

NEWS

Extracting value from acid mine drainage



The CSIR has developed a zero liquid discharge technology to minimise the ecological footprints of acid mine drainage (AMD). AMD has been a thorny issue in South Africa for many decades and continues to contaminate both freshwater sources and the environment. Acid mine drainage is a direct result of the weathering of sulphide-bearing minerals during and after the mining of valuable minerals, such as coal and gold. These hazardous chemicals have a direct effect on living organisms and

the host environment; hence the urgent need to contain and mitigate the risk of contamination.

Conventional technologies to treat AMD often rely on the use of a lime and filtration technology that generated toxic sludge. This has prompted the need to look for alternative technologies with a minimum or zero ecological footprint. The CSIR's quest to find an alternative cleaner technology to curtail the impact of AMD on the environment resulted in the development of a robust treatment technology called magnesite softening reverse osmosis.

The game-changing technology relies on a combination of activated magnesite, softeners and reverse osmosis to recover valuable minerals at different stages of the process. The technology has been tested and validated at a laboratory and a pilot plant with a 20 000 litre per day capacity, located at the CSIR in Pretoria. The plant's robustness has been assessed against effluents that emanate from coal and gold mines.

The CSIR has designed and is at the advanced stage of constructing a modular pilot plant with a capacity of 0.5 million litres per day. This initiative will foster the concept of a circular economy, waste valorisation and beneficiation. Revenue generated from the re-sale of recovered minerals will offset the running costs of the system, making it self-sustainable.

The quality of effluent can be controlled through the installation of reverse osmosis membranes to produce high-grade water. The process has been patented and its efficiency as a means of converting waste streams into an environmentally friendly resource has been demonstrated over five years.

Research and development partners, to date, include Exxaro, one of the largest black-empowered diversified mining companies in South Africa; South32, a globally diversified mining and metals company and the Trans-Caledon Tunnel Authority.

Source: CSIR

Berg estuary joins list of SA Ramsar sites

On World Wetlands Day, 2 February, South Africa celebrated the declaration of its 28th wetland of international importance. The Berg Estuary in the Western Cape was declared as a Ramsar Site under the Convention on Wetlands of International Importance in time for the marking of World Wetlands Day.

"The declaration of South Africa's 28th Ramsar site is an indication of the importance of conserving and protecting these unique environments that are considered super ecosystems because of their contribution to the provision of water and because they provide habitats to a large variety of migratory birds, especially water birds," said the Minister of Forestry, Fisheries and the Environment, Barbara Creecy.

The Berg Estuary, which is one of 290 estuaries in South Africa, is the second wetland of international importance to be declared in the country in two years. In 2021, the Ingula Nature Reserve in the northern Drakensberg was declared the country's 27th Ramsar Site.

Situated at Velddrif, close to St Helena Bay where the Berg River flows into the sea, this estuary spans an area of 1 162 ha. The West Coast fishing village is situated in the Bergrivier Local Municipality.

The Berg River forms one of only four estuaries on the West Coast of southern Africa that always have water. This is in addition to the main estuarine channel which is a floodplain encompassing five major wetland types of importance

to 250 species of waterbirds. These are ephemeral pans, commercial salt pans, riparian marshes, saltmarshes (which are the third largest on the Cape coast) and intertidal mudflats.

Although estuaries comprise less than 2% of South Africa's territory, these highly productive ecosystems contribute R4.2 billion per annum to the South African economy. They are focal points for development, tourism and recreation, as well as important for supporting biodiversity, livelihoods and marine fisheries. The Berg Estuary, in particular, contributes about 60% of the estuarine habitat on the West Coast and is therefore extremely important in terms of the biodiversity, cultural and economic activities that it supports.

SA government still main funder of R&D, survey shows



The Minister of Higher Education, Science and Innovation, Dr Blade Nzimande, has welcomed the increase in government funding for research and development (R&D) activities, but expressed concern at the general decline in R&D funding from other stakeholders, as reflected in the latest national survey.

The results of the 2019/20 National Research and Experimental Development (R&D) Survey released late last year indicates that the main sources of funding for R&D in South Africa are the government (including science councils and university own funds) and business sectors. Whereas government funding of R&D increased by R1,942 billion from the previous year, business funding dropped by R5,175 billion. Funding from abroad, which went mostly to the private sector,

increased by R664 million.

The national R&D Survey is undertaken annually by the Centre for Science, Technology and Innovation Indicators (CeSTII) of the Human Sciences Research Council (HSRC) on behalf of the Department of Science and Innovation (DSI), with support from Statistics South Africa (StatsSA).

The latest trends in R&D expenditure show a similar trajectory to that of the economy in general. Gross domestic product (GDP) growth decreased by 1,4 of a percentage point to 0,1% in 2019, after taking into account the revisions due to StatsSA's benchmarking and rebasing of the GDP series to the 2015 year.

Gross domestic expenditure on research and development (GERD) for 2019/20 amounted to R34,485 billion at current rand values. GERD is an aggregated measure of in-house R&D expenditure performed domestically in five institutional sectors, namely government, science councils, higher education institutions, the business sector, and the not-for-profit sector. The medical and health sciences and social sciences are key

research areas. The 2019/20 results show the strongest focus of R&D activity to be in the medical and health sciences (21,5%), followed by the social sciences (16,9%) and engineering sciences (13,4%).

The minister requested the DSI, the HSRC-CeSTII and the National Advisory Council on Innovation (NACI) to convene a round-table engagement in February, where key role players including government, business, state-owned entities, universities, science councils and experts could reflect on the survey results and help formulate advice for consideration by Cabinet.

The focus of the round-table was on identifying the measures required to achieve the National Development Plan (NDP) target of raising the level of R&D investment in South Africa to 1,5% of GDP by 2030.

To access the report, Visit: http://www.hsac.ac.za/uploads/pageContent/1046484/RD_StatisticalReport2019-20_%20WEB.pdf

Innovative sanitation solutions for Gauteng communities

Adequate sanitation remains a challenge especially in South Africa's informal settlements. The Water Research Commission through the South African Sanitation Technology Enterprise Programme (SASTEP) is working with its municipal and innovation partners to introduce next generation sanitation solutions to provide improved, hygienic, and dignified solutions to address sanitation service delivery backlogs, sanitation related – water scarcity issues and new sanitation innovations.

A SASTEP initiative involving Johannesburg Water and two commercial partners, Enviro Options and WEC Projects, was launched during the 2021 World Toilet Day at two informal settlements in Soweto. The Clear Recirculating Toilet System, installed at the Mofolo North informal settlement, uses a full water cycling process for the treatment of sewage. An advanced Biofilm-MBR treatment process is employed as the core technology for treatment, producing

a stable and clean effluent that is further disinfected to ensure safety of the effluent for reuse.

The system has been licensed from Clear (Suzhou) Environmental Technologies Co. Ltd and will be manufactured locally by Enviro Options, a leading South African dry sanitation company with over 26 years of experience in manufacturing and supplying safe, off-the-grid, non-sewered sanitation. Enviro Options has successfully completed the transfer of technology and have started local manufacture of units. The installation at Mofolo North informal settlement will service 75 households. The NEWgenerator, installed at Time-house Informal Settlement, Soweto, is a compact, portable, and modular resource recovery machine that eliminates waste while recovering fertilizer nutrients, renewable energy, and clean water. The system uses an anaerobic baffled reactor design followed by a nanomembrane filter operated at subcritical water flux to extend the longevity of the membrane.

Permeate from the filter is treated for reuse as flush water by electrochemical chlorine production from table salt. The unit is equipped with solar panels to generate sustainable energy for the operation of the NEWgenerator system. The NEWgenerator is an off-grid sanitation system developed by the University of South Florida (USF) which has been licensed and will be manufactured locally by WEC Projects, a leading provider of engineered solutions in the water and wastewater treatment industry. The installation at Time-house Informal Settlement, Soweto will service 25 households.

Through funding from the Bill & Melinda Gates Foundation (BMGF), SASTEP has supported the capital cost of these two installations as well as the operation and maintenance during the 12-month demonstration period. Post-demonstration, Johannesburg Water will take over the management of the facilities for the informal settlements.

GLOBAL

Water is essential in the fight against AMR, study concludes

Responsible manufacturing of pharmaceuticals along with the provision of water and sanitation services are key to reducing the spread and impact of antimicrobial resistance.

Antimicrobial resistance (AMR) is one of the world's greatest health threats, according to a recent study published in the *Lancet*. The analysis, which covered more than 200 countries and territories found an estimated 1.27 million deaths attributed to bacterial AMR in 2019. Nicolai Schaaf who leads the Stockholm International Water Institute's (SIWI's) work on tackling AMR says "To fight antimicrobial resistance, antibiotics manufacturing must prioritise the prevention of pharmaceutical waste polluting water."

SIWI's Responsible Antibiotic Manufacturing Platform (RAMP) was set up to put an end to the unsustainable practices of antibiotics production which is leading to the degradation of both human and environmental health. In a blog Rachael Kupka of the Global Alliance on Health and Pollution, called for a Science Policy Panel on Chemicals, Waste and Pollution which would bring visibility and focused attention to the critical issue of pollution such as water pollution. Tackling one of the key drivers of AMR – emissions from the production of antibiotics – through collaboration will be instrumental to tackling AMR on a global scale.

The World Health Organization warns that AMR could claim 10 million lives per

year by 2050, jeopardising the efficiency of the treasure that antibiotics are to human health and a century worth of medical progress. The use and misuse of antibiotics in human health care, livestock and crops are the major drivers of AMR. Pollution from pharmaceutical production must not add to this risk.

"Water plays an essential role in the fight against AMR" says Nicolai Schaaf. "Access to safe water is not only a key determinant for health, reducing the dependency on antibiotics and the vulnerability to AMR. Curbing emissions of antibiotics to waterbodies prevents these from turning into incubators for resistant bacteria."

Dragonflies threatened as wetlands disappear around the world

The destruction of wetlands is driving the decline of dragonflies worldwide, according to the first global assessment of these species in the IUCN Red List of Threatened Species™.

Their decline is symptomatic of the widespread loss of the marshes, swamps and free-flowing rivers they breed in, mostly driven by the expansion of unsustainable agriculture and urbanisation around the world.

The assessment of the world's dragonflies and damselflies reveals that 16% out of 6 016 species are at risk of extinction, as their freshwater breeding grounds increasingly deteriorate. In South and Southeast Asia, more than a quarter of all species are threatened, mostly due to the clearing of wetland and rainforest areas to make room for crops such as palm oil. In Central and South America, the major cause of dragonflies' decline is the clearing of forests for residential and commercial construction. Pesticides, other pollutants

and climate change are growing threats to species in every region of the world, and are the greatest threats to dragonflies in North America and Europe.

"Dragonflies are highly sensitive indicators of the state of freshwater ecosystems, and this first global assessment finally reveals the scale of their decline. It also provides an essential baseline we can use to measure the impact of conservation efforts," said Dr Viola Clausnitzer, Co-chair of the IUCN SSC Dragonfly Specialist Group. "To conserve these beautiful insects, it is critical that governments, agriculture and industry consider the protection of wetland ecosystems in development projects, for example by protecting key habitats and dedicating space to urban wetlands."

The Pyrenean desman (*Galemys pyrenaicus*), a semiaquatic mammal and found only in rivers in Andorra, France, Portugal and Spain, has moved from Vulnerable to Endangered. This

unusual species is related to moles and has a long, sensitive nose and large webbed feet. It is among the last of its evolutionary line; one of only two remaining desman species in the world. The Pyrenean desman population has declined throughout its range by as much as 50% since 2011, largely due to human impacts on its habitats. Disruption to river flow and reduced water levels as a result of hydropower plant, dam and reservoir construction and water extraction for agriculture make significant areas inhospitable to the desman, isolate populations, and markedly reduce desman prey and shelter. Invasive alien species, illegal fishing using poison, nets and explosives, increasing droughts due to climate change, excavation of riverbeds and banks and water pollution further threaten the desman. Preserving and restoring the natural flow of rivers and surrounding vegetation, controlling invasive alien species and tackling climate change are key for this species to recover.

AI could boost accuracy of lightning forecasts



Machine learning – computer algorithms that improve themselves without direct programming from humans – can improve lightning forecasts, a new study shows.

Lightning is one of the most destructive forces of nature, but it remains hard to predict. Better lightning forecasts could help to prepare for potential wildfires, improve safety warnings for lightning, and create more accurate long-range climate models.

“The best subjects for machine learning are things that we don’t fully understand. And what is something in the atmospheric sciences field that remains poorly understood? Lightning,” says Daehyun Kim, an associate professor of atmospheric sciences at the University of Washington. “To our knowledge, our work is the first to demonstrate that machine learning algorithms can work for lightning.”

The new technique combines weather forecasts with a machine learning equation based on analyses of past lightning events. The hybrid method, presented at the American Geophysical Union’s autumn meeting towards the end

of last year, can forecast lightning over the southeastern US two days earlier than the leading existing technique.

“This demonstrates that forecasts of severe weather systems, such as thunderstorms, can be improved by using methods based on machine learning,” says Wei-Yi Cheng, who did the work for his University of Washington doctorate in atmospheric sciences. “It encourages the exploration of machine learning methods for other types of severe weather forecasts, such as tornadoes or hailstorms.”

Researchers trained the system with lightning data from 2010 to 2016, letting the computer discover relationships between weather variables and lightning bolts. Then they tested the technique on weather from 2017 to 2019, comparing the AI-supported technique and an existing physics-based method, using actual lightning observations to evaluate both.

The new method forecast lightning with the same skill about two days earlier than the leading technique in places, like the southeastern US, that get a lot of lightning. Because the method was trained on the entire US, its performance

wasn’t as accurate for places where lightning is less common.

The researchers hope to improve their method using more data sources, more weather variables, and more sophisticated techniques. They would like to improve predictions of particular situations like dry lightning, or lightning without rainfall, since these are especially dangerous for wildfires.

The researchers believe their method could also be applied to longer-range projections. Longer-range trends are important partly because lightning affects air chemistry, so predicting lightning leads to better climate models.

“In atmospheric sciences, as in other sciences, some people are still skeptical about the use of machine learning algorithms—because as scientists, we don’t trust something we don’t understand,” Kim says. “I was one of the skeptics, but after seeing the results in this and other studies, I am convinced.”

Source: University of Washington

NEW WRC REPORTS

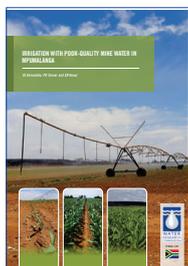


Guidance for attaining regulatory approval of irrigation as a large-scale, sustainable use of mine-water

The beneficial reuse of treated mine-impacted water is not currently a priority in South Africa. Although the discharge of effluent to water resources should be the option of last resort, it is often the first choice of many in the mining industry and industry as a whole, due to its simplicity and low cost. While pollution from mine-impacted water is a significant problem with high costs often associated with treatment, the potential increase in water availability if this water can be used untreated or partially treated for irrigation offers opportunities for making additional water available to supplement traditional water resources. The current regulations surrounding mine closure certification and water use licence applications do not prevent irrigation with mining-impacted water, but there is an absence of guidance to sufficiently inform both mining companies and regulators too make informed decisions regarding irrigation in the post-mining landscape. Guidance for attaining regulatory approval of irrigation. In this light, this project aimed to review the policy and regulatory framework to provide guidance for the establishment of the irrigation of agricultural land as a large-scale, sustainable use of mine water during mine operation and post-closure. The goal is to ensure that this water is viewed as a national agricultural asset for beneficial use, not as problematic wastewater that requires disposal, in an enabling regulatory environment with clear guidelines as to the process to follow in order to get regulatory approvals. The outcome of this project is therefore a comprehensive guideline for the relevant stakeholders engaged in a decision-making process regarding whether a specific mine water source can be applied for irrigation, as well as what ongoing monitoring would be required to maintain the applicable licences and approvals once implemented, considering community and environmental safety.

WRC Report no. TT 837/21

Web link: <https://bit.ly/3JQQF82>



Irrigation with poor-quality mine-water in Mpumalanga

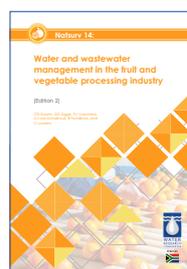
The mining industry in South Africa produces large volumes of mine-impacted water and the agricultural industry requires large water inputs to improve and maximise crop yields. A noteworthy opportunity, therefore, arises for the use of mine water for irrigation, if monitored and correctly managed, to facilitate sustainable mine closure. It could also provide an alternative strategy for operating mines, and for the use of mine water, with or without treatment, depending on the quality. Success with mine water irrigation has been demonstrated in several previous Water Research Commission (WRC) studies. However, this approach to using suitable mine water has not received traction, partly due to the difficulty of authorising such use, which is partially

due to a lack of confidence in the viability of this practice. This project evaluates and demonstrates successful irrigation with untreated mine water on a single unmined site, and evaluates issues associated with setting up irrigation on a rehabilitated site. In addition, factors that are likely to affect the success of using untreated acid mine drainage (AMD) and partially treated AMD for irrigation are investigated in depth. The economic viability of mine water irrigation projects is analysed, which leads to the development of a technical guideline to assist mines and regulators to establish irrigation projects using mine-water.

WRC Report no. TT 855/1/21 (main report) and TT 855/2/21 (technical guidelines)

Web link main report: <https://bit.ly/3JPII2U>

Web link technical guidelines: <https://bit.ly/33OZrEh>



Natsurv 14: Water and wastewater management in the fruit and vegetable processing industry (Edition 2)

In the 1980s, the Water Research Commission (WRC) and Department of Water and Sanitation (DWS), as it is now known, embarked on a series of national surveys of the water and wastewater management of several industries in South Africa. These so-called 'NATSURV reports' have been well used over the past three decades. However, the South African economy and its industrial sectors have either grown or in some cases shrunk considerably since the 1980s, leading to a changed economic landscape. New technologies and systems have been adopted by some of the industries, meaning that certain information contained in the national surveys can be considered outdated or obsolete. Furthermore, initiatives like the UN CEO mandate, water stewardship initiatives, water allocation and equity dialogues, and others suggest a growing awareness of water use, water security, and wastewater production. In this context, it is now considered an opportune moment to review the water and wastewater management practices of the different industrial sectors surveyed in the NATSURV reports and make firm recommendations on directions for change. This project is a revision and update of one of the NATSURV reports, namely 'NATSURV 14: Water and Wastewater Management in the Fruit and Vegetable Processing Industry'.

WRC Report no. TT 863/21

Web link: <https://bit.ly/350i5K1>



A feasibility study to evaluate the potential of using water sensitive design principles to strengthen water planning for the Waterberg Industrial Complex

The focus on water management has changed from traditional methods where water supply, water treatment and stormwater management were considered separately, to more integrated approaches taking sustainability into consideration. The

Water Reconciliation Strategies collated by the Department of Water and Sanitation (DWS) identified various water-stressed catchments in South Africa. The need for optimisation of reuse options, water efficiency and conservation and water demand management are highlighted in several water management studies carried out in South Africa. One such area is the Limpopo Water Management Area (WMA) North which experiences low rainfalls and high evaporation. Applying the principles of WSD holds potential to reduce the risk of water shortage in the area by reducing the need to abstract water from resources while also protecting the area from flash flooding. The present study investigates the potential of implementing the WSD options in the Waterberg District Municipality within the Limpopo WMA considering the existing infrastructure, planned development, institutional arrangements, existing partnerships and taking retrofitting current infrastructure into consideration. The project team incorporated Biomimicry Life's Principles in the approach to water management systems.

WRC Report No. TT 854/21

Web link: <https://bit.ly/355wuo8>

The dynamics and predictability of rainfall producing systems in the South African domain

Medium-range forecasting (MRF) is an initial value forecasting problem, during which the forecast skill (and therefore predictability of synoptic weather systems) diminishes exponentially by the end of the ten-day cut-off period. This reduction in forecast skill has been attributed to inadequate observations that have errors, imperfect numerical weather prediction model physics and poorly understood dynamical processes that underlie the evolutions of the weather systems. Based on these problems aforementioned, the motivation behind this project was that to improve the predictive forecast skill at this MRF time scale, it is necessary to identify and understand the dynamical processes that precede the weather systems of interest. In the case of this project, the weather systems of interest were the ridging South Atlantic anticyclones and the cut-off low (COL) pressure systems.

WRC Report No. 2829/1/21

Web link: <https://bit.ly/3lj1AXG>

Pilot-scale semi-passive treatment of ARD – Evaluation of treatment products for downstream use

The project aimed to evaluate, at pilot scale, an integrated semi-passive system for the treatment of acid rock drainage (ARD). Specifically, the system is designed to treat water originating from diffuse sources, such as waste rock dumps, coal discards, tailings impoundments and low-volume discharges. The technology is not aimed at treating high-volume discharges that are actively pumped from underground basins. The project draws on recent research that aimed to address three of the primary constraints that have prevented the more widespread implementation of technologies based on biological sulphate reduction. These are the high cost of the organic electron donor, the retention of biomass within the sulphate reducing unit and the management of the sulphide product.

WRC Report No. 2762/1/21

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

A conceptual framework for the costing of deteriorating water quality and identifying mechanisms to better fund water quality management

In 2019, the Institute of Natural Resources (INR) was awarded a research project through a WRC solicited call entitled: "CONCEPT NOTE 10: A Research Framework to accurately determine the financial impact of deteriorating water quality and identify mechanisms to better fund water quality management". This report is the final deliverable in the associated project entitled "A Conceptual Framework for the Costing of Deteriorating Water Quality and Identifying Mechanisms to Better Fund Water Quality Management". The aim of the project was to develop a holistic, but conceptual water-quality costing-framework as a tool to give focus and support to assessing the various costs of deteriorating water quality. The result of this project was the development of a conceptual framework that sets out the landscape of potential costs of deteriorating water quality and costing approaches. The framework guides the user to identify potential costs for a particular context. This information can be used towards identifying suitable water resource management actions and potential economic policy instruments to incentivise and / or fund these actions.

WRC Report no. 2948/1/21

Web link: <https://bit.ly/3lmd9gK>

Design of acid mine drainage remediation plant

Basic oxygen furnace slag (BOFS) is a final waste material in the steel making process and contains high concentrations of oxides which have the ability to substantially increase the pH and alkalinity of acidic waters. This research investigated AMD treatment or pre-treatment using BOFS by assessing the extent of remediation achieved in a laboratory (1-25 l/day) and pilot scale (200-1000 l/day) system. Another industrial by-product, sugarcane bagasse, was also used in the study to further remediate AMD after the BOFS treatment step and the efficacy of this biological treatment step is also evaluated. The aluminium, calcium, iron, manganese, magnesium and sulphate removal efficiency as well as the pH and alkalinity rise of the system were determined in order to evaluate the effectiveness of the scheme. Dissolution of the BOFS in the system was also assessed to determine the reduction of free oxide content in BOFS that causes volume instability. Following the collection and interpretation of laboratory and pilot scale data, a larger scale design for the process was proposed.

WRC Report no. 2757/1/21

Web link: <https://bit.ly/3CPLeD9>

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

FRESHWATER BIODIVERSITY

High mountain minnow lives on, 20 years after dam rescue mission

The massive Lesotho Highlands Water Project was still in the planning phase when scientists predicted a major threat to a very rare fish species. Racing against the clock, they used off-road motorbikes, horses and mobile fish tanks to move hundreds of the fish out of harm's way. Thanks to their dedication, the Maloti Minnow lives on. Tony Carnie reports.

James McCafferty



Much like tossing a pebble into a pond, the ripple effects of building massive dams and water engineering projects can spread out far and wide. The power of those ripples can be devastating to certain life forms, especially when the project involves storage dams that are big enough to supply the vast Gauteng industrial area, and an artificial channel to link two separate river systems.

That was the situation several decades ago when group of fish scientists saw trouble on the horizon for a very small and rare species of freshwater fish due to the imminent construction of the Lesotho Highlands Water Scheme.

The original scheme involved building five large dams and several tunnel systems to provide electricity for Lesotho and to transfer billions of cubic metres of water to South Africa. Good

news for people and industry . . . but the potential death knell for the largest population of the Maloti Minnow (*Pseudobarbus quathlambae*), a critically endangered fish species that had adapted to living in several freezing, high mountain river systems in Lesotho.

Dr Johann Rall was one of the South African fish scientists who helped to translocate hundreds of these fish to other rivers as an insurance policy for their survival. He was so worried about their future that he began a captive breeding project to multiply their numbers. As a further safeguard, he also initiated a cryopreservation project to store fish sperm at very low temperatures.

At the time, Rall was a young zoology student at Rand Afrikaans University, where he later completed both his MSc and PhD

degrees on the ecology and conservation of this globally-unique minnow.

Why was this fish in trouble?

The Maloti minnow (prior to a more recent re-discovery in KwaZulu-Natal) was endemic to Lesotho. On average, the adults grow to a length of about 8 cm – slightly longer than a torch battery – and the majority of the population lived in mountain streams protected by the towering Semonkoangeng Falls.

For millennia, this giant 192 m barrier of vertical stone had prevented alien trout, yellowfish and other indigenous predatory fish from migrating upstream to eat or displace the rare minnows that had evolved over many, many centuries in a unique natural river sanctuary.

While the minnows also faced other threats due to human impacts, the Lesotho Highlands Water Scheme would involve flooding large sections of critical river habitat following construction of the Mohale and Katse dams. Another very significant threat was the new artificial tunnel that would link the Katse and Mohale. This tunnel would effectively bypass the Semonkoaneng Falls and allow predatory fish to eat the upstream minnows once protected naturally by the waterfall.

Freshwater fish expert, Prof Paul Skelton, noted that this inter-basin transfer scheme would allow smallmouth yellowfish (*Labeobarbus aeneus*), Orange River mudfish (*Labeo capensis*), rock catfish (*Austroglanis sclateri*) and exotic trout species to migrate upstream. “The Maloti minnow is now a really small fish

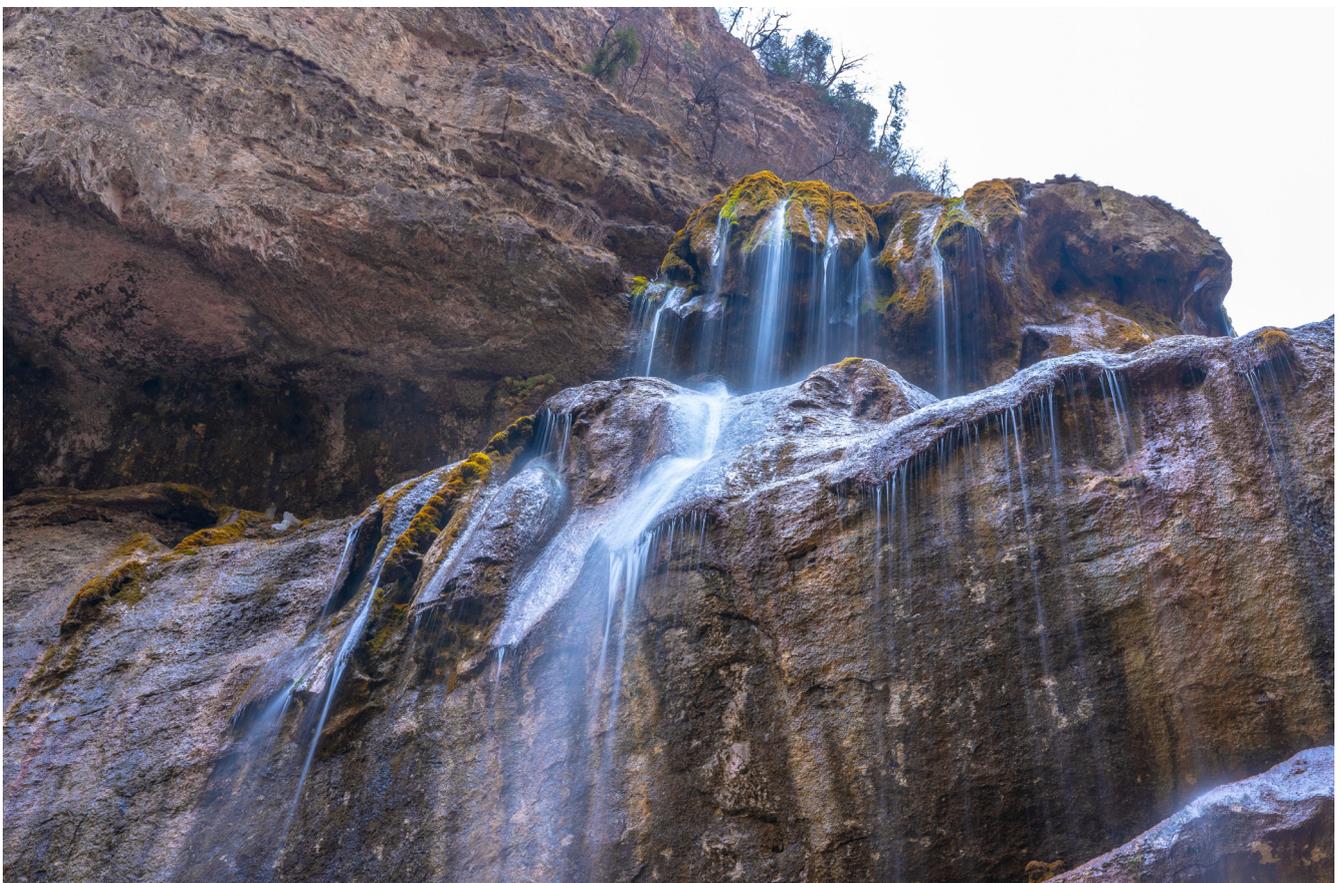
in a big pond, with other larger, more aggressive fish,” he warned at the time.

“My intuition is that that the yellowfish will prey on small minnows, and compete with adults for food and habitat. The mudfish may also compete with the minnows, and could also change the stream habitat by suspending benthic sediments while feeding,” he said.

While some minnows were found in other rivers within Lesotho, Rall noted that the Mohale population was a separate, evolutionary significant unit (ESU) compared to minnows in the eastern part of the country. Rall estimated that the Mohale ESU also made up 77% of the total extent of occurrence of the Maloti Minnow and the new Mohale Dam was expected to affect 97% of the Mohale ESU from the introduction of trout and yellowfish if no mitigation measures were put in place.

“Thanks to the efforts of conservationists in the early 2000s – and their foresight – the future is not all that bleak.”

So, during 2002/03 Rall and his colleagues sprung into action to translocate insurance populations to at least three distant river systems. Time was tight, the terrain was remote and roads



Lesotho's secluded rivers, fed from mountain streams, have provided a perfect habitat for the Maloti minnow.

James McCafferty



Nthabiseng Morokole collects fish samples from the Senqunyane River.

rudimentary in many places. But over a period of several months, the team managed to capture and move nearly 1 700 of the tiny fish.

"We collected from the three main rivers (Senqunyane, Bokong and Jorodane) to ensure maximum genetic diversity. We had a 1 000 l water trailer equipped with oxygen cylinders, zeolite and a water pump."

The cylinders were needed to ensure that the fish had enough oxygen to survive a long trip, while the zeolite mineral additives were used to purify ammonia and other organic waste from the temporary fish holding tanks (as captured fish often vomit and defecate due to the collection stress).

The captured minnows were then kept for 24 hours in a "fresh out tank" to ensure the best quality water for the journey to their new homes – trips that could take up to 48 hours.

This was largely due to cold weather and poor terrain, forcing the team to use off-road motorbikes and horses at some points, recalls Rall, who now works in New Zealand as a consultant. Incredibly, none of the captured fish died during the journeys.

A future ensured

Twenty years down the road, the wisdom of translocation has been confirmed by a recent research project led by Dr Jim

McCafferty an ichthyologist and freshwater fish consultant with Advance Africa Management Services. Speaking at the annual Conservation Symposium hosted by Ezemvelo KZN Wildlife and other nature conservation groups, McCafferty noted that the minnows still face an "uphill battle for survival".

"But thanks to the efforts of conservationists in the early 2000s – and their foresight – the future is not all that bleak," he said.



James McCafferty

Refiloe Ntsohi, Nthabiseng Morokole, Mpho Baholo and Tseou Terai on a biodiversity unit survey along the Makhaleng River.

During a recent (2017 - 2019) survey McCafferty and his colleagues revisited the remote rivers to monitor the current status of the translocated fish in the Jorodane, Makhalleng, Maletsunyane, and Quthing Rivers.

A previous survey in 2006 showed that the fish had survived in only three of the four rivers to which they were translocated near 20 years ago. As no follow-up surveys had been undertaken since 2006 it was critical to assess the status of the translocated populations (potentially representing the last remnants of the Mohale ESU).

More recent surveys suggested that while the minnows had disappeared from the Makhalleng and Quthing rivers, they were still alive in parts of the Jorodane and Maletsunyane.

The Maletsuyane population was also at high risk because of its proximity to a recreational trout fishing area. Alien brown trout were currently isolated from the minnows by a small weir, but there were serious risks if trout were to be released above the weir.

As a result, the Lesotho Highlands Development Association has

developed a conservation action plan which includes proposals for a new zonation plan for those rivers which still host the minnows.

"It is critical that these minnow populations, and activities in the catchment areas, are routinely monitored and managed to prevent the introduction of non-native fishes and to limit poor land-use practices," McCafferty told the symposium.

More recently, however, further research has indicated that minnows are still present in the Quthing and Makhalleng rivers, suggesting that relocations to each of the four rivers may have worked. The conservation project has also been supported by staff from the Lesotho Highlands Development Authority Biodiversity Management Unit survey team.

"They are an incredible group of ladies that I mentored and who have been involved in the surveys throughout," says McCafferty. "They are now responsible for ongoing monitoring of the minnow populations and are immensely passionate about conserving them."



The Katse Dam. While the Lesotho Highlands Water Project has brought much needed water resources to South Africa and income for Lesotho it has not been without its environmental impacts.