already shaping the resilience of South Africa's cities and the security of the groundwater resources on which millions of people increasingly depend.

Understanding the urban vadose zone requires a shift in how we think about groundwater. Aquifers cannot be viewed in isolation from the subsurface processes that sustain them. Cities have transformed the landscape above ground, and research increasingly shows that they have transformed the water cycle below it as well. As South Africa increasingly turns to groundwater to strengthen water security, protecting aquifers cannot begin at the borehole. It begins by protecting the recharge environment that sustains them.

To download the report, ***Framework for natural and anthropogenic changes to the urban vadose zone*** (**WRC report no. TT 954/1/25**), visit: https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20954%20final%20web.pdf

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THE WATER WHEEL

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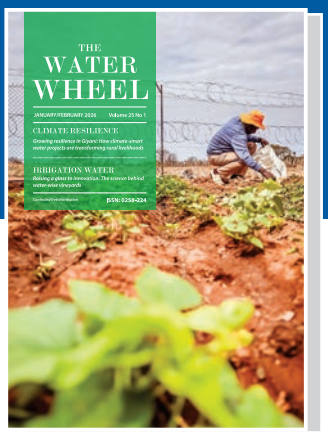

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The Water Research Commission not only endeavours to ensure that its commissioned research remains real and relevant to the country's water scene, but that the knowledge generated from this research contributes positively to uplifting South African 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.

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