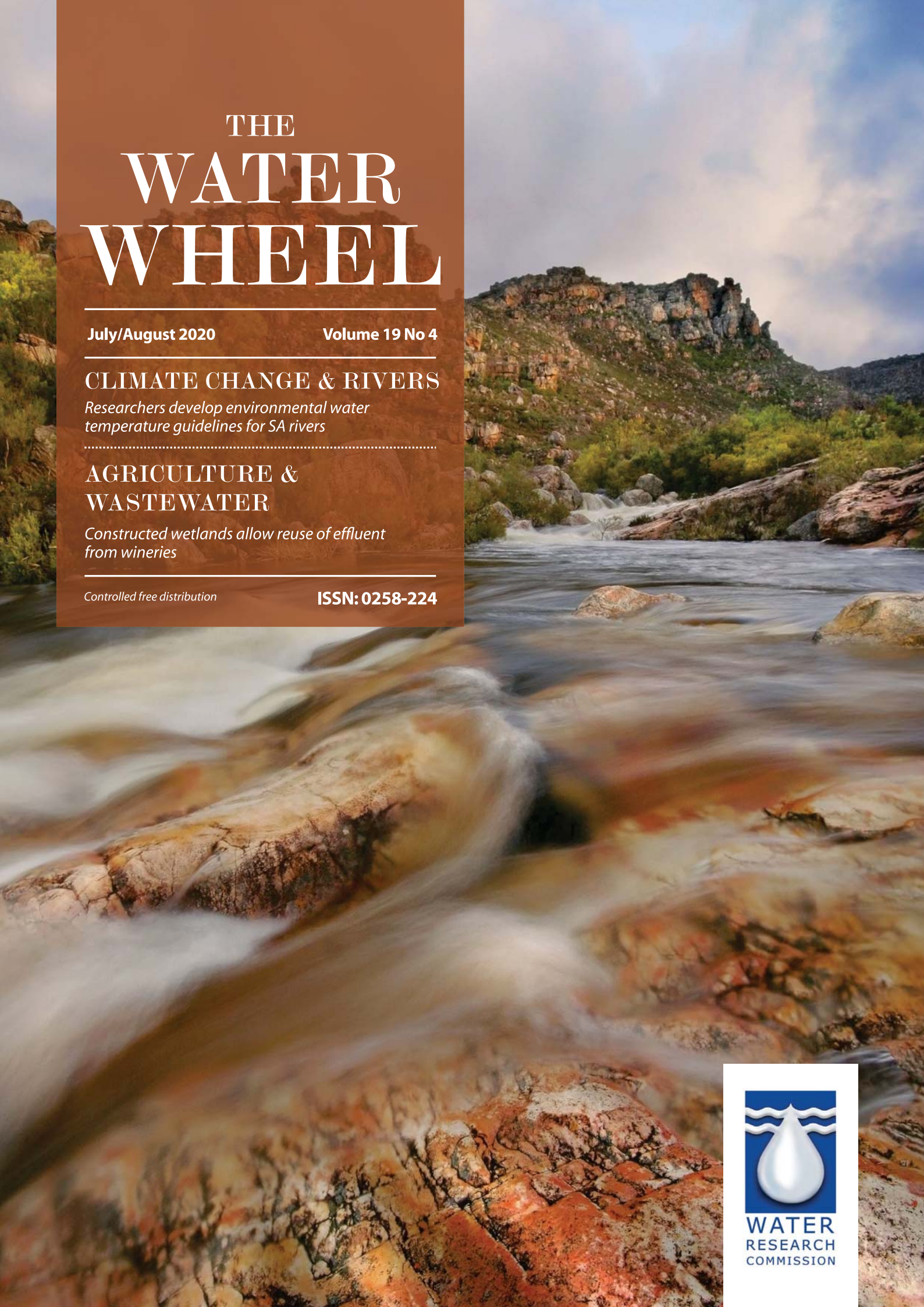


THE WATER WHEEL

July/August 2020 Volume 19 No 4

CLIMATE CHANGE & RIVERS

Researchers develop environmental water temperature guidelines for SA rivers

AGRICULTURE & WASTEWATER

Constructed wetlands allow reuse of effluent from wineries

Controlled free distribution

ISSN: 0258-224

WATER RESEARCH COMMISSION

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

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

Editorial offices:
Water Research Commission, Private Bag X03, Gezina, 0031, Republic of South Africa.
Tel (012) 761 9300. **Fax** (012) 331-2565.
WRC Internet address:
http://www.wrc.org.za
Follow us on Twitter:
@WaterWheelmag
Editor: Lani van Vuuren,
E-mail: laniv@wrc.org.za;
Editorial Secretary: Dikeledi Molutsi,
E-mail: dikeledidk@wrc.org.za;
Layout: Anja van der Merwe,
E-mail: anjavdm@wrc.org.za

CONTENTS

04 **UPFRONT**

12 **CLIMATE CHANGE AND RIVERS**
Researchers develop environmental water temperature guidelines for SA rivers

17 **COVID-19**
Can the novel coronavirus be transmitted with water? – Researchers investigate

22 **YOUNG WATER PROFESSIONAL**
Love for the environment sets Ashton's path in water sector

24 **WORKING FOR WATER**
Bon voyage to the 'village elder' – WRC wishes Guy Preston well upon retirement

26 **WOMEN IN SCIENCE**
Moves afoot in Africa to keep more women in science careers

28 **WATER PERSONALITY**
Roland Schulze – A lifetime dedicated to water

32 **AGRICULTURE AND WASTEWATER**
Constructed wetlands allow reuse of effluent from wineries

36 **WATER AND THE ENVIRONMENT**
Global award for South Africa's 'frog lady'

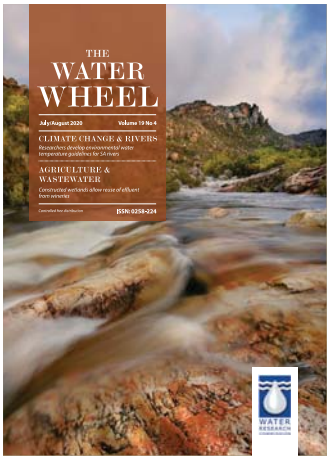
38 **INDUSTRIAL WATER**
A decision support tool for industrial water reuse in South Africa

42 **WATER USE IN ORCHARDS**
New app can predict apple orchard water use up to a week in advance

46 **DISEASE RESEARCH**
Diagnostics and aquatic emerging fungal diseases

48 **WATER KIDZ**
Hail – Freaky force of nature

50 **LAST WORD**
Pongolapoort Dam – The concrete giant of northern KwaZulu-Natal



New guidelines, based on years of dedicated research, is assisting decision-makers to manage the environmental temperatures in rivers. See article on page 12.

FLUID THOUGHTS

WRC CEO, Dhesigen Naidoo

Putting the spotlight on the human right to water

June is youth month in South Africa. It is when we remember the heroes and heroines who began a student protest on 16 June 1976 that fundamentally altered the global view of Apartheid South Africa.

It was a turning point that exposed the human rights abuses of the Apartheid ideology and the actions of an oppressive race-based state this, in turn, put in motion a series of events that eventually resulted in Nelson Mandela being inaugurated as the first President of the Democratic non-racial South Africa we know today.

It is, therefore, fitting that this new organisation, HumanRight2Water (HR2W), a global organisation that seeks to assist us to achieve the full suite of human rights as envisaged in the 2010 United Nations declaration, launched in June 2020, in the spirit of the class of 1976. On 28 July 2010, through resolution 64/292 the United Nations General Assembly recognised the human right to water and sanitation and acknowledged that clean water and sanitation are essential to the realisation of human rights. In 2015, this was followed by the adoption of Sustainable Development Goal number six where the Summit of World Leaders adopted among others, the target of universal access to clean water and safe sanitation, for every person on Earth, by 2030.

I have to point out that it is a privilege to be in the company of a very accomplished team of founder members who have incredible track records in this domain, now members of the Board and the Chair of the Committee of Experts. A special mention to the CEO, and fellow Founder member, Amanda Loeffen, largely responsible for the genesis of HR2W, and her wonderful, highly skilled team.

Covid-19 has fundamentally altered the world. It has become the unwelcome disruptor of the twenty-first century. In addition to the health, economic and social challenges associated with the pandemic, it has introduced both perspective and humility. It has returned us to basics in many ways. It has emphasised the primacy of basic needs and resources – water, and sanitation, being paramount among them.

Ironically, in this time of global and local lockdowns, and some of the most severe restrictions in modern times – we are seeing and appreciating the primacy of human rights and a human rights-based approach to recovery and development. We have, for the longest time, been functioning in a global water sector that is trying to solve the water challenges of the twenty-first century, still far too dependent on twentieth century technology and solutions, and, even worse, nineteenth century operating rules informed by outdated policy paradigms.

An innovative creative approach, strongly informed by the Bill of Rights Agenda, will enable us to successfully recover from this pandemic in a manner that affords us the chance to accelerate the global SDG project in line with UN Agenda 2023 and set course for a sustainable development paradigm for our future development trajectory.

We can and must put in our best efforts to register this Covid-19 moment in the future history books as a turning point of our global fortunes toward a better, more equitable, more sustainable world!

This was the opening address of Dhesigen Naidoo in his capacity as President of the global non-governmental organisation, HumanRight2Water, at its launch webinar with the theme 'Emergency responses linking Corona pandemics (COVID 19) and human rights to water and sanitation', which was held on 3 June 2020.

Arne Hoel/WorldBank

BACK TO TOP

NEWS

South Africa joins the international fight for water rights

The launch of the Human Right 2 water, a global non-governmental organisation (NGO) could not have happened at a more opportune time.

As the world grapples with the impact of the Corona pandemic, the protection of the right to life and health have never been more important. The leadership team is Water Research Commission (WRC) CEO, Dhesigen Naidoo, as President, with former Waterlex Executive Director, Amanda Loeffen as CEO and Michel Jarraud, former Secretary-General of the World Meteorological Organisation (WMO), as chair of the Committee of Experts.

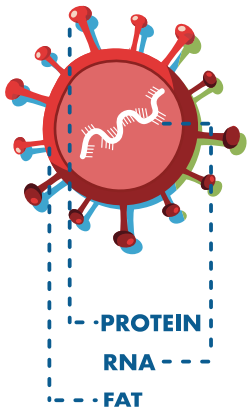
"The global Covid-19 pandemic has brought the world to a pause point forcing us to relook the fundamentals," noted Naidoo. "It has emphasised the criticality of water to deal with the immense challenge both in containment as well as treatment and recovery. There is a strong need for a human-centred strategy, the core of which has to be a human rights-based approach. This will afford an opportunity to enable this Covid-moment into a turnaround point toward a more sustainable and caring world, with heightened resilience to better deal with future shocks."

The UN Human Development Report estimates that the current rates of resource overuse and depletion together with increased levels of pollution will result in two thirds of the world's population likely to be living in water stressed areas. According to this UN Report the rate of increase of water is already leading to chronic water shortage in an increasing number of regions. South Africa had made great strides during the early years of democracy with this human rights-based approach to water access and water management led by Kader Asmal and his team. A revolutionary water law that sought to address unequal access through linking water issues to human rights, social justice, and environmental sustainability, the National Water Act of 1998 had been lauded globally.

"As we strive toward the SDG deadlines, in a time of an almost perfect storm of global crises with the Covid-19 pandemic riding alongside the economic downturn, an increasing climate emergency and a multilateral system that is under attack, a return to a basic value system represents an important building block on the road to recovery. HumanRight2Water is available as a knowledge partner to assist governments and regions to develop laws, policies and strategies to increase water security to fulfil basic needs while making water available for growth and development," said Naidoo.

Human Right 2 Water is an international NGO registered in Switzerland operating through a virtual structure, bringing together the skills of its membership and experts in water and sanitation governance and international human rights from around the globe. The NGO hopes that through the continued push for realising human rights in law, policy and practice, that they can help all people to realise a wide range of human rights, including the right to health, a healthy environment, food, and a life lived in dignity.

Information resources on water and Covid-19



The following Covid-19 and water related resources are available:

- Water Research Commission http://www.wrc.org.za/corona-virus/
- International Water Association https://iwa-network.org/news/information-resources-on-water-and-covid-19/
- Global Water Research Coalition http://www.globalwaterresearchcoalition.net/
- World Health Organisation https://www.who.int/water_sanitation_health/news-events/wash-and-covid-19/en/
- Water Supply and Sanitation Collaborative Council https://www.wsscc.org/2020/03/31/covid-19-transmission-and-sanitation-and-hygiene-services/

BACK TO TOP

NEWS

Sector loses engineering stalwart

The water sector community was saddened to hear of the death of Prof Will Alexander, who passed away in June at the age of 95.

Prof Alexander's foray into engineering started during World War II when he served in North Africa and Italy as a member of the South African Engineering Corps. He resumed his studies after the war and graduated from the University of Witwatersrand in 1949. He joined the Department of Irrigation (now the Department of Water and Sanitation) in 1950 where he was employed for 34 years. For 19 of those years he was in the field of construction, working on such iconic dam construction projects such as Rooikrans Dam, Floriskraal Dam, Leeuw Gamka Dam, Erfenis Dam, the Gamtoos canals and the Orange Fish Tunnel. From 1970 to his retirement in 1984, Prof Alexander occupied the post of Chief of the Division of Hydrology and Manager or Scientific Services in the department. He was personally responsible for national water resource management and flood routing during regional droughts and floods. Close to 100 technical reports were printed by the government printer during this period. He also initiated the popular 'Hydro' courses for practitioners starting in 1975. From 1985 to 2000 he was a professor in the Department of Civil Engineering at the University from Pretoria where he supervised scores of undergraduate and post-graduate students.

In 2006, the South African Institution of Civil Engineering conferred an honorary fellowship on Prof Alexander. He made a remarkable impact on the South African engineering profession. Even after retiring as a professor emeritus he continued to undertake research on water, flood and climate issues.

- In 2014, Prof Will shared a personal account of his first two decades in the water sector. Readers can access the article here [https://bit.ly/2B9De5h]

SABS passes standard for reusable sanitary towels

Government has welcomed the announcement of washable reusable sanitary towel standard by the South African Bureau of Standards (SABS).

The SABS passed the first reusable sanitary standard: The manufacture of Washable, Reusable Sanitary Towels (SANS 1812) on 6 May 2020. The publication of this standard is one of the first standards for washable sanitary pads in Southern Africa and is leading the way for other African countries to follow.

Welcoming the announcement, the Department of Women, Youth and Persons with Disabilities (DWYPD) said the momentous act allows women and girls another safe option to manage their menstruation. "DWYPD offered support and guidance through the standards process because our position has always been one of pro-choice. Women and girls need safe choices for ways to manage their menstruation.

"Support offered by the department demonstrates the commitment the South African government has in meeting the diverse menstrual health needs of women and girls in South Africa through the department's Sanitary Dignity Implementation Framework," the department said.

With this new SABS standard, the department said, consumers can be confident that a washable reusable menstrual pad offers women and girls an option that is affordable and longer lasting than a single use pad.

Director of Social Empowerment and Participation in the department of Women, Sipiwo Matshoba, said the new standard puts South Africa on the map as a leader in the menstrual health and hygiene sector.

"This is an important and exciting milestone that we have reached in order to broaden product choice in line with the sanitary dignity implementation framework," Matshoba said.

Source: SAnews.gov.za

BACK TO TOP

Alien plants significant threat to South African water security – ARC

Over the past 300 years or so, the intentional and accidental introduction of more than 400 alien, or non-native plant species, has gradually resulted in an infestation covering over 80 000 km^2 of the South African land mass as well as freshwater bodies.

This is according to the Agricultural Research Council (ARC) – Plant Health and Protection. The research council is undertaking a number of projects on the biological control of invasive alien plants (IAPs) in South Africa, funded by the Department of Forestry, Fisheries and Environment: Natural Resources Management Programme.

"IAPs have invaded water catchment systems, watercourses and wetlands and are the biggest long-term threat to the water security in South Africa. They have invaded agricultural lands, especially encroaching marginal lands used for stock grazing, consequently reducing the stock carrying capacity," the ARC said in a statement.

"Perhaps of more importance, is the fact that IAPs pose a huge threat to our indigenous environment by out-competing native species, transforming and destroying delicate ecosystems beyond recovery."

The great majority of IAPs are invaders of natural and semi-natural habitats, which pose a direct threat to our unique environment. These IAPs threaten the existence of native species through competition and displacement, hybridisation and the alteration of water, nutrient and fire regimes. For example, invasive Australian Acacias and Hakeas have invaded large areas of the unique Cape Floral Kingdom and pose a devastating threat to the last remaining areas of specific Fynbos ecotypes in the Western Cape. These invasive Australian tree species also enrich the soils with nitrogen, to the detriment of the local fynbos and Protea species that only thrive in poor quality soil conditions.

A large number of species of invasive floating and submerged water weeds have invaded our dams and riverine systems, causing havoc to the aquatic ecosystem function and biodiversity. These IAPs cause increased water losses through excessive evapotranspiration and completely change the nutrient recycling regime in the ecosystem. Numerous other IAPs clog rivers and stream banks, causing increased siltation and the collapse of the natural water flow, leading to excessive flooding event following rains.

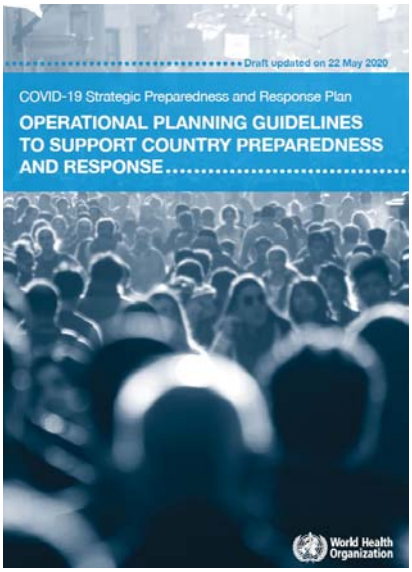
"The infestations of many IAPs continue to spread and increase in density, which only intensifies our battle against the impacts of IAPs on our unique environment in South Africa," noted the ARC. "Climate change is also likely to intensify the negative impacts of IAPs on native biodiversity. Further investment and research in the biological control of IAPs can provide some hope for the development of cost-effective and environmentally sustainable management strategies to mitigate the threat to our environment caused by IAPs."

Source: ARC

BACK TO TOP

GLOBAL

WHO publishes updated COVID-19 operational guidelines



The World Health Organisation (WHO) has published updated practical operational guidelines that may be used by national authorities to develop and update their Covid-19 national plans across the major pillars of Covid-19 preparedness and response.

The updated document identifies water and sanitation service providers as performing critical functions that must continue during a widespread outbreak of COVID 19, and specifically calls for water utilities and small-scale providers to provide sufficient safe water to allow for infection prevention and control measures in healthcare facilities, hand hygiene in homes, public and collective settings.

The guidelines call for ensuring that hand hygiene stations are available, supplied and functioning at all gathering places in Covid-19 affected areas, high-risk areas and humanitarian settings.

- To download the guidelines click here [https://www.who.int/publications-detail/draft-operational-planning-guidance-for-un-country-teams]

Inland fisheries integral to achieving SDGs

Exploring the relationship between well-managed inland fisheries and global sustainability, a paper published in June in ***Nature Sustainability*** concludes that inland fisheries can contribute substantially to increased food security, poverty alleviation, livelihoods, human well-being and ecosystem function.

The new study, ***Inland Fish and Fisheries integral to achieving the Sustainable Development Goals***, looks closely at how integrating inland fishery services into development programmes and policy decisions would support progress towards the UN Sustainable Development Goals (SDGs). The analysis shows that ecosystem benefits associated with inland fisheries make a substantial contribution towards achieving the goals towards No Poverty (SDG 1), Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), Responsible Consumption and Production (SDG 12), and Life on Land (SDG 15).

"Despite the importance of inland fisheries, they tend to be overlooked during water usage and policy decisions. Human demands on freshwater, such as hydropower, industry, agriculture, and domestic requirements, largely take precedence over fish, fisheries, and the habitats that support them," said co-author Julie Claussen, Director of Operations at the Fisheries Conservation Foundation. "Freshwater is a basic human need and water security issues are imperative, yet a failure to recognise the role that inland fisheries play for many communities weakens the ability to achieve sustainability goals."

Freshwater fishes are a vital contribution to biodiversity, and the fisheries for many of these species provide an essential source of food and livelihoods for people around the world. More than 40% of known fish species are found in freshwater, even though freshwater habitat covers less than 1% of the globe. Yet like other freshwater species, freshwater fishes are highly threatened.

The IUCN Red List of Threatened Species shows that around one in three freshwater species of vertebrates, invertebrates and plants are threatened with extinction.

"Nearly a billion people, particularly in developing parts of the world, are estimated to depend on inland fisheries as a source of food and nutrition," said Ian Harrison, co-author and Co-Chair of the Freshwater Conservation Committee of IUCN's Species Survival Commission, referring to a 2016 study. "Proper sustainable management of inland fisheries is closely linked with protecting aquatic ecosystems, their biodiversity, and the various important services they provide to people," he continued. There is also a strong correlation between stable, high-yield fisheries and high fish species richness, according to another 2016 study by IUCN.

BACK TO TOP

New website creates central space to view online web courses

The Covid-19 pandemic has put a pause on seminars hosted physically on university campuses. But in mid-March, a small team of MIT mathematicians began to notice that institutions around the world were finding ways to continue hosting seminars, online.

To virtually attend these talks, however, required hearing about them through word of mouth or digging through the webpages of individual departments or organisers. Enter researchseminars.org, a website the MIT team formally launched in June, that serves as a sort of crowdsourced Ticketmaster for science talks. Instead of featuring upcoming shows and concerts, the new site lists more than 1 000 free, upcoming seminars hosted online by more than 115 institutions around the world.

"We've had a lot of feedback from users who say, 'thank you so much for building this, I feel like part of a community again,'" says Drew Sutherland, principal research scientist in MIT's Department of Mathematics.

The site is designed so that any verified organiser can add their own seminar listing. In this way, the team hopes the site can serve as a centralised, crowdsourced portal to the latest scientific advances being presented anywhere in the world. Users can filter seminars by topic, then click on a listing for details on how to virtually attend. After entering a password — or in more discerning cases, solving a math puzzle — they can sit in on live talks they might have been unable to attend in person. In the first few weeks the site had drawn about half a million pageviews, from visitors in 160 countries.

If reactions on Twitter are any indication, the site has been a bright source of connection for academics who've been isolated from their campuses, and from each other, for weeks and months since the pandemic's start.

For instance, Jordan Ellenberg, a math professor at the University of Wisconsin at Madison, tweeted that the new site "is like the departure board at O'Hare if you could just get on any flight you wanted and they were all free."

While the site initially focused on mathematics courses, the team has since added more topics to the website, including seminars in physics, biology, and computer science in response from scientists in other subject fields. They're also working out ways to host social platforms on the site, such as chat rooms that run in parallel with scheduled talks. Visit www.researchseminars.org

Build back better and preserve biodiversity after Covid-19 pandemic – UN Chief

Recovery from the Covid-19 pandemic must also lead to countries uniting to preserve the natural world, in line with global commitments to achieve a better future for all people and the planet.

This is according to top officials at the United Nations, who were speaking during the observance of the International Day for Biological Diversity on 22 May.

In a video message for the day, UN Secretary-General António Guterres focused on the symbiotic relationship between humans and all other life on Earth, stressing that preserving and sustainably managing biodiversity is necessary for mitigating climate disruption, guaranteeing water and food access, and even preventing pandemics.

"Covid-19 (which emanated from the wild) has shown how human health is intimately connected with our relationship to the natural world. As we encroach on nature and deplete vital habitats, increasing numbers of species are at risk. That includes humanity and the future we want", he said.

"As we seek to build back better from the current crisis, let us work together to preserve biodiversity so we can achieve our Sustainable Development Goals. That is how we will protect health and well-being for generations to come."
With the pandemic as a backdrop, the International Day for Biological Diversity is being commemorated under the theme 'Our solutions are in nature'.

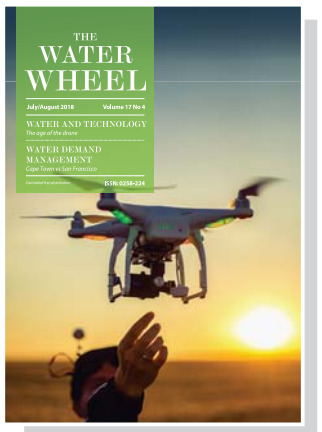
For the UN General Assembly president, the Covid-19 pandemic has amplified "the fragility of our way of life, our health systems and our global economy", thus heightening inequalities and threatening the world's most vulnerable communities.

Tijjani Muhammad-Bande insisted that these issues are interconnected. He said hunger was already on the rise before the crisis, with more than 820 million worldwide not getting enough to eat. Food security was also being undercut by biodiversity loss, desertification and climate-related shocks, while one million animal and plant species are facing extinction.

BACK TO TOP

THE WATER WHEEL

SUBSCRIPTION



Contact Details

Name: _____

Company: _____

Designation: _____

Tel: _____

Fax: _____

E-mail: _____

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

_____

_____

_____

_____

WATER RESEARCH COMMISSION

The Water Wheel

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

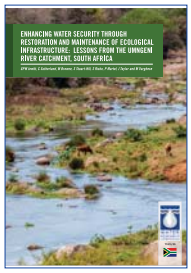
BACK TO TOP

NEW WRC REPORTS

Framework towards water-sensitive spatial planning and land use management

Everything society does, from its economy to its culture, depends – in part – on safe, stable access to water resources. Water sensitivity has gained global awareness as the risks associated with climate change, increasing resource demands due to population growth, and environmental degradation due to rapid urbanisation continue to escalate at an alarming rate. In 2011, the Water Research Commission (WRC) commenced with water sensitive-related research activities by soliciting research proposals aimed at guiding urban water management decision makers on the use of water-sensitive urban design (WSUD) within the South African context. The resultant framework states that water-sensitive settlements comprise three components: water-sensitive urban design, water-sensitive urban planning and water-sensitive urban management. In 2016, the WRC embarked on a new research project to bring WSUD into an even larger municipal planning environment. To achieve water sensitivity within the broader municipal planning environment, this project adopted new-term water-sensitive spatial planning (WSSP), which replaces water-sensitive urban planning (WSUP) as it relates to the entire municipal area (built up and natural environments), instead of just the urban environment.

WRC Report no. TT 809/1/20 and TT 809/2/20 (Guideline)



Enhancing water security through restoration and maintenance of ecological infrastructure: Lessons from the Umngeni River Catchment, South Africa

The uMngeni River Basin supports over six million people, providing water to South Africa's third-largest regional economy, contributing approximately 11%, or about R460 billion, to national GDP. The critical question facing the catchment is how to sustain and enhance water security in the catchment. The role of ecological infrastructure (EI) in enhancing and sustaining water and sanitation delivery in the catchment has been recognised. The overall aim of this project was to identify where and how investment into the protection and/or restoration of EI can be made to produce long-term and sustainable returns in terms of water security assurance. In short, the project aimed to guide catchment managers when deciding 'what to do' in the catchment to secure a more sustainable water supply, and where it should be done.

WRC Report no. TT 815/20

Water use and yield of soybean and grain sorghum for biofuel production

A significant expansion of agricultural production is required to meet the demands for feedstock required by biofuel manufacturers. South Africa is a water-scarce country. Thus, the greatest challenge facing the biofuel industry will be to increase crop production using less water (i.e. improve crop water use efficiency). The research focus of this project was guided by recommendations made in the previous biofuel project (**Project K5/5221**), as well as by policy related to biofuel production in South Africa. The project aimed to meet the demand for knowledge regarding the expected water use and yield of soybean and grain sorghum produced by rural farming communities, as well as to determine best agronomic practices for maximising attainable yield. To assist the government and, in particular, agricultural extension services, information on which cultivars are best suited for biofuel production in particular areas, as well as advice on how to manage fertility, weeds and pests/diseases, was also considered.

WRC Report no. 2491/1/20

Trace study of water PhDs in South Africa

This document reports the employment findings of a tracer investigation of water and sanitation-related Doctoral degrees awarded during the period 2013-2017 from South African universities. This is the first investigation of this nature in the fields of water and sanitation in South Africa and probably internationally. Tracer surveys – also known as graduate destination surveys or alumni surveys – are undertaken internationally informing policy authorities of the characteristics and opinions of PhD graduates. The objectives of the investigation were as follows:

- Do we train too many or too few water-related PhDs?
- How mobile are doctorate-holders between sectors?
- When do doctorate-holders leave research for a career in management?
- Are water-related PhDs remaining in the country?
- Can we trace the work experience of water-related PhDs?

Furthermore, the findings of the investigation can express an opinion related to the appropriateness of current targets in the Research, Development and Innovation Water Roadmap (2015).

WRC Report no. 2851/1/20

To download a free copy of these reports
Visit: www.wrc.org.za.

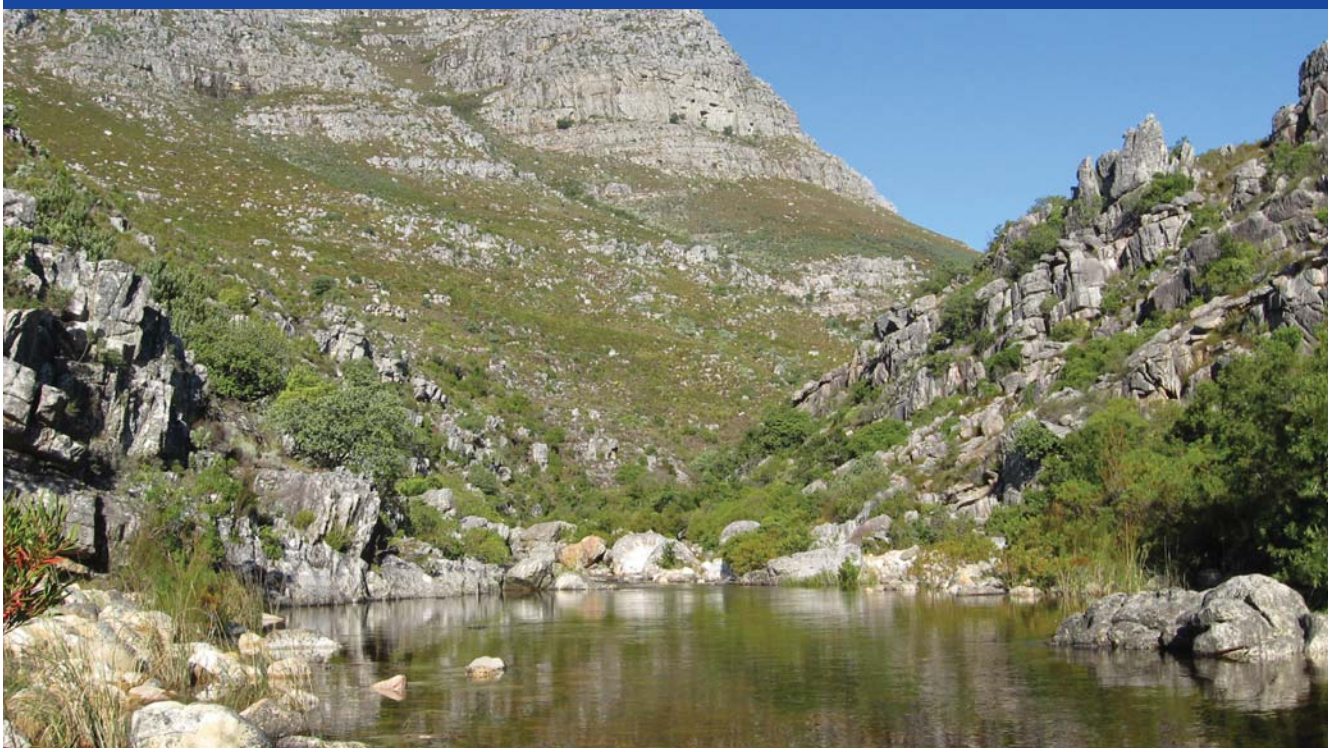
BACK TO TOP

CLIMATE CHANGE AND RIVERS

Researchers develop environmental water temperature guidelines for SA rivers

Environmental water temperature guidelines have been developed for South Africa's perennial rivers. The Water Wheel reports about the research that underpins it, and the processes and tools available to help water practitioners use it to its fullest potential. Article by Jorisna Bonthuys.

All photographs supplied



It is a well-known fact that effective water resource management needs reliable data, Dr Helen Dallas, Executive Director of the Freshwater Research Centre (FRC), highlighted. "Reliable data underpins good water governance, and effective water management helps with adaptation to climate change."

Dallas and Dr Nick Rivers-Moore recently published a comprehensive technical manual for setting water temperature targets for South Africa's perennial rivers. Dallas has over 30 years' experience working on and leading collaborative research projects on the ecology, conservation and management of aquatic ecosystems in southern Africa. She is a C2-rated researcher with the National Research Foundation, and a research associate of the University of Cape Town and the Nelson Mandela University. Rivers-Moore, a fellow researcher at the FRC in Cape Town, is an aquatic ecologist with 20 years of experience in this field.

The manual is part of their ongoing efforts to support evidence-based decision-making among water practitioners in the country. The researchers produced two volumes on the topic of environmental water temperature guidelines for rivers. The Water Research Commission (WRC) funded this research.

The first volume provides the technical background to the project, including an overview of water temperature, thermal impacts and the effect of thermal changes on river organisms. Included in this document is an outline of the engagement with water resource practitioners during the project, as part of a process to ensure alignment between the tool and practitioners

BACK TO TOP

needs. It also provides a summary of the protocol for establishing environmental temperature guidelines for perennial rivers in South Africa, demonstrated with three case studies.

For those wishing to gain more detailed information, it also includes, as a resource, a list of previous publications related to this research.

The second volume is a technical manual for setting water temperature targets. It provides guidance on when water temperatures in rivers should be considered and how to assess changes in water temperature, among other aspects.

The manual serves as a road map for water resource practitioners needing to incorporate water temperature into resource directed measures, including ecological reserves and resource quality objectives, and source directed controls. These allocations are a legal requirement to ensure adequate water flow and quality for the ecosystem health of rivers.

Dallas said: "This manual speaks directly to several tools, packaged into a toolbox, developed for establishing environmental water temperature guidelines for our rivers."

The current rate of climate change affects rivers through changes in water temperature and flow, and adds to stressors that are already impacting freshwater ecosystems.

Both these documents emanate from a project entitled 'Environmental water temperature guidelines: bridging the gap between research and implementation'.

The aim of this research was to translate knowledge generated over more than a decade of thermal research on South African rivers into a protocol for those practitioners and decision-makers responsible for the protection of our rivers.

"This project aimed to bridge the gap between research and management and implementation, by taking the body of research on water temperature and packaging it in ways that best serve the end-users," the researchers said.

The researchers developed new tools and resources for water resource practitioners, including a spatial framework and a national map of river system resilience that could help inform their decisions.

The heat is on

Southern Africa is considered a 'critical region' of water stress. Scientists have identified the region as a climate change hotspot, with southern Africa warming at about twice the global rate of temperature increase.

Climate patterns are already shifting in the region, thereby impacting on water resource planning. Freshwater resources are considered particularly vulnerable to global climate change and access to better data for decision-making is becoming increasingly urgent, given climate change.

The current rate of climate change affects rivers through

Drs Helen Dallas and Nick Rivers-Moore were the lead researchers on the project.

BACK TO TOP

Thermal experiments to determine upper limits.

changes in water temperature and flow, and adds to stressors that are already impacting freshwater ecosystems. "Climate-related extremes in water temperature will affect many species," Dallas said. "Freshwater species are more restricted in their movement and the smaller water bodies they inhabit heat up more rapidly."

Climate change is making the waters too warm for many species. Dallas and some of her colleagues at the Freshwater Research Centre have been investigating the effect of climate change on freshwater fish species of the Cape Fold ecoregion (CFE). This is one of 93 ecoregions in Africa, with each ecoregion containing a distinct assemblage of natural communities and species. The CFE region is home to many range-restricted endemic freshwater fishes, of which the majority face the risk of extinction. Climate change models developed for this region predict a warmer and drier climate over the next 50 to 100 years, signs of which have already started to show.

From a climate change perspective, climate resilience can be strengthened through healthy ecosystem services that rely on well-functioning river catchments. These 'services' refer to the benefits that humans derive from nature, including natural flood control and water purification.

Focus on elevated water temperature

Water temperature has significant effects on aquatic life in rivers, Dallas highlighted. "Understanding the response of aquatic organisms to warmer water temperatures offers valuable insight into the ecological consequences of climate change on many freshwater species," she said.

The establishment of water temperature guidelines that protect aquatic ecosystems depends on an understanding of a river's 'thermal signature' and the vulnerability of its animal and plant life to changes in water temperature. Climate change impacts on aquatic life can be significant. Issues around water temperatures in rivers should be taken seriously, the researchers pointed out. This project highlighted some of these issues.

Pest insects like larval blackfly, for instance, thrive under certain flow and water temperature conditions. Blackfly populations attack livestock and, in particular, sheep. Under current flow and water temperature conditions, outbreaks of adult blackfly along the Orange River are already causing major losses for the stock farming industry calculated to exceed R500 million per annum. Previous research estimated that a 2°C increase in current water temperature could result in pest blackfly populations increasing by a twenty-fold factor annually, in addition to the number of generations increasing by 25% annually.

"Understanding the response of aquatic organisms to warmer water temperatures offers valuable insight into the ecological consequences of climate change on many freshwater species."

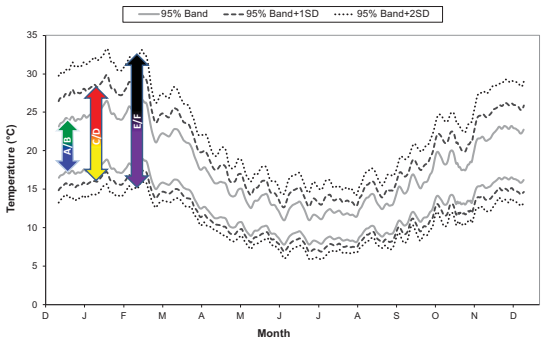
This example, highlighted in the technical report, underlines how important it is to track water temperature in rivers and use this information to inform analysis and decision-making. Dallas added: "This information (water temperature data) is also needed to improve water-air temperature models and to develop reference thermographs for different regions. [A reference thermograph is the expected natural pattern of water temperature over a one-year period against which water temperature at an impacted river can be compared] Modelling water temperature data is difficult — there is a clear need for logged water temperature data."

Several human activities change water temperature in rivers. These activities tend to increase temperature rather than decrease it. Water abstraction in summer, during natural low-flow periods in winter rainfall regions, will have a more significant thermal impact compared to abstraction in winter.

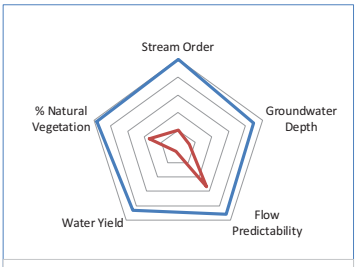
Changes in water temperatures (and flow) in rivers have many effects on aquatic life, including biological effects on river organisms. Such changes may include the spread of invasive and pest species (such as blackfly), an increase in waterborne and vector-borne diseases (including cholera and malaria), the extinction of vulnerable species, shifts in species distribution and range, and changes in biodiversity.

"These and other thermal impacts need to be mitigated, but to do so effectively, researchers and water managers need to understand the effects of thermal changes on rivers," Dallas said.

BACK TO TOP

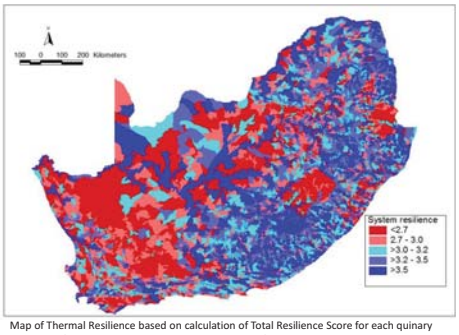


Reference thermograph showing ecological categories



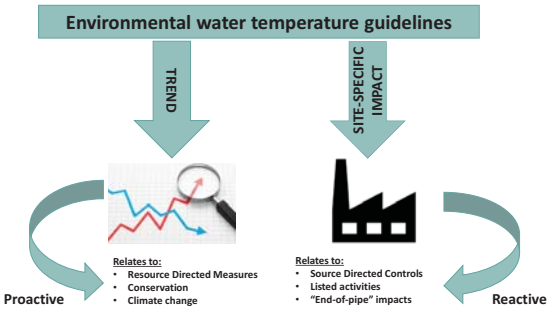
Radar plot showing the relative importance of five site variables potentially affecting system resilience. The blue line represents a site with high resilience, while the red line represents a site with low resilience.

Resilience radar



Map of Thermal Resilience based on calculation of Total Resilience Score for each quinary catchment (low resilience = red; high resilience = blue)

Map of thermal resilience



Environmental water temperature guidelines

"Realistically, very little can be done directly to mitigate impacts on water temperature. The most practical approach is to mitigate those insulators and buffers that indirectly affect water temperature," the researchers said.

The use of environmental water temperature guidelines may, therefore, be both proactive and reactive, the researchers highlighted. It can serve as a benchmark for tracking thermal change in rivers. It may also be a response to an existing thermal impact or a proposed impact for which a user has, for instance, submitted a water use licence application. This could include plans related to the water use of industries or mines, land-use changes, and groundwater abstraction.

Currently, there are very little time-series water temperature data available for South Africa's rivers, particularly data sets for longer than one full thermal year. The researchers estimate that such data sets are available for only 1% of the quinary sub-catchments, which represent nested hydrological catchments, covering the country.

Dallas and Rivers-Moore developed a spatial framework to help fill this data gap. This framework provides information on the system resilience of rivers, among others. The researchers also provide a protocol that comprises two processes needed for establishing environmental water temperature guidelines, namely the screening process, and the evaluation process.

Screening and evaluating processes

Screening information includes details of system resilience, water quality and habitat, the sensitivity of river organisms, thermal impacts and a thermal risk assessment.

The screening process allows people using these guidelines to determine if the water temperature should be examined at a particular site. A workflow diagram has been generated to guide the water practitioner during this process.

"Not all sites, reaches and rivers need to be managed for water temperature," Dallas explained. "Asking the right questions allows one to evaluate the importance of maintaining an appropriate thermal regime at a particular site."

For site-specific impacts, aspects such as the likely thermal impact of an activity (important especially in source-directed controls and water licensing) and the sensitivity of the site and its river organisms (for instance, endangered cold-water fish species) to thermal change, are considered.

Three key questions must be asked when assessing whether water temperature needs to be considered before quantifying thermal stress and assessing risk. These questions are:
How resilient is the site, reach or river to changes in water temperature?

Are there other hydrological, physicochemical (water quality) and habitat considerations that could increase or reduce thermal impacts?

How sensitive are the river organisms?

"The spatial scale of screening may vary from a site to a reach to a river, depending on the size of the river," Dallas added. "So, for

BACK TO TOP

example, a site on a large fifth-order river would be screened at site-scale, while a small first-order tributary may be screened at the river-scale."

The first question enables practitioners to determine just how resilient a particular river system is. The resilience of a river – an indication of its ability to withstand external impacts – is likely to be affected by variables, such as stream order, groundwater depth, flow predictability, water yield and catchment transformation.

Dallas and Rivers-Moore have integrated these and other factors into a map of thermal resilience. This map allows users to evaluate if the site, reach or river is likely to be resilient or vulnerable to thermal stress based on five catchment variables.

The second question is answered by considering water quality issues, the potential for algal blooms or invasive aquatic weeds to dominate and whether or not the river's flow is natural or transformed, among others. The third question can be answered by considering the ecological state of a river or reach and if endemic or species of conservation importance, are for instance present at the site.

These questions have been integrated into a thermal risk assessment matrix which is the final stage of the screening process. The risk rating is then generated based on predetermined risk classes: low, moderate, high, and very high risk. This guides users as to whether water temperature needs to be further examined at a particular site, in which case the user continues with the evaluation process.

A thermal sensitivity index based on aquatic macroinvertebrates has also been developed, whereby each taxon is assigned a thermal sensitivity weighting. These weightings have been applied to most taxa used in the South African Scoring System (SASS). This assessment tool of biota (animal life) in rivers is widely used to determine the condition or 'health' of rivers.

The evaluation process also allows practitioners to set thermal targets for specific reference sites, reaches or rivers, using either logged water temperature data or modelled water temperature data, and to evaluate changes in water temperature at comparable sites.

The protocol includes details of collecting water temperature data, the spatial framework within which the reference thermographs are created, and calculations of model accuracy. This information can be used to generate a thermal report card for a particular river.

The thermal assessment provides specific guidelines for the timing and the duration of mitigation measures if needed. Dallas says: "Mitigation plans can then be developed, including for instance to limit water extraction from a particular river or during the hot summer months."

Next steps on monitoring

The processes and tools developed in this project provide water resource practitioners with the necessary knowledge and tools for incorporating water temperature guidelines into resource directed measures, including ecological reserves and resource quality objectives, and source directed controls.

There are now two key follow-on actions to be taken, according to the researchers. The first is to roll out a national water temperature monitoring programme. The second action is to automate the processes developed in this project.

Dallas said: "There is a clear need to roll out a national water temperature monitoring programme. This will need to be driven by the government with support from organisations that have a vested interest in tracking long-term change in water temperature.

"If we can establish a network of thermal monitoring programmes, this could offer many benefits to society," Dallas said.

Automation of the processes can be achieved by securing funding to develop a thermal module linked to the Freshwater Biodiversity Information System (www.freshwaterbiodiversity.org), currently being developed by the FRC. This system is a platform for hosting, visualising and sharing freshwater biodiversity information for South African rivers.

"The systems and climate-related changes we are dealing with are complex, and we need to ensure water practitioners have the best possible data to help manage these," she concluded.

To download the manual, ***Environmental water temperature guidelines for perennial rivers in South Africa*** (**WRC Report no. TT 799/2/19**), click here: https://bit.ly/3fUSwd2

Visit www.frcsa.org.za for more information.

BACK TO TOP

COVID-19

Can the novel coronavirus be transmitted with water? – Researchers investigate

From dirty water, to clean water – what are the risks for Covid-19 transmission? Petro Kotzé took a look at current research being conducted in this space.

All photographs courtesy Petro Kotzé

The ongoing Covid-19 pandemic has been closely associated with one of South Africa's most precious resources – water. Water has run like a thin thread alongside the appearance of the virus causing the pandemic; at first, when the importance of hand-washing and basic hygiene became clear and, more recently, followed by questions on whether the virus can be spread via contaminated water.

To understand the capacity of Covid-19 to be transmitted via any water, whether it is sewage, wastewater from homes or hospitals, or leakages from burial sites, the nature of the virus needs to be understood.

The SARS-CoV-2 virus

A virus is a collection of genetic material; consisting of **deoxyribonucleic acid** (DNA) or **ribonucleic acid** (RNA) inside a protein shell. To cause infection, it must copy itself inside a living host's cells. In this way the virus can cause a disease. Examples are polio, Ebola and hepatitis.

Viruses are non-enveloped or enveloped. The first (non-enveloped viruses) consists of the genetic material inside its protein capsid. These are often responsible for waterborne diseases. Examples are the norovirus and rotavirus. In comparison, enveloped viruses consist of the genetic material

BACK TO TOP

covered in a thin membrane called a lipid layer. The Spanish Flu in 1918 as well as Swine Flu in 2009 were both pandemics caused by enveloped viruses (H1N1 Influenza A subtypes). Ebola is another enveloped virus.

The group of coronaviruses are enveloped viruses. The Severe Acute Respiratory Syndrome epidemic (SARS-CoV) and the Middle East Respiratory Syndrome (MERS-CoV) are examples, as is SARS-CoV-2, the virus responsible for the current ongoing Covid-19 pandemic.

The group of coronaviruses get their name from the Latin word for crown (***corona)*** because the proteins on its surface are in the form of projecting spikes, which attach to the host's' cells. This virus mainly targets the tissue that lines the outer surfaces of organs and blood vessels and the inner surfaces of cavities in many internal organs. Once attached, the RNA genome enters the host cell and starts to multiply.

The virus is able to transfer when an infected person coughs or sneezes in close contact with an uninfected person, and this person inhales the droplets. The virus can also be transferred when a person picks up such a droplet from a surface, and transfers it to themselves by touching their mouth, nose or eyes with their contaminated hands.

How long can SARS-CoV-2 survive outside a host?

Outside of the host body, the virus cannot replicate, although there is evidence to suggest that coronaviruses can persist on surfaces, says microbiologist and senior researcher with the CSIR, Lisa Schaefer. The amount of virus deposited, temperature, humidity and UV light can determine how long viruses stay active outside the body. Virus particles that are expelled when an infected person coughs or sneezes may have a protective layer of mucous that helps them survive. The spiked envelope of the coronaviruses is vulnerable and easily destroyed by soap, disinfectants, low pH, heat, and detergents. When a pair of infected hands is washed with soap, for example, the lipid envelope is destroyed, and the virus cannot attach to a cell and cause infection any longer.

A study published in the ***Journal of Hospital Infection*** reviewed the literature on all available information about the persistence of human and veterinary coronaviruses on inanimate surfaces. Because the morphology and chemical structure of SARS-CoV-2 are similar to those of other coronaviruses for which there are data about both survival in the environment and how to effectively inactivate it, this information provided insight into the potential reaction of SARS-CoV-2.

An analysis of 22 studies revealed that human coronaviruses such as SARS coronavirus, MERS coronavirus or endemic human coronaviruses can persist and remain infectious on inanimate surfaces like metal, glass or plastic, at room temperature, for up to nine days. At a temperature of 30˚C or more the duration of persistence is shorter. Veterinary coronaviruses have been shown to persist even longer, for 28 days. The study also found that the viruses can be efficiently inactivated by disinfection within one minute.

More recently, researchers from the National Institutes of Health, Centers for Disease Control and Prevention, the University of California, Los Angeles (UCLA) and Princeton University examined how long the virus SARS-CoV-2 survived in the air as well as on copper, cardboard, plastic and stainless steel. They found the virus to be detectable in aerosols for up to three hours, up to four hours on copper and up to 24 hours on cardboard under the right environmental conditions. This coronavirus can last up to three days on plastic and stainless steel, though the amount of the virus left on those surfaces decreases over time.

Still, says Schaefer, it is important to note that viruses persisting on surfaces may not necessarily still infect other people.

As for the virus' survival in drinking water or sewage, the CSIR advises that we do not yet have all the answers about SARS-CoV-2 in water and the perseverance of infectious viral particles in the environment. However, there is sufficient knowledge about similar viruses and viruses more resistant than the SARS-CoV-2 virus to have some certainties.

The risk to drinking water supplies

According to the World Health Organisation (WHO), there has been no evidence of SARS-CoV-2 survival in water of any kind to date and, according to a guidance document updated in

The highly polluted Jukskei River flows through the back alleys of Johannesburg

Can coronaviruses enter groundwater through burial sites? The likelihood is very low.

BACK TO TOP

The likelihood of the SARS-Covid-2 virus to survive in any wastewater is thought to be low, but yet to be confirmed.

May, the risk of coronaviruses to water supplies is low. Though the presence of the SARS-CoV-2 in untreated drinking-water is possible, it has not been detected in any drinking-water supplies yet. Other coronaviruses have also not been detected in surface or groundwater sources. The CSIR also announced that drinking water and groundwater pose a very low risk of SARS-CoV-2, as has international bodies such as the United States Environmental Protection Agency (EPA), which has recommended that people continue to drink tap water as usual.

Schaefer explains that waterborne viruses tend to have a much sturdier casing (non-enveloped viruses with protein capsids) than that of the casing surrounding SARS-CoV-2 (enveloped viruses) that enables them to persist in water for longer periods of time. This suggests that enveloped viruses, such as SARS Cov-2, are unlikely to survive as long in the water system.

The virus has also been detected in stool samples of some of the small percentage of patients with Covid-19 that develop diarrhoea, which has raised questions about the potential spread of the virus via stool and sewerage systems.

The risk due to contaminated sewage

During a presentation for the Water Research Commission (WRC) on coronaviruses in water and risk of infection, Prof Natasha Potgieter, Head for Environmental Health at the Domestic Hygiene and Microbial Pathogens Group, explained that for the virus to be transferred via stool, it must have the ability to survive in human waste, retain its infectivity and come in contact with another person, which can most likely happen via aerosols.

This could be the case, for example, if water droplets infected with stool is inhaled by another person – such as when a toilet is flushed with the lid open. Schaefer adds that in cases such as these, the highest risk remains to householders living in a home with an infected person.

Once the infected water leaves the home via the sewerage system, the chances of infection seem to become smaller. The RNA remnants of the virus have been found in untreated sewage, first by microbiologists at the KWR Water Research Institute in the Netherlands. They analysed wastewater from treatment plants in the Netherlands, including Schiphol airport and Amersfoort. In this way, their data told them the virus was present in the population before the first patients appeared.

This was later verified by the National Institute for Public Health and the Environment (RIVM), who also took samples. The two studies concluded that RNA traces of the virus were present in untreated wastewater. No traces were found in treated wastewater.

This knowledge is now put to the test in different countries in attempts to monitor the spread of the virus, including South Africa (see box on the WRC new project on page 21).

The Dutch researchers also tested treated effluent from wastewater plants that was discharged into surface water, and found no trace of the coronavirus.

Yet, questions remain. Though there have been no reports of faecal-oral transmission of COVID-19, it is not known whether the virus in sewage is able to infect a person. Schaefer explains that the technique to detect the virus in wastewater picks up fragments of the RNA nucleic acids, but is not able to determine if the virus is intact and infectious. The presence of viral RNA is not necessarily a transmission risk; however, the presence of infectious virus is a transmission risk, she explains.

The amount of virus released from the body (shed) in stool and how long the virus is shed are also not known. These are all questions that limit our capacity to understand the risk of transmission of Covid-19 from the faeces of an infected person.

Potgieter said that until we have more answers, it's impossible to say what the risk of the virus is to a community without functioning wastewater treatment systems in place. According to Schaefer, due to the state of some of the wastewater treatment systems in South Africa, infection via contaminated wastewater is a possibility but, in her opinion, unlikely because of the virus' anticipated short survival time in the environment. "The question remains whether any viral RNA detected is actually infectious virus."

What about water contamination from mass burial sites?

According to Prof Matthys Dippenaar, Associate Professor at the University of Pretoria's Department of Engineering Geology and Hydrogeology, the bigger concern is the handling of the body, rather than the actual burial process. "If cemeteries: are cited and managed appropriately are appropriate, we are not altering the load of possible contamination," he said during a recent presentation on the topic for the WRC. Dippenaar was team leader for the project 'State-of-the-Art Cemetery Guidelines: Impacts of Interments on Water Resources and subsequently, terms of reference for the investigation, management and monitoring of new and existing cemeteries in South Africa' (**WRC Report no. 2449/1/28**).

Dippenaar explained that, in general, the body is not the contaminant at cemeteries. Rather, the bigger concern is the metals, nutrients, organics and pathogens from medical implants, jewelry, the metals attached to the coffin and so forth. The pathogens, bacteria and viruses that are the actual cause of

BACK TO TOP

According to recent information, the risk of coronaviruses to water supplies is low.

death tend to die off in an oxygenated environment, such as a coffin.

We have good guidelines in South Africa that comply with international guidelines, noted Dippenaar and, as long as we choose the locations for the graveyards well, we will be safe. He added that though we still need to confirm the persistence rate of the virus in all environmental conditions, the locations of cemeteries are chosen because the geography is such that the rate of the water that moves through substrata is retarded. By the time it reaches any groundwater table the pathogens would probably have died off.

In an online presentation on the topic for the WRC, Dr Eunice Ubomba-Jaswa (WRC Research Manager for Water Resources Quality and Management) added that as soon as a host dies, the virus will also start dying and, the timespan for survival in a dead body is relatively low. Rather, she said, the danger could lie in the time between dying and handling of the body, or when an autopsy is conducted, in case an organ is punctured, for example. When attending a funeral, she maintained, you are more likely to be infected from another person that is alive and infected.

According to a fact sheet recently released by the WRC more research, including the development of better techniques for studying this type of virus is necessary to better assess the risks associated with wastewater.

"We don't know if the remnants in wastewater are infective; it's highly unlikely, but we don't know for sure," says Schaefer. More questions that need answering is whether the pandemic can be monitored through a sewerage system in South Africa, as has been proven in a developed country such as the Netherlands.

In the interim, cautions the WRC, the best way forward is to take due care at all times.

Boxed: Sources:

- ***Aerosol and surface stability of HCoV-19 (SARS-CoV-2) compared to SARS-CoV-1.*** van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, Tamin A, Harcourt JL, Thornburg NJ, Gerber SI, Lloyd-Smith JO, de Wit E and Munster VJ.
- ***Survival of surrogate coronaviruses in water*** by Lisa Casanova, William A. Rutala, David J. Weber, Mark D. Sobsey
- ***Persistence of coronaviruses on inanimate surfaces and their inactivation with biological agents*** by G. Kampf, D. Todt, S. Pfaender and E. Steinman
- ***Water, sanitation, hygiene, and waste management for the COVID-19 virus***, Interim guidance 23 April 2020 by the WHO and UNICEF
- KWR, 2020. Update COVID-19 Sewage Research (https://bit.ly/382OYm9) csir.co.za

BACK TO TOP

National programme on monitoring COVID-19

The WRC recently launched the national programme on monitoring COVID-19 spread in communities using a water- and sanitation-based approach. Sue Matthews reports.

Research teams around the world are investigating the potential of wastewater surveillance as a monitoring tool for COVID-19, and on 20 May 2020 the Water Research Commission launched a national programme to do the same. The launch took place via a two-hour Zoom webinar, with a number of presentations or talks by representatives of the WRC and partner organisations, as well as a brief address by the Minister of Human Settlements, Water and Sanitation, Lindiwe Sisulu.

"Part of what we're wanting to do is develop a South African chapter of the wastewater surveillance programme, and hopefully expand this into an African chapter," explained WRC CEO, Dhesigen Naidoo, in his introduction. He added that it could also provide a platform for building a much stronger surveillance system to address the wide array of emerging pollutants that are an increasing concern around the world.

The keynote speaker for the launch was Dr Peter Grevatt, CEO of the Water Research Foundation (WRF), a global organisation based in the United States. In April, the WRF convened an online international summit, 'Environmental surveillance of Covid-19 indicators in sewersheds', with discussions focused on four topics: interpretation of data, communication, sample collection (the where, when and how) and sample analysis. Typically, samples are taken from sewage at the point where it enters a wastewater treatment works (WWTW), and these are analysed using polymerase chain reaction (PCR) techniques to detect fragments of RNA, which serve as the 'genetic fingerprint' of SARS-CoV-2, the virus responsible for Covid-19.

Dr Grevatt pointed out that the data could be used to track trends and monitor changes in occurrence of Covid-19 in communities, potentially providing an early warning signal of new outbreaks and allowing the impact of interventions to be assessed. But although some indication of the prevalence of the disease in the community is certainly possible, determining the actual number of cases would be far more complicated, as this requires an understanding of the amount of RNA that infected individuals shed in their faeces, and how this differs between asymptomatic and severe cases.

To ensure that credible information can be provided to decision-makers, the WRF is organising an international inter-laboratory comparison to assess which methods produce the most reliable results, and to what extent sample results can be reproduced by the participating labs. Other research priorities are to understand how the virus's RNA fingerprint changes over time in the wastewater matrix (which would have implications for the timing and location of sample collection), and to determine the impact of sample storage and pre-treatment methods on signal strength.

The WRC's Group Executive: Research and Development, Dr Stanley Liphadzi, then gave an introductory overview of South Africa's envisaged surveillance programme. He noted that South Africa has some 900 WWTW and these are concentrated in cities, which is where most of the country's confirmed COVID-19 cases occur, but non-sewered sanitation systems typical of informal settlements and rural areas would not be overlooked. The programme would be conducted in three phases, starting with a 'proof of concept' phase and progressing to pilot-scale monitoring before the full-scale national surveillance programme is implemented.

Research Manager, Dr Nonhlanhla Kalebaila, provided more detail on the WRC initiative, pointing out that it will include projects aimed at establishing the role of water and sanitation environments in the transport and transmission of the virus. One of the projects that has already been commissioned for the first phase is a preliminary study on the wastewater-based epidemiology approach that will test and validate protocols for sampling and analysis. It will also provide an initial interpretation of data, to be published as a State of Knowledge report on SARS-CoV-2 in South Africa's water and sanitation environments. The project builds upon an earlier WRC study that applied the same approach to assess the use and abuse of pharmaceuticals in communities.

A second project, being done in collaboration with the National Institute of Occupational Health, involves the evaluation of health risks associated with occupational exposures to biological and chemical contaminants at WWTWs. The SARS-CoV-2 virus will receive special attention as one such biological contaminant. The project team will examine the virus's occurrence in wastewater, aerosols and sludge, and determine whether it is present in a live and potentially infective state. Currently, it is thought that wastewater treatment processes are adequate for removing the virus, or at least rendering it inactive, but the researchers will investigate this. If the live virus is detected, the implications for WWTW workers' safety and for non-potable water reuse, such as irrigation of crops or sportsfields, will be assessed too.

The WRC had issued an 'expression of interest' call for the programme, seeking experts to serve on a national advisory panel as well as laboratory services for sample analyses, and inviting researchers to submit proposals for projects. Implementation of the programme will rely heavily on partnerships and collaborations, as well as co-funding from different stakeholders.

Kalebaila reported that there are already projects within the WRC portfolio that are looking at human pathogens in water, but efforts will be made to address a number of knowledge gaps relating to SARS-CoV-2. For example, is there any risk of faecal-oral transmission via ingestion of contaminated food or water? And how could South Africa's national building regulations be strengthened to ensure water and sanitation safety, given that a 2003 outbreak of SARS in a Hong Kong apartment complex was linked to a faulty plumbing system that allowed virus-laden aerosols to be drawn into apartments? If such incidents do occur here, protocols for incident management and response will clearly be needed. The large-scale use of disinfectants during such incidents, as well as in routine sanitising of taxi ranks, hospitals, schools and workplaces, might have implications for aquatic ecosystems, so this needs to be investigated too.

During the Q&A session, Kalebaila confirmed that some of the projects would involve taking samples from on-site toilet systems, such as VIP and pour-flush toilets, and testing the methods on these samples. Once there's sufficient confidence in the methods and the results, these systems can be included in the programme's reporting.

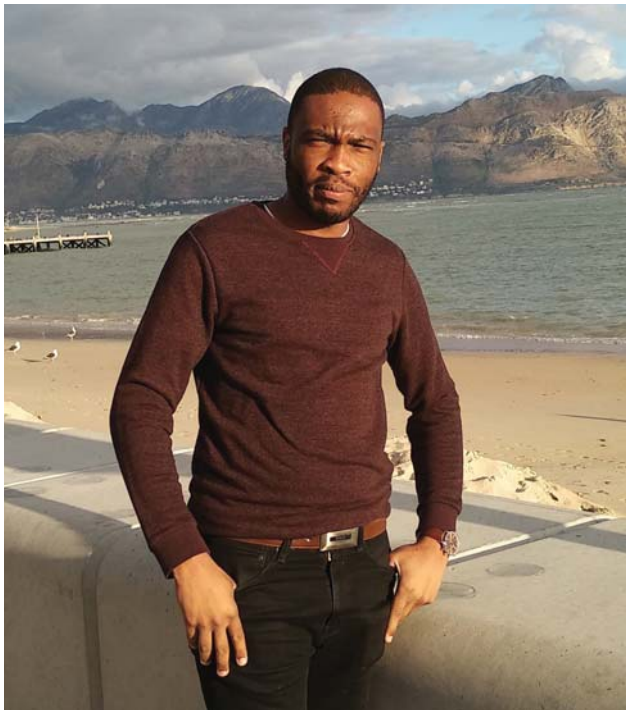
"Dealing with the non-sewered environment may be the big contribution that South Africa can make, because that part resembles a lot of the developing world," added Naidoo. "We also want to make a substantial investment in new innovations in this domain – finding cheaper, more accessible techniques."

BACK TO TOP

YOUNG WATER PROFESSIONAL

Love for the environment sets Ashton's path in water sector

Ashton Busani Mpofu has been appointed as the national lead for the Water Institute of Southern Africa's (WISA) Young Water Professionals programme. Bridget Lepere found out what inspires this dynamic young man.



New national lead of the WISA Young Water Professionals, Ashton Mpofu.

Ashton is a water sector analyst for GreenCape, a sector development agency and non-profit organisation. He engages various stakeholders in the sector, advising and seeking greener solutions for the sector. He specialises in market research, consultancy and business support for a water resilient and sustainable green economy.

Ashton's appointment follows many years of being an active member in the YWP programme, where in 2018 he was elected as the vice national lead. This year, he reluctantly accepted the honour of national lead as he jokingly pokes fun at the idea that his age is now in contention with the title of the programme. Nevertheless, he adds that he heeded the call once more, highlighting that what he has always wanted to do is serve and this role and his job at GreenCape allows him to do so seamlessly.

Ashton's role as national lead involves leading the national committee of diverse water professionals, steering the decision-making and strategies, implementing the goals of transformation and empowerment within the sector and ensuring thatevery member's voice is heard and their needs addressed.

Born in Bulawayo, Zimbabwe Ashton was brought up in a humble home of primary school teachers. After many years of teaching, his father decided to make a career change to become an accountant, and it was this adjustment that nurtured his interests in entrepreneurship. But, as fate would have it, Ashton's great performance in maths and science led him in the opposite direction.

During Ashton's high school years at John Talac Missionary School, also known as Ingonya Missions, he was pushed into the science stream by his teachers, where his liking for the sciences grew even more despite his aspirations and passion for business. He also happened to be the best biology pupil in his grade, receiving medals and accolades for his great performance. The better he got in these subjects, the more unreasonable his case against continuing in the science stream became, so he continued until completing high school.

His aptitude in biology made him consider a career in medicine, however, the fear of blood and scalpels made him decide otherwise. Thus, he fell back on his love for the environment and his nomination as president of the environmental club back in high school. This channelled his ambition to study environmental science, then later chemical engineering.

Ashton's mind was now set on chemical engineering and he worked even harder to improve on his chemistry, so he applied for scholarships, but the sponsor willing to pay for his varsity fees had already pre-selected a course in dentistry for the lucky recipient at the Cape Peninsula University of Technology.

BACK TO TOP

However, Ashton's determination impelled him to select a course in analytical chemistry in his first semester, and in the second semester he was granted a place in the chemical engineering class. Fast forward to his third year, he did a module in water treatment and that is when his path became clearer. He knew then that this was the direction which his career would take as his passion for helping people and saving the environment made it the obvious choice.

"The main challenge faced by the youth, including those in the water sector, is unemployment and poverty."

While completing his degree he worked for a mining company, mainly doing research and developmental work on recovering minerals from waste materials from the mines and treating its wastewater. His supervisor persuaded him to take on a research project funded by the Water Research Commission (WRC) on wastewater treatment in the tannery industry for his Masters degree, which he gladly accepted. The project also looked at ways in which tannery and leather manufacturing sludge could be used to produce biogas. It was this work with the WRC that reinforced Ashton's convictions to save the planet by looking for viable and sustainable solutions for the tanning industry and the environment.

Working on this project gave him real life experience and afforded him the opportunity to learn while making a difference in the mining and tanning industry. "Water was becoming the new gold and everyone was beginning to talk about water and that is when we realised that we needed to focus more on water as we knew it could run out at any time," he explains.

Ashton believed that this research could make the tanning industry more sustainable. His research focused on quantifying the amount of water used for production. This was necessary for the sustainability of the industry as the competition of leather textiles, water scarcity and high waste management costs would soon make tanneries obsolete. It was talking to the realities of challenges faced by the tanning industry, while seeking feasible solutions to saving them and making them adapt to the fast changing economy. "One of the things that I found to be striking was the enormous production of solid wastewater sludge," explained Ashton. "The tanning process is very wasteful; about 50% of the intake material becomes wastewater sludge. So I thought let's find a way of reducing the solid waste from the tanneries instead of disposing of it at landfills." A sustainable and applicable way of dealing with this problem was to use anaerobic digestion as a biological process to reduce the amount of sludge sent to landfills, Ashton found.

Accordingly, the WRC undertook further studies into this study, and is currently looking into tannery wastewater to salvage value added materials such as sulphur, bio-methane and possibly bio-fertilisers to be inclusive of the secular economy dynamic. While further feasibility studies need to be carried out in order to prove that the anaerobic digester processes could be implemented to solve the tannery industry woes, they looked at retrofitting anaerobic digesters to treat the wastewater itself and produce the value added materials. "It is very difficult in South Africa to take research into application. On the research side we are very quick to do the studies and publish the work, but we don't even think about patenting the work because as researchers we are not obliged to tap into that stream so that these ideas are applicable in industry. There is thus a need for increased collaborations between research and industry," Ashton notes.

He says the main challenge faced by the youth, including those in the water sector, is unemployment and poverty. Those young people from rural areas, from underprivileged communities where services such as sanitation are limited, are worst off. "These are some of the things we as young water professionals are scratching our heads about and trying to solve. We know that the national government is working on something, but as YWP's when looking into the future we do not want to be sitting with the same problem and not have done something. We have to look into the issue of jobs while, at the same time, dealing with issues of experience. Some water professionals have the qualifications, but the water sector sometimes requires one to have a vast number of years of experience to work."

Ashton concludes by saying the challenges range from accessibility to water and facilities, to unemployment, but the primary issue for many water professionals is water security for a better future and for the economy because without water there is no future.

Who are the Young Water Professionals?

The South African Young Water Professionals (YWP) Programme is focused on bringing people working in or interested in the water sector together in a meaningful way. The YWP is a network of people who are passionate about all aspects of water and its intrinsic linkages to people, economies, development, nature, dignity and life itself. The programme is aimed at helping people in the earlier stages of their studies and careers to find their 'professional home' in the South African water sector, understand and explore the challenges and opportunities of the sector, build the skills they need to be influential contributors to the sector and develop meaningful networks that will provide the insight, support, access and opportunities needed to build exciting, meaningful and challenging careers. The YWP is an international initiative spear-headed by the International Water Association (IWA). In South Africa, the YWP is in partnership with the Water Institute of South Africa (WISA). WISA is a volunteer organisation representing the professional water industry in Southern Africa.

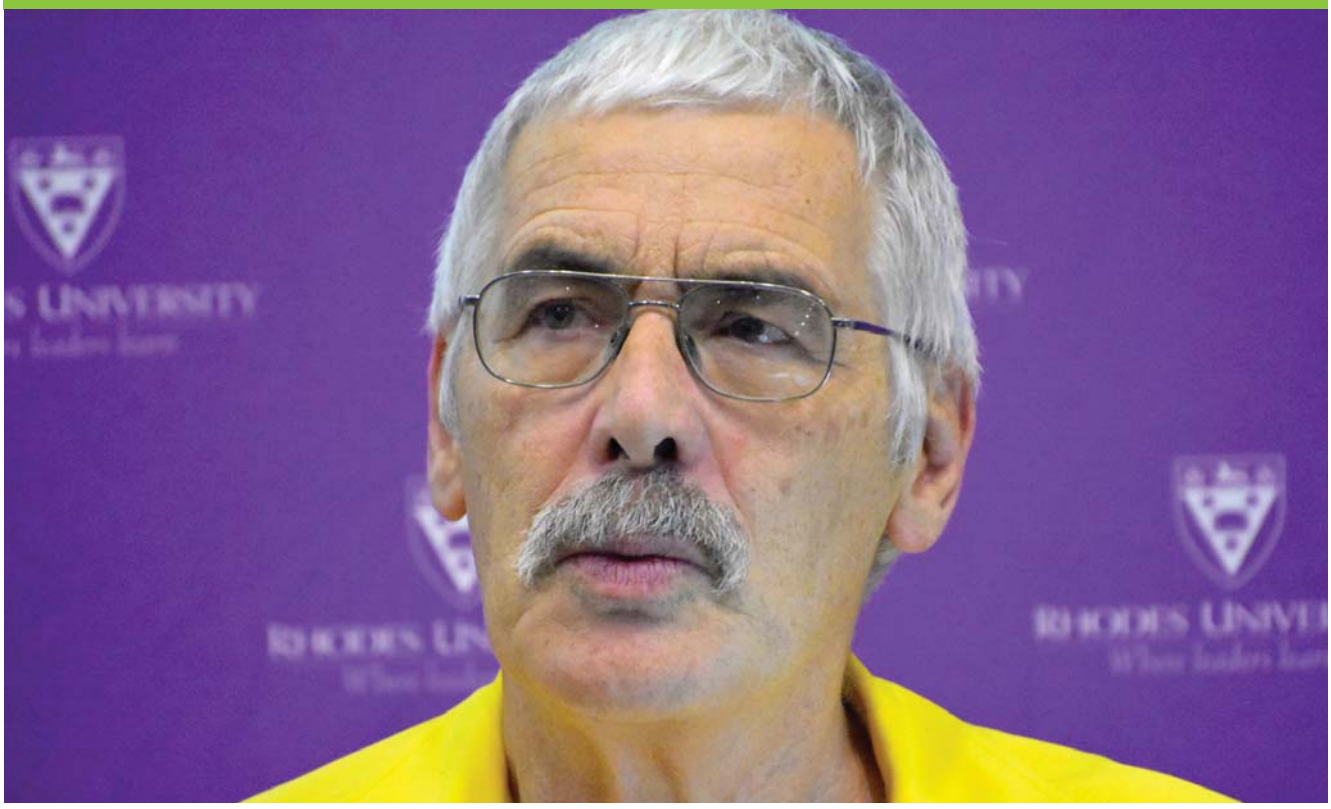
For more information, Visit: www.ywp-za.org

BACK TO TOP

WORKING FOR WATER

Bon voyage to the 'village elder' – WRC wishes Guy Preston well upon retirement

Water Research Commission CEO, Dhesigen Naidoo, Executive Manager, Jay Bhagwan, and Research Manager, Bonani Madikizela, sat down (virtually) with Dr Guy Preston, Deputy Director-General: Environmental Programmes at the Department of Environment, Forestry and Fisheries, who is set to retire this year.



Rhodes University

Preston, who entered government service when he became an advisor to former Minister of Water Affairs & Forestry, Kader Asmal, in 1995, is celebrating a quarter of a century in the employ of government. He is considered the founder of water conservation in South Africa and global award-winning initiatives such as the Working for Water Programme.

At present, Preston is responsible for environmental biosecurity, focusing on the prevention of the introduction of potentially invasive species into the country, as well as regulating invasive species. He leads 14 programmes, including Working for Water, Working for Wetlands, and Working on Fire, among others, which together provide work opportunities for over 70 000 previously unemployed people.

"Dr Guy Preston is one of the stalwarts of this democracy around water conservation, and of one of the most extensive public works programmes in the world. He has created behind him a

BACK TO TOP

vast wake of capacity, sharing his knowledge, inspiration and zeal for us to move towards a more sustainable world," noted Naidoo.

When asked about the highlights of his career, Preston immediately mentioned working with minister Asmal. He described Asmal as a 'significant' person to work with. "He was very demanding, but had a real commitment [to the sector] and a lovely sense of humour. He created an abundance of opportunity and paved the way for various initiatives. We started more than 50 projects that first year, which was very ambitious, and many of them did not work. But some did get off the ground, such as the National Water Conservation Campaign, with Working for Water as one of the flagship programmes."

"We had access to people of extraordinary talent in building up that programme, and there are people with great passion," noted Preston. "It has been just over 25 years since we started, and many of the same faces are still there." Preston worked for the Department of Water and Sanitation for 16 years before moving over to the Department of Environment, Forestry and Fisheries as it is now known to continue managing his programmes there.

While it was not the case at the time the Working for Water programme was started, the impact of alien invasive plant species on South Africa's catchments is now well accepted. "Invasives are the single biggest long-term threat to our water security, and we must do all we can to control them," maintained Preston. Studies by researchers, including Preston's son, Ian Preston of Rhodes University, have shown that up to 50% of the annual inflows into the Berg River Dam catchment (Western Cape) and De Hoop Dam catchment (Limpopo) could be used up by alien invasive plants over a period of 45 years if they are left uncleared.

Preston proposed that in a post-Covid-19 world, labour-intensive environmental programmes, such as Working for Water and Working for Wetlands, could go a long way towards including previously marginalised people in the mainstream economy, while restoring and protecting valuable ecological infrastructure. "The United Nations is increasingly talking about a Global Green New Deal – aimed at bringing about a more equal distribution of income and reversing decades of environmental degradation. Our programmes have shown what can be done to get as close to sustainability as we can while providing opportunity for employment and skills development."

A successful offshoot from the Working for Water programme has been the eco-furniture programme, where school desks and other furniture is manufactured from felled alien invasive trees, such as blue gum and pine. "We have put around 700 000 learners behind school desks with this project," noted Preston. His department was also investing, through its Value-Added Industries Programme, in woodwool cement-fibre board, for use in the construction of buildings. "The properties of this board is extraordinary," noted Preston. Made from a mixture of invasive plant material (75%), cement and fly ash, the board is fire resistant, while its thermal and acoustic properties make it a suitable substitute for brick and mortar.

While a close eye had to be kept on known invasive species, such as wattle, gum and pine trees, the country also needed to take note of new arrivals, said Preston. The list of invasive species is ever increasing. New threats are emerging every day as has been shown with the arrival of the Polyphagous shot hole borer beetle in South Africa in 2017. Famine weed (***parthenium hysterophorus***) is another devastating invader establishing itself in the country. A daisy from the Caribbean, it can grow to over 1.8 m high, displacing native species, and each plant can set tens of thousands of seeds per year.

What advice would Preston give young people entering the sector? "Do everything with passion and enthusiasm. It is not easy to achieve the desired results – I remember working 18-hour days. But keep at it because you will reap the rewards." Preston ends the conversation with some advice to the water leadership of South Africa: "The sustained functioning of our [natural] systems is pivotal to society's future. We need to invest more in conserving these systems and we need to understand the long-term consequences of the decisions we make."

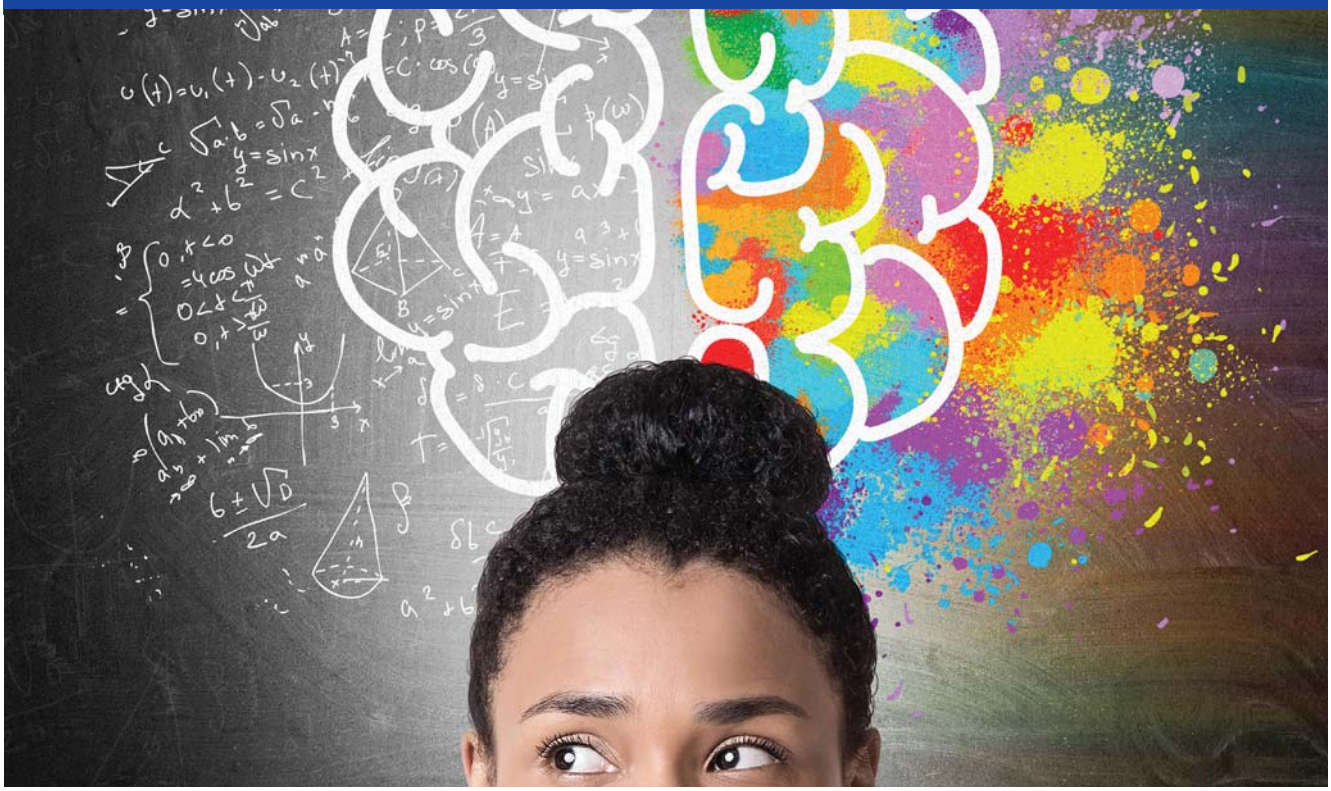
Watch the video interview with Guy Preston here:

BACK TO TOP

WOMEN IN SCIENCE

Moves afoot in Africa to keep more women in science careers

Women scientists have a vital part to play in scientific leadership and in contributing to Africa's development and transformation. So writes Barbara Tiedeu, Associate Professor of Biochemistry at the University of Yaounde I, in Cameroon, for The Conversation.



Despite their important role, women remain substantially under-represented in higher education and in science, technology, engineering, and mathematics (STEM). This is because women are generally seen and treated by society as being inferior and less capable than men. This then spills over into their educational and professional lives.

This is a global issue. Women account for 53% of the world's bachelor's and master's degree graduates and 43% of PhD graduates. But they make up only 28% of researchers in all fields. And, only 30% of women in higher education move into STEM-related fields.

The situation is no different in sub-Saharan Africa; in fact, in some countries in the region it's worse. Only 30% of sub-Saharan researchers in all subject areas are women. Happily, there have been some improvements in recent years. Between 2011 and 2013, for instance, there was an increase in the percentage of women researchers in South Africa, Egypt, Morocco, Senegal, Nigeria, Rwanda, Cameroon and Ethiopia.

But it isn't all good news. Many women leave scientific research careers at a fairly junior level. Gender disparities persist in the scientific workforce, largely leaving women scientists in junior positions with little responsibility and power to make decisions, as well as limited leadership opportunities.

The result is that scientific work is missing women's perspectives and contributions. This weakens the science agenda. But examples are emerging of how to close the gender gap in African STEM.

BACK TO TOP

Growing initiatives

The UNESCO STEM And Gender Advancement (SAGA) project is one. It keeps track of gender data and supports the design and implementation of science, technology, and innovation policy instruments that affect gender equality. To track and monitor women's representation, the African Development Bank's gender equality index captures progress on the appointment of women to posts of responsibility. The index shows the legal, social and economic gaps between men and women, giving African leaders the evidence to begin dismantling the barriers that prevent women from fully contributing to the continent's development.

The Boardroom Africa maintains a database of talented women leaders and senior executives, making them easy to find. It also trains, certifies, mentors and prepares women for board membership. The Boardroom Africa helps organisations benefit from diversity by placing women directors and shifting the boardroom gender balance.

The Gender Summit Africa platform provides evidence of when, why, and how biological differences (sex) and sociocultural differences (gender) affect outcomes. Its goal is to make gender equality in research and innovation the norm and a sign of quality. Africa has hosted two Gender Summits: GS5 in South Africa and GS14 in Rwanda.

The recognition of achievements is crucial to driving gender equity. The African Union Kwame Nkrumah Awards for Scientific Excellence Programme honours two outstanding African women scientists from each of Africa's five geographical regions. This programme promotes scientific development, encourages perseverance in research or academic careers, nurtures ambition, and raises the profile of science and technology innovation so that it contributes to Africa's development.

As part of building skills and mentoring the next generation of African scientists, the African Union declared 2015 as the Year of Women's Empowerment and Development Towards Africa Agenda 2063. It also adopted the Science, Technology and Innovation Strategy for Africa 2024, which examines among other things the role women can play in accelerating Africa's transition to an innovation-led, knowledge-based economy which meets society's needs.

Convened events that aimed to amplify the voices and concerns of African women and girls have included UN sessions of the Commission on the Status of Women and the International Conference on Population and Development. Mentorship programmes such as COACh-Cameroon and the Higher Institute for Growth in Health Research for Women (HIGHER Women) Consortium have trained hundreds of women in career-building scientific skills, such as applying for grants, leadership, ethics, research quality, and project management. Individually and through workshops, mentors provide professional guidance on dealing with African traditional, societal, and cultural pressures on women.

Annual evaluations show empowerment and improved assertiveness and self-confidence among participants, resulting in an upsurge in their careers. For example, they have been able to get research grants, attend conferences, publish more scientific articles, and achieve promotion.

Other spheres

All these efforts can contribute to closing the gender equity gap in STEM in Africa. But change is needed in other spheres too. Many women in research have to balance their careers with family responsibilities. A strong family support system has been key to the success of many women. Africa's ability to harness scientific and technological knowledge is crucial for its socioeconomic development and competitiveness. This potential cannot be fully realised without the inclusion and advancement of women.

Oluwafunmilayo Josephine Para-Mallam and Dorothy Nyambi also contributed to this article.

This article was first published on www.theconversation.com

Covid-19 pandemic amplifying gender disparaties in science – study

Early evidence suggests that women, including female researchers, are disproportionately affected by the Covid-19 pandemic, with negative consequences to their productivity. This is according to Goran Murić and co-authors at the University of Southern California's Information Sciences Institute.
Murić, who is a postdoctoral research associate, and colleagues analysed the proportion of male and female researchers that published scientific papers during the pandemic. They used data from biomedical preprint services and Springer-Nature journals to show that the fraction of women publishing during the pandemic drops significantly across disciplines and research topics, after controlling for temporal trends. By geocoding author affiliations, the authors show that gender disparaties are exacerbated in poorer countries, even though these countries had less of a gender gap in research prior to the pandemic. The results illustrate how exceptional events, such as global pandemic can further amplify gender inequalities in research. The authors believe that their work could inform fairer scientific evaluation practices, especially for early-career female researchers who may be disproportionately affected by the pandemic.

To read the full study,
Visit: https://arxiv.org/abs/2006.06142

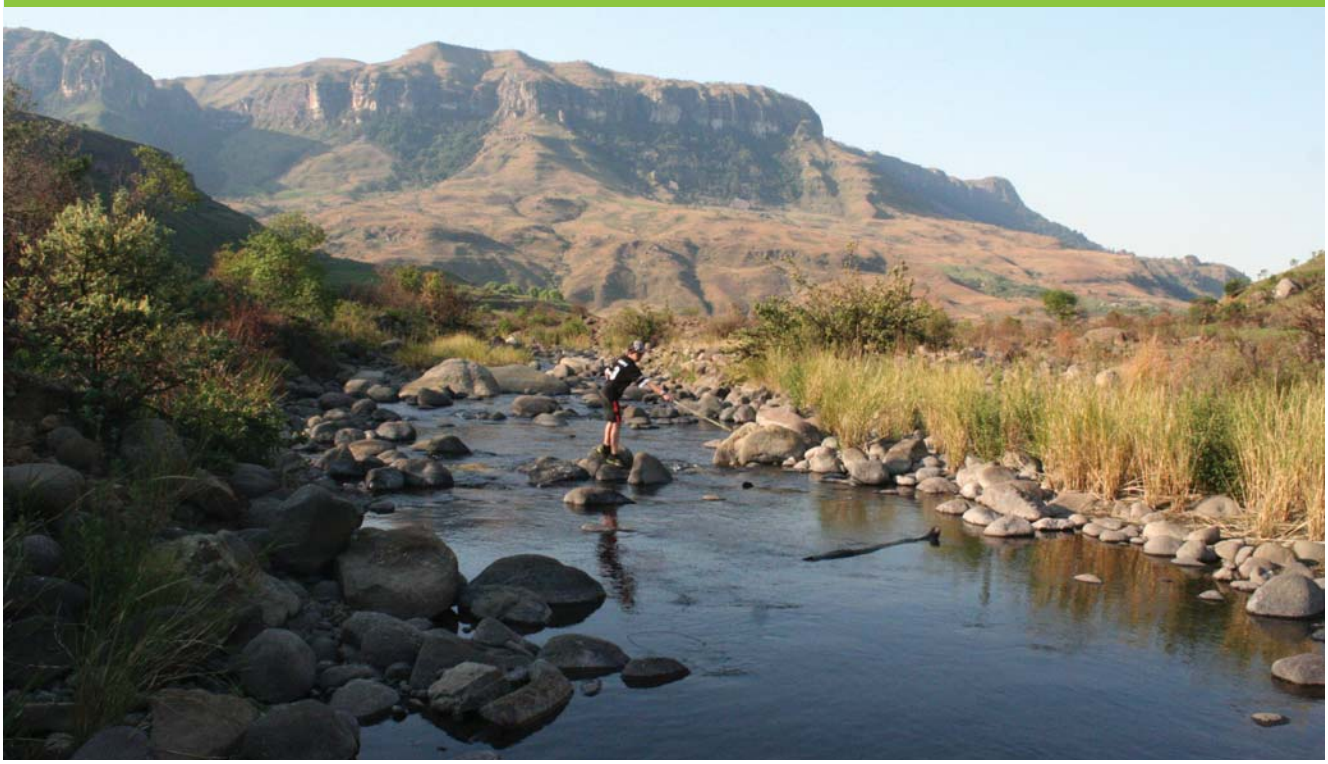
BACK TO TOP

WATER PERSONALITY

Roland Schulze – A lifetime dedicated to water

Prof Roland Schulze pioneered South Africa's first university degree course in hydrology and is renowned internationally for his research on climate change and water conservation. Schulze, who has also supervised and mentored several generations of young water researchers at the University of KwaZulu-Natal, reflects on some of the highlights of a distinguished career spanning more than five decades. Article by Tony Carnie.

Tony Carnie



Growing up in the village of Harburg in the KwaZulu-Natal Midlands, Roland Schulze attended a very intimate little school. There were only 26 pupils in the whole school, spread through from Grade 1 – 8. Young Roland was always first in his class, though he is quick to point out that there was only one other boy in class – the son of the local dipping inspector, who always came second.

"We had one teacher for four classes, but they were very progressive and often we would have lessons under the trees, where we would build models of the local landscape or listen to Mozart for music appreciation."

As his Matric year drew closer, Schulze moved to the Hermannsburg Deutsche Schule to complete the last four years of high school. Hermannsburg, the oldest private school in the province, was established in 1856 to educate the children of Lutheran Church missionaries, many of whom would settle in nearby villages, such as Wartburg, Harburg or New Hanover (Neu-Hannover).

Though Schulze still has one of those delightfully old-school Natal colonial accents, his heritage is unmistakably Lutheran, and the family speak German as their first language at home. "Both my parents were born in South Africa, with my mother's side of the family arriving in the 1880s and my father's side in the 1890s.

BACK TO TOP

Courtesy Roland Schulze

Roland Schulze, Emeritus Professor of Hydrology at the University of KwaZulu-Natal.

"My parents grew up during the Great Depression, and had to leave school at age 14 to start working, but we had a very loving home. My mom later also had to go out to work so that I could go to high school and university, where I studied physical geography and chemistry at the then University of Natal.

After completing his MSc degree Schulze started lecturing physical geography at the Pietermaritzburg campus in 1969. Five decades later, though formally retired, Schulze remains on campus as Emeritus Professor of Hydrology in the Centre for Water Resources Research, within the School of Agricultural, Earth and Environmental Sciences.

"My wife, Waltraut, has also been very supportive. We have been married 52 years and, in a way, she gave up her career for mine. We have been blessed with two children and seven grandchildren."

Schulze, now 77, says he has developed a life philosophy similar to that of a rugby centre: "You need to spot the gap and to take that gap. You also need to know when to take the ball and run, and when to pass it. On defence, you need to work out when to attack from the front, or from the side."

A number of events shaped his career path. In 1969, for example, he was inspired to study more about water after reading Prof Roy Ward's book, ***Principles of Hydrology***.

"Schulse has published more than 140 refereed journal papers, more than 100 consulting reports and personally supervised nearly 90 MSc or PhD students."

The then recently-established Water Research Commission in the early 1970s also played a significant role by providing financial support to Schulze for a new project on small water catchments. This opened the way for several other research projects on a larger scale.

"From those small beginnings in local catchments I started out as a one-person operation. Eventually, we expanded to now include seven full-time hydrology staff, several PhDs and part-time lecturers."

Schulze was also responsible for initiating proposals to offer a specialist hydrology degree at the University of Natal – the first university in the country to offer this degree.

He also played a central role in developing the ACRU (Agricultural Catchments Research Unit) Model, a multi-purpose water modelling system which has since been used for land use impact studies in many parts of South Africa as well as in Zimbabwe, Eritrea, New Zealand, Chile, the USA and Canada.

The same model has also been adapted to model the potential impact of elevated CO_2 and temperature levels and to study shifts in water resources and maize production in southern Africa due to global climate change.

Schulze remains very concerned about current water consumption patterns in a water-scarce nation. "My vision for the water industry in general is that we become more efficient in the use of water, particularly in light of population increases and climate change, which might cause us to have less water than we are used to in the future.

"More than 60% of our water is used for irrigation, so we have to become much more efficient. If irrigation agriculture were to become just 20% more efficient, we could immediately save 12% of our national water resources.

"The second major area of concern is the volume of leakage from municipalities. Maintenance is a word we really have to relearn to reduce the volume of water losses we are seeing."

His third major concern is the loss of available water resources from sewage pollution. Schulze says this level of pollution cannot be allowed to continue, but it seemed that several municipalities only react when a crisis develops.

"We also need more technical expertise in the Department of Water and Sanitation. Many of our well-qualified people are no longer in the country. We simply can't afford to lose such people.

BACK TO TOP

I think in appointing technical staff we need to get beyond the rhetoric of the mid-1990s."

Schulze believes correct water pricing is essential to promote wiser user of water.

"As it becomes more expensive you will use it more sparingly. But you have to be clever about pricing – it cannot just be punitive. There has to be a balance between charging a fair rate and incentivising users. So, if you have been good, you should get some benefit," he states.

While much of Schulze's career has revolved around water, his focus started to shift increasingly towards climate change in the late 1980s when he was invited to a meeting in Swaziland by Prof Peter Tyson from the University of the Witwatersrand's Climatology Research Group.

Schulze acknowledges that there are still several uncertainties associated with climate modelling at a downscaled level, yet a wide range of general circulation models around the world are projecting very similar trajectories, especially with regards to increased temperature and water evaporation.

"The country has been divided into nearly 6 000 quinary catchments for which we have 50 years of historical daily climate data for each of these sub catchments and we use these as a baseline for climate change models.

"Climate change has opened a lot of doors for me because it was still a new discipline in the early 1990s. At that time there were still very few South African experts."

In addition to his research into climate change Schulze is currently working with the fruit, macadamia and sugar industries. He believes some industries are taking a really hard look at themselves in terms of climate impacts and he thinks that clever industries will respond by changing how they do things, where they do things and when they do things in the coming decades.

Does he believe governments, industry and other stakeholders are moving fast enough to avoid dangerous levels of climate change?

"I believe Europe and South Africa have both recognised the seriousness of the problem, though there is one major player to the west of Europe who has yet to be convinced. Fortunately, his scientists are still doing some good work in this field"

Schulze says he favours a solutions-based approach to the climate change debate, rather than a doomsday view.

On a personal note, he says he is often asked about the best piece of advice he ever received. "It happened in America shortly after I turned 58. I was working with Prof Pete Hawkins of the University of Arizona.

"Pete asked me how old I was, and remarked that the years between 60 and 65 should be the best time in anyone's life. His advice was that people should aim as far as possible to do only what they really liked to do at this period of their lives.

"So, on the plane back to South Africa, I started to make a list of things I no longer wanted to do. Over the next two years I gradually started to tick them off my list and, by the time I was 60, I had managed to free myself of most of the things I did not like doing at work.

"I still see people slaving away at things they dislike – but we need to remember that we only have this life once."

Though he admits that his time-management skills could be better, his advice is to focus on one issue at a time, and to isolate yourself where possible to improve your concentration. "There is a difference between being a manager and a leader. I have always seen myself as a leader who likes to think and to ponder, rather than someone who simply ticks boxes."

Schulze lists some of the highlights of his career as being inducted as a member of the Academy of Science of South Africa in 2009 and being appointed a Fellow of the University of Natal in 1991 in recognition of distinguished academic achievement.

In 2013, he was also voted South Africa's top water researcher following a nationwide survey. The cherry on the top came in

Courtesy Roland Schulze

Schulze, with wife Waltraut, after receiving a Lifetime Achievement Award, Cape Town 2018.

Schulze delivers his acceptance speech after receiving a Lifetime Achievement Award in Cape Town in 2018.

Courtesy Roland Schulze

BACK TO TOP

Lani van Vuuren

Schulze is a popular speaker at water-related events.

2018 when he was awarded a Lifetime Achievement Award at the African Utilities Industry Awards for his achievements at a continental level.

He has also published more than 140 refereed journal papers, more than 100 consulting reports and personally supervised nearly 90 MSc and PhD students. "If you have a happy life at home, your work life is more likely to be positive and I think I have had a very fulfilled professional and personal life.

"I was lucky enough to have tremendous opportunities to travel abroad – about 176 times, the last time I counted."

Apart from numerous trips as part of his work with the United Nations' Intergovernmental Panel on Climate Change, Schulze also took full advantage of UKZN's facility for a six-month sabbatical every five years. "I spent excellent time at universities in England, the United States and Europe and our children were also able to experience going to school in very different environments.

"I still see colleagues making excuses not to go on sabbaticals by saying their wife has a good job or that they don't want to disrupt their children's education, but from my perspective I have always made very good use of these opportunities to the benefit of my research. They were excellent."

Outside of work, he was a warden of Lutheran Church for 11 years, attends church regularly and does not see any conflict between religion and science. "There are no problem areas for me whatsoever. The Bible was written more than two thousand years ago, when people had to think in much simpler terms. But the essential messages remain the same, such as: Love your neighbour."

Schulze retired just over a decade ago when he reached 65, but is still an Emeritus Professor at UKZN, and is also engaged in projects with Stellenbosch University, the WRC, eThekwini Municipality, the Western Cape provincial government and a number of agricultural industry groups.

"I am still helping people at UKZN with their projects and sometimes feel a bit like the departmental psychologist, but I really enjoy the collegiality of sharing a cup of coffee with fellow academics.

"My approach to retirement has always been that the work must look for me, and not me looking for the work – and I'm afraid that it keeps finding me!"

Some of the pertinent reports Roland Schulze authored or co-authored for the Water Research Commission

- Modelling impacts of climate change on selected South African crop farming systems (**WRC report no. 1882/1/16**)
- Developing water-related climate change adaptation options to support implementation of policy and strategies for 'Water for Growth and Development' (**WRC report no. 1965/1/15**)
- An evaluation of the sensitivity of socio-economic activities to climate change in climatically divergent South African catchments (**WRC report no. 1843/1/12**)
- Handbook on adaptive management strategies and options for the water sector in South Africa under climate change (**WRC report no. 1843/2/12**)
- A 2011 perspective on climate change and the South African water sector (**WRC report no. TT 518/12**)
- Development and applications of rainfall forecasts for agriculturally-related decision-making in selected catchments of South Africa (**WRC report no. TT 538/1**2)
- Delineating river network quinary catchments for South Africa and allocating associated daily hydrological information (**WRC report no. 2020/1/12**)
- Climate change and water resources in southern Africa. Studies on scenarios, impact, vulnerabilities and adaptation (**WRC report no. 1430/1/05**)
- Development and evaluation of an installed hydrological modelling system (**WRC report no. 1155/1/04**)
- Modelling the impacts of land cover and land management practices on stream flow reduction (**WRC report no. 1015/1/03**)
- Estimation of streamflow reductions resulting from commercial afforestation in South Africa (**WRC report no. TT 173/02**)
- Development of a distributed hydrological modelling system to assist in managing the ecological reserve to the Sabie River system within the Kruger National Park (**WRC report no. 884/1/01**)
- Design rainfall and flood estimation in South Africa (**WRC report no. 1060/1/01**)
- Long duration design rainfall estimates for South Africa (**WRC report no. 811/1/00**)
- Impacts of sugarcane production and changing land use on catchment hydrology (**WRC report no. 419/1/98**)
- Hydrology and water quality of the Mgeni catchment (**WRC report no. TT 87/97**)
- Distributed hydrological modelling system for the Mgeni catchment (**WRC report no. 234/1/92**)
- Crop water requirements, deficits and water yield for irrigation planning in southern Africa (**WRC report no. 118/1/88**)

BACK TO TOP

AGRICULTURE AND WASTEWATER

Constructed wetlands allow reuse of effluent from wineries

South African wineries are setting the example to effectively treat winery effluent with green infrastructure. Petro Kotzé reports.

All photographs courtesy Petro Kotze

The farm Vriesenhof, nestled at the food of the Stellenbosch mountains.

'***n Boer maak 'n plan*** (a farmer makes a plan), as the Afrikaans saying goes. In South Africa, artificial wetlands are allowing some famers to make cost-effective, efficient and green plans in reply to one of the biggest negative impacts associated with agriculture, namely water pollution.

In the winelands of the Western Cape, constructed wetlands are now an accepted treatment option for the large volumes of wastewater produced during the wine production process. Some farmers also use it to treat sewage (following bacterial treatment) to potable standards. Vriesenhof owner and cellar master, Jan 'Boland' Coetzee, has the proof on paper. Test reports consistently show that effluent from his farm, a combination of greywater, treated sewage and cellar water, to be of drinking water quality. His main technology of choice to achieve this is a near-40 metre strip of palmiet and reeds.

Test results show that the treated water contains faecal coliforms of 12 mpn/100 ml. ***E-coli*** readings are 3 mpn/100 ml, pH is at 5.6, conductivity at 30.3, chemical oxygen demand (COD) at 24.2, Calcium at 12 mg/L, Magnesium at 7 mg/L, Sodium at 39 and Potassium less than 0.4 (measures taken in 2016).

For Coetzee, the decision to construct the wetland was not difficult. He could see that water that initially ran through a natural reedbed emerged cleaner in the reservoir on the

BACK TO TOP

other side. Building an artificial and lined system added the extra peace of mind that the water did not contaminate the environment on his farm, nestled at the foothills of the Stellenbosch Mountains.

Acceptance of this green engineering technology has come a long way in the past decade, since Dr Reckson Mulidzi wrote his dissertation on the environmental impact of winery effluent in the Western and Northern Cape provinces in 2001. The study was part of a multi-disciplinary research programme that was started as a result of a lack of information on the disposal practices of winery effluent in South Africa.

Since then, research and legislation has moved forward. Currently the research team manager at the Agricultural Research Council (ARC): Infruitec-Nietvoorbij Soil and Water Division, Mulidzi explains that they are now also investigating how far untreated and diluted winery effluent can be used to irrigate vineyards, an especially appealing option in water scares regions. However, for wineries where space and resources allow for it, the choice of artificial wetlands remains a relatively easy and affordable method to treat effluent to irrigation standards.

The wastewater from wine

Wineries produce large volumes of low-quality wastewater, particularly during the harvest period. In short, wine is produced through crushing and fermenting grapes, and then straining off the skins and seeds. The liquid is then stored, clarified and matured. This process generates a lot if liquid and solid wastes.

Liquid waste is mostly generated through cleaning, as the winery must be kept meticulous throughout the production process to avoid contamination and spoilage. The composition of the effluent varies from one winery to the other, but often contains simple organic acids, sugars and alcohols from grapes and wine as well as sulphur and potentially some fertilizers, pesticides and herbicides.

Solids include stalks, seeds and skins, sediments with pulp, tartrates, yeasts, and bentonite clay and diatomaceous earth (two soils with fine particulates) from the clarification processes.

Historically, this wastewater was mostly disposed of directly to the land in South Africa, to irrigate pastures for livestock. Of all the detrimental impacts, the biggest was due to the effluent's very high chemical oxygen demand (COD), notes Mulidzi. The decaying process of the organic matter in the wastewater consumes a lot of oxygen. Where it is discharged, oxygen is also taken out of the receiving waters. This can result in the water becoming toxic, killing off plants and aquatic life. Furthermore, the volume of wastewater that needed disposing led to soil degradation, and it could seep into groundwater and nearby streams.

Though it was already clear at the time that winery effluents posed definite pollution problems, there were few other affordable options available to farmers. Mulidzi says constructed

Most of the wastewater generated by wineries is from the cellars, and is generated during the production process.

BACK TO TOP

Jan Coetzee constructed a wetland on his farm, Vriesenhof, to treat various streams of effluent generated on the property. The result is water of a potable standard.

wetlands offered a viable solution. Over and above cost savings, these structures were simple to use and open to anyone that had the required space. There is some technical knowledge necessary, he explains, especially since winery effluent is very strong and can be detrimental to some plants. For this reason, Nietvoorbij provides advisory services to farmers on the construction of wetlands, should they want to employ this technology.

About five years ago, Coetzee took up the offer, and constructed a wetland on his property on advice from Nietvoorbij. Years down the line, the structure is still performing exceptionally well, and sets a good example of the quality of treated effluent that can be achieved on a winery when wastewater of various sources is treated with an artificial wetland.

The Vriesenhof wetland

The wetland treats about 20 000 liters per day of grey and blackwater. The blackwater, or sewage, is run through a bacterial treatment process first, before being led to a central tank.

During the harvest season, a further 15 000 litres of effluent from the wine production process is added. The so-called cellar water is led to the same central tank, after the removal of solids.

From here, the cellar water, treated blackwater and greywater from the property is put through a chlorine filter. This combined water then runs down a short series of small ponds for oxidation into the wetland. From here, the water travels through the vegetation for about 40 metres (the wetland was lengthened over time) to a reservoir. At the time of ***the Water Wheel's*** visit, the reservoir was dotted with yellow-beak ducklings and, according to Coetzee, various bird species visit throughout the year. While the water is potable at this point, it is abstracted to irrigate pastures.

Maintaining the artificial wetland is not difficult, notes Coetzee, and they mostly only need to trim the vegetation every now and again. Results such as those from Vriesenhof are not unique, and constructed wetlands have proven to be effective for treating winery effluent, removing solids, lowering COD, neutralizing pH and rendering wastewater of quality sufficient for irrigation use.

Irrigation with effluent after treatment by constructed wetland

An ARC Infruitec-Nietvoorbij study found that winery wastewater treated by a constructed wetland was a viable option for irrigating cabbage. Mulidzi, who was the project leader, says the practice not only saves water, but the treated water can contribute nutrients required by the crops, leading to further cost savings on purchasing fertilizer.

For this study, a wetland of 50 m x 6 m and 1 m deep was constructed. It was filled with dolomitic gravel, and planted with the local species bulrush (***Typha latifolia***) and common reed (***Phragmitis australis***). The wetland proved to remove more than

BACK TO TOP

The reservoir where all the final effluent is led to after treatment by the constructed wetland. From here, water is extracted for irrigation of pastures.

90% COD and after treatment, was used to irrigate cabbage as part of a poverty alleviation project for farm workers. The experiment entailed the application of four types of water: Clean irrigation water with fertilizer, clean irrigation water without fertilizer, and wastewater after treatment with a constructed wetland with and without fertilizer.

The results indicated that wastewater, after treatment with constructed wetland, could not only safely be used for irrigation of cash crops, but could improve the nutritional status of the soil. It was concluded that cabbage can be irrigated with the wastewater from wineries without the danger of associated diseases and that the practice can reduce the cost of fertilizer because the wastewater contained essential element such as phosphorous, potassium and nitrogen.

What a constructed wetland needs to work

Available land, funds and effective management incorporated with some creativity and flexibility are listed in reports as necessary to construct a wetland for wastewater treatment.

Recommendations include a compulsory pre-treatment system for removing solids, as these contain more than 40% of the COD load, and will otherwise clog the system. Then, rainwater should be included in the system. The wetland should be designed so that its capacity is bigger than required because once it rains, the added water will decrease the retention period of the wastewater in the system, by pushing the effluent to the outlet.

According to Mulidzi, the duration that the water stays in the wetland is the most important factor to bear in mind. At a minimum, it should be five days. Studies have shown the difference in final water quality when the retention time is shortened from 14 to 7 days to decrease from 80% to 60%, though the property owner's capacity to allow for this could depend on the space available for the wetland to be constructed.

A 10% safety factor should be incorporated into a design to allow for unknowns such as fluctuations in the composition of the effluent. The extra capacity also allows for the removal of wilted plants from parts of the wetland when necessary, without affecting its overall performance. Then, a combination of more than one type of plant is essential as various types of plants tolerate wastewater differently and their ability to remove nutrients from the effluent also differs.

The costs and benefits of treating effluent with constructed wetlands

The knock-on benefits of treating wastewater with constructed wetlands have been well documented. It can reduce the costs and energy required associated with conventional water treatment, and could reduce the cost of fertilizer if the water is used for irrigation. Where water is limited, the reuse of wastewater can lead to water savings, in turn, leading to more sustainable farming operations. Wetlands are aesthetically pleasing, and increase the biodiversity of the property.

Translating this into monetary worth is not as a simple task, according to Mulidzi, as the valuing of natural resources in economic terms is a complicated and tricky process. It's not easy to set the price for the quality of the environment as well as the aesthetic value of natural resources such as wetlands.

For Coetzee, no such questions remain. Sitting around his kitchen table on the farm, he points out the exact lay of the land, how the water flows through it from the mountaintops to the nearby Blaauwklippen River and beyond. His water readings and tests go back years, as he meticulously documents the quality of the water as it runs through his farm and beyond, and the impact that their agricultural activities have on it. For him, it is about creating a closed system, in which any contamination generated by his farming activities cannot impact the environment beyond, or below, his borders. For this, the choice of wastewater treatment system was very a simple one.

The constructed wetland on Vriesenhof, as the water runs down from the central tanks.

BACK TO TOP

WATER AND THE ENVIRONMENT

Global award for South Africa's 'frog lady'

Tony Carnie

Much like canaries in a coal mine, frogs are an early warning system when it comes to the health of aquatic environments. When they start to die or disappear, you can bet it spells bad news for the country's rivers, wetlands and freshwater areas. Report by Tony Carnie.

All forms of life need water to survive, but frogs and other amphibians are especially dependent on living spaces with healthy freshwater supplies. Dr Jeanne Tarrant – one of six global winners of the 2020 Whitely Fund for Nature awards – explains that while frogs have rudimentary lungs, they breathe primarily through their skin.

And without water to moisten their thin and highly permeable skin, most frog species would be unable to breathe in oxygen or expel carbon dioxide. The breeding cycle of amphibians is also closely tied to water. For example, their soft, jelly-like eggs have to remain moist, and most species will lay their eggs in or close to freshwater. When they hatch, the young tadpoles will spend their first part of their lives in water.

As a result, we should be paying more serious attention to the future of amphibians, says Tarrant, considering that 41% of all amphibian species are at risk of extinction globally, making them one of the most threatened group of animals on the planet.

Tarrant, head of the Endangered Wildlife Trust's threatened amphibian programme, was one of six conservationists who was honoured in April by the UK-based Whitley Fund for Nature. The award comes with £40 000 in funding to support her quest to protect South Africa's threatened amphibians.

BACK TO TOP

Dr Jeanne Tarrant, winner of the 2020 Whitley Fund for Nature award, has been honoured internationally for her work to conserve South Africa's threatened amphibians.

Tarrant, a graduate of Rhodes and North West universities, says almost two-thirds of the country's 135 frog species are found nowhere else in the world.

One especially threatened species, Pickersgill's Reed Frog, is endemic to the KwaZulu-Natal coast, where rapid expansion of sugar farms and other development has reduced the remaining kingdom of this species to a land area of only 144 km^2. To turn that around, Tarrant and other amphibian experts initiated a captive breeding programme at the Johannesburg Zoo to turbo-boost their dwindling numbers, along with several projects to protect their remaining living spaces. (For more information about this programme, read 'Collaborative conservation effort to save one of SA's smallest frogs' in the Water Wheel March/April 2014 (https://bit.ly/382H5gv).

Supported by the Whitley Fund for Nature, Tarrant's team will produce a 10-year conservation and research strategy for South African frogs. They aim to protect 20 000 ha of amphibian habitat conserving eight species. "While South Africa has excellent environmental legislation, illegal developments continue to destroy frog habitats. Our aim is to not only improve appreciation of frogs through research and education, but use our slippery friends as flagships for the wider conservation of vital freshwater and terrestrial areas that are under the increasing threat of humans," explains Tarrant.

"The fact that almost half of amphibians are experiencing declines should be a massive wake-up call to humanity that all is not right with our planet – most people, however, are unaware that amphibians are even in trouble."

Edward Whitley, Founder of the Whitley Fund for Nature, said: "Jeanne is an inspiring leader who tirelessly advocates for amphibians – an often overlooked group. We hope that this award will allow her to spread her important message far and wide, and bring about real change for amphibians and their habitat through science, policy, and community education."

Tarrant ranks habitat loss as the single biggest threat to amphibians, followed by water pollution. The use of frogs in the pet trade or laboratory experiments is also an emerging threat. In some African cultures, frogs have been associated with witchcraft, often making them feared by locals.

Tarrant says her educational work aims to dispel such myths and to raise awareness and appreciation of the important role frogs play in the health of the environment and ecosystem. Tarrant, who grew up on her parent's farm in Underberg in the Southern Drakensberg, has been exposed to frogs since she was a young girl, but they only hopped into her professional life in around 2006 when she enrolled at North West University for her Masters degree, followed by her PhD and Post-Doctoral studies.

While normally presented to winners by charity Patron HRH The Princess Royal at an annual Ceremony in London, the 2020 Whitley Awards ceremony has been postponed due to the Covid-19 pandemic. The winners will receive their funding now, and there are plans to invite them to a ceremony and related events in London later this year should circumstances allow.

Tarrant's outreach and awareness work has involved hundreds of children from across the country.

Named after the herpetologist, Martin Pickersgill, who discovered the species in Mount Edgecombe in 1978, the tiny Pickersgill's Reed Frog is one of the country's rarest amphibians.

BACK TO TOP

INDUSTRIAL WATER

A decision support tool for industrial water reuse in South Africa

A CSIR project is developing a decision support tool to increase the reuse of water in South African industry. Article by M Steyn, B Genthe, I Banoo, M Thwala, T Roos, C Walters and F Ramakhwatho.

Water scarcity, increased pollution, unprecedented population growth and climate change are all driving the need to reuse water to secure the future of the country. It is clear that South Africa's already strained water resources will become even more stressed in the near future. The Department of Water and Sanitation (DWS) (2017) predicts that by 2030 water demand will reach 17.7 billion m^3, far more than what is available to allocate. Responsible and efficient water management is fast becoming a pressing reality for domestic users, agriculture and industry alike. The challenge is therefore to do the most with the little water we currently have.

The water use per sector according to the latest National Water and Sanitation Master Plan (DWS, 2018) is depicted in Figure 1. The main water users in South Africa are agriculture (61%) followed by domestic water use (27%) and Industry (7%). Figure 2 represents a breakdown of the main industrial water users in South Africa (Cloete et al, 2010).

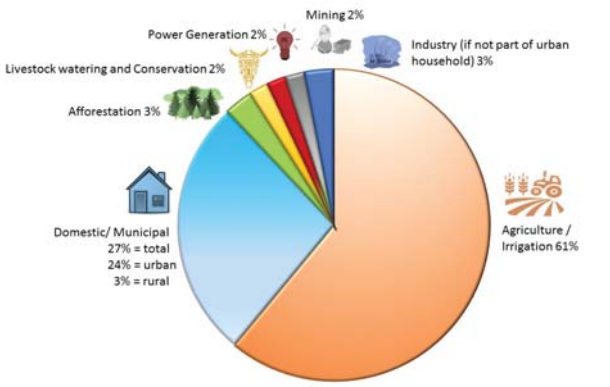


Figure 1: Water use per sector in South Africa (DWS, 2018).

BACK TO TOP

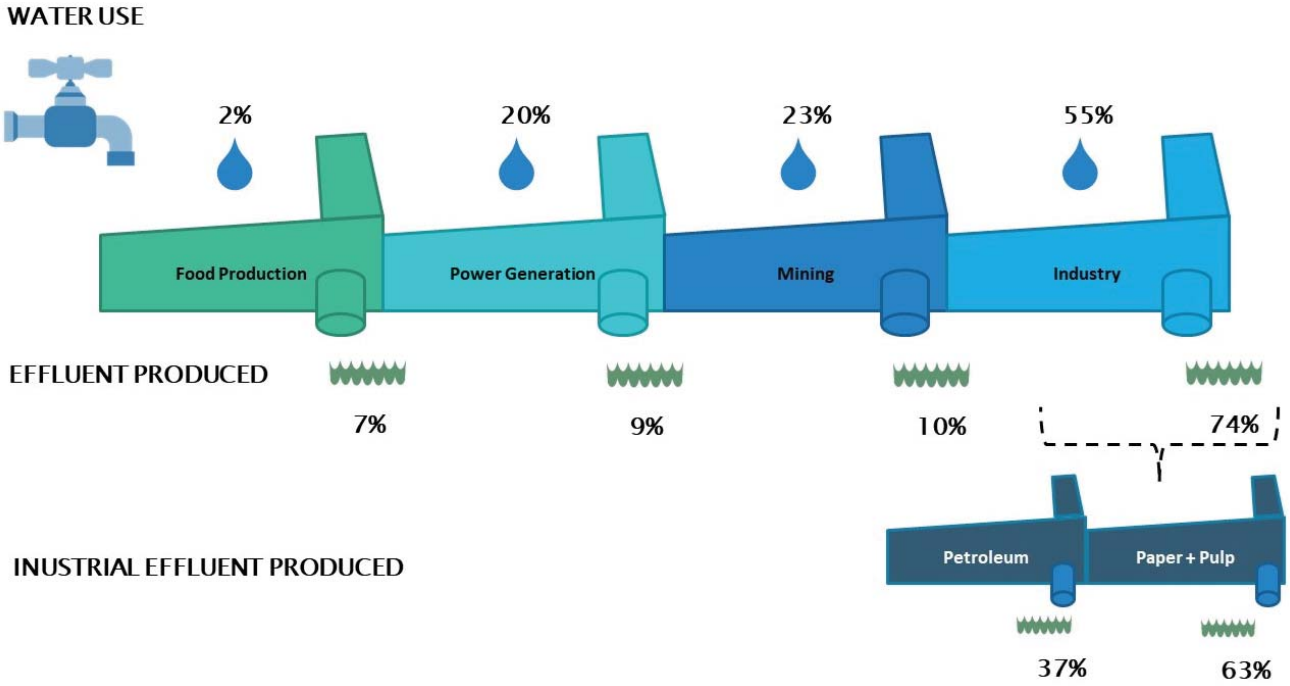


Figure 2: Industrial water use and effluent production in South Africa.

Various types of water can be reused and, depending on the intended use, the wastewater may require treatment prior to reuse, and may either be treated to potable or non-potable standards. Water reuse can occur at a variety of scales, including onsite reuse where the water is reused at the same site where it was first used. Indirect reuse is where treated wastewater is returned to local water resources and is later abstracted and reused by downstream water users. An example of direct reuse of treated effluent delivered directly to an industrial water user is Mondi Paper in the southern part of eThekwini municipality receives treated domestic effluent from the Southern Wastewater Treatment Works, freeing up sufficient drinking water for approximately 300 000 people (eThekweni Municipality, 2011).

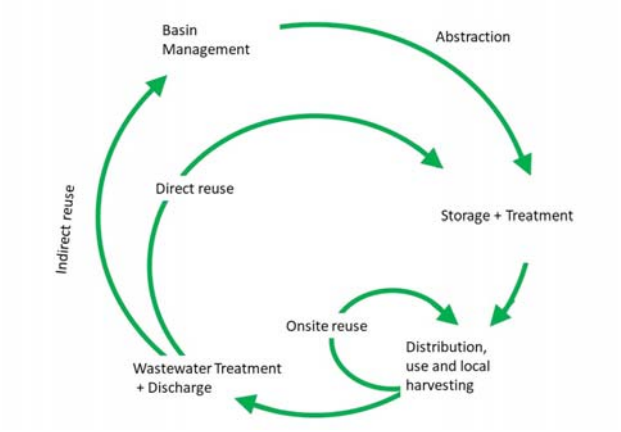


Figure 3: Scales of water re-use (adopted from Green Cape, 2018).

Treated domestic wastewater has long since been reused for various purposes, such as irrigation of sports fields and crops as well as for reclaimed drinking water (e.g., Atlantis managed aquifer recharge plant). More recently wastewater has been treated and used directly for drinking (e.g., Beaufort West).

While there is still much more that can be done with domestic wastewater, the value of industrial effluent is yet to be realised globally. This is shown in the GreenCape's Market Intelligence Report (2018) where the total Gross Value Add (GVA) for moderate and highly water intense users in the Western Cape Province in 2016, excluding agriculture, was calculated to be R155 billion (Quantec 2017).

An assessment of the industrial effluent reuse potential of the country will assist in identifying where water can be made available for development. Industrial companies are increasingly exploring the reuse of their effluent (wastewater) streams. Internationally, there is a general move towards zero liquid discharge, and several industries in South Africa already reclaim and reuse significant amounts of wastewater, such as the mining and sugar sectors.

In June 2018, Nestlé South Africa announced the launch of its R88 million zero-water dairy manufacturing facility in Mossel Bay, in the Western Cape. It was estimated that the facility would allow Nestlé to reduce the factory's water consumption by more than 50% during the first year of implementation by reusing the water recovered from the milk evaporation process, saving 168 million litres of water a year. It is estimated that Nestle will eventually reduce its municipal water consumption to zero (Engineering News, 2018).

As part of its new organisational strategy, the CSIR intends to become increasingly responsive to support the country's industrial development needs. A three-year CSIR project funded by Parliament aims to assess the feasibility of reuse and recycling of industrial effluent to augment national water resources. The CSIR project team, led by Bettina Genthe from the Integrated

BACK TO TOP

Water Analytics and Solutions research group, is working on a national decision support system to assist metropolitan municipalities, and decision makers within these municipalities, to identify possible sources of industrial effluent available for reuse.

One of the project objectives is to evaluate a toxicity bioassay toolkit that could assist with the decision making. In terms of water quality and potential risks, effluent is seldom treated or tested beyond a few basic chemical parameters. This project therefore aims to identify and test a number of bioassays and to recommend a battery of bioassays to assess water quality for reuse potential. Based on effluent quality the reuse of the effluent might only be suitable for specific uses and these will be identified based on lab testing with such assays.

The Mondi Paper example described earlier provides a real-life example of where industrial effluent produced by one industry is directly reused by another industry. The CSIR project team visited some of these industries to learn more about what has been done to date and the CSIR team is currently working with these industries and the metropolitan municipalities to identify other possible examples and potential pilot sites.

The electronic decision support system will provide information on industry location via GIS maps. The maps will display the volumes of water consumed as well as the volumes of effluent produced in each location. Effluent quantities will be logged once received from the metros. To date, the project team made use of publicly available data. The team identified locations (GPS coordinates) from Natsurv documents (an example of this is shown in Figure 4) and mapped the industry data on GIS maps. From there the team made use of the publicly available WARMS (Water use Authorisation & Registration Management System) data that provides data on the licensed use of water in each municipality. By overlaying the industry location and industrial water uses, the team could identify available effluent volumes and quality for reuse by other industries.

The project team has further engaged with stakeholders in the latter phase of the project, and is awaiting data from metros on the actual water use and effluent volumes produced in the respective areas. This will validate the WARMS data, which is based on licensing and not a true reflection in all cases of actual volumes used and effluent volumes produced or its availability for reuse. In cases where industries are already reusing their own effluents, the team will also produce a map of existing case studies and where effluent is not available for reuse.

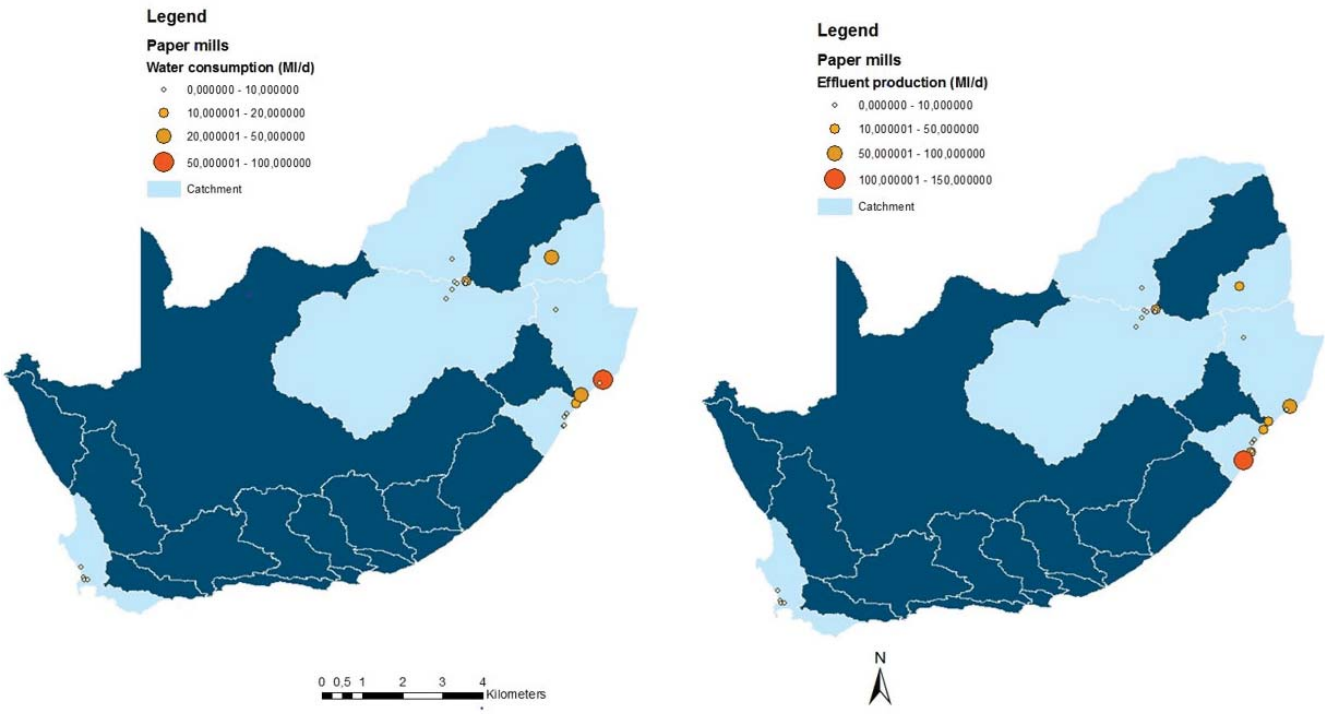


Figure 4: Water volumes consumed and effluent volumes produced by paper mills in South Africa.

Figure 4 is an example of one of the maps produced by the team which highlights the location and water consumption volumes of paper mills in South Africa followed by the effluent volumes produced by each of these paper mills. Higher volume consumption of water or higher effluent volumes are indicated with darker and bigger circles. It is envisaged that the final decision support tool will have clickable links for each registered industry. The user can then click on the map or a specific area to view further information about the effluent qualities, volume and availability as well as the reuse compatibility for specific industries based on effluent qualities and distances to other industries. Transport of effluent over large distances is often not feasible due to additional costs and risk (e.g. spills and accidents).

BACK TO TOP

Reused water can play an important role in water security in a water scarce country such as South Africa as it can augment or partially substitute freshwater resources needed for domestic purposes and future development. Van Niekerk and Schneider (2013) caution that receiving water quality objectives must be clearly defined and the impact of reuse on water quality must be carefully managed and that in some instances, more advanced treatment may be required to further encourage reuse. During the next phase of the project, the toxicity bioassay information for certain effluent qualities will be finalised to help municipalities identify possible reuse opportunities. The tool will be ground-truthed by the municipalities and further improved by accurate data. As a final output, the team plan to publish a national industrial water reuse atlas for South Africa.

It is envisaged that in future, cost estimates or savings for reusing effluent compared to extracting potable water can be added to the decision support system for further decision making. Such a tool will be very handy, especially if a possible day zero scenario (WWF, 2019) happens in future. Decision-making would be easier and faster and could be based on potential cost savings.

References

- T.E. CLOETE, A. GERBER, and L.V. MARITZ, 2010. A First Order Inventory of Water Use and Effluent Production by SA Industrial, Mining, and Electricity Generation Sectors. WRC Report nr. 1547/1/10
- DWS (Department of Water and Sanitation), 2017.Strategic overview of the water sector in South Africa 2017. Pretoria, South African Government.
- DWS (Department of Water and Sanitation), 2018. National water and Sanitation Master Plan. Volume 2: Plan to Action. Final Draft. Version3.3. 31 March 2018. Pretoria, South African Government.
- Engineering News, 2018. Nestlé launches 'zero water' manufacturing facility in Western Cape. 5 June 2018. https://m.engineeringnews.co.za/article/nestl-launches-zero-water-manufacturing-facility-in-western-cape-2018-06-05/rep_id:4433
- eThekwini Municipality, 2011. The Durban Water Recycling Project. http://www.durban.gov.za/ City_Services/water_sanitation/Services/Pages/durban-recyling.aspx
- Green Cape, 2018. Water: Market Intelligence Report. GreenCape, Cape Town; www.greencape.co.za
- Quantec 2017. Regional Output and GVA at basic prices by industry and 2011 local municipal/wardbased metro region level 1993-2016 (v2 18Aug17), Online: Quantec.co.za. in Green Cape; Water: Market Intelligence Report, 2018.
- Van Niekerk, AM., and Schneider, B. 2013. Implementation Plan for Direct and Indirect Water Re-use for Domestic Purposes – Sector Discussion Document. Water Research Commission Report KV 320/13. November 2013. ISBN 978-1-4312-0484-7.
- WWF, 2019. Cape Town: Avoiding "Day Zero" 14 February 2019 Accessed 23 April 2020. https://wwf.panda.org/?343091/Cape-Town-Avoiding-Day-Zero

BACK TO TOP

WATER USE IN ORCHARDS

New app can predict apple orchard water use up to a week in advance

A current multi-year project funded by the Water Research Commission (WRC) has seen the successful development of a smartphone applications (app) for forecasting orchard water use a few days in advance using readily available data from apple orchards as inputs. Article by Sebinasi Dzikiti, Trevor Lumsden, Zanele Ntshidi, Nompumelelo Mobe and Mark Gush.

Over the years, the WRC, in collaboration with fruit industry partners, has funded several research projects aimed at establishing the water requirements of orchards across South Africa. Many of the studies focused on apple orchards in the prime production regions in the Western Cape (e.g. Volschenk et al., 2003; Dzikiti et al., 2018; Gush et al., 2019). In addition, there are currently ongoing related projects in these areas (e.g. Midgley et al., 2019). So, the volume of good quality data of actual orchard water use measurements is growing.

With this in mind, a study aimed at consolidating and adding value to these data was initiated by Dr Mark Gush, now with the Royal Horticultural Society in the UK. The priority of the study was to develop a simple but scientifically credible tool that operates on platforms that are easily accessible to farmers to assist them with irrigation planning in real-time. The resultant innovation comes at the right time when the fruit industry is grappling with water scarcity as a result of frequent droughts and the increasing demand for the limited water resources.

The project, funded by the WRC, commenced in April 2018 and ends in October 2020. The first phase of the study involved developing the methods and identifying the right data to use. The project team decided to develop the app following the internationally recognised FAO 56 principles (Allen et al., 1998) which irrigators are familiar with. According to this approach, the

BACK TO TOP

orchard water requirements, which numerically are equal to the crop evapotranspiration (ET_c), is calculated as the product of a crop factor (K_c) and the reference evapotranspiration (ET_o).

Thus, selecting an accurate online source of daily weather forecasts to predict ET_o a few days in advance was an important consideration. Equally important was the identification and improvement of an approach to estimate the orchard crop factors using readily available data (tree height and fractional vegetation cover). The development and field testing of the application (hereafter called the Orchard Water Use APP or simply APP) were the next steps. The final phase of the project is the roll out of the app on Google Play Store, which is expected before October 2020.

The orchard water use app

The app currently works on Android Smartphones only, however, it will be available on other platforms soon. A schematic representation of the app is shown in Figure 1. Once the app has been successfully installed on the smartphone, the following steps are initialised. On the landing page:

- User enters the orchard information (e.g. orchard coordinates, tree height, fractional vegetation cover, soil type, irrigation system and cover crop status)
- This information is required to calculate the basal (K_{cb}) and crop factors (K_c) using an algorithm developed by Allen and Pereira (2009) and adapted for apple orchards by Mobe et al (2020). This approach enables accurate crop factors to be derived taking phenological stage and canopy size into account. The performance of the crop factors algorithm was tested using actual measured daily water use data collected over entire growing seasons in 13 apple orchards comprising different cultivars and age groups, planted in different apple growing regions in the Western Cape

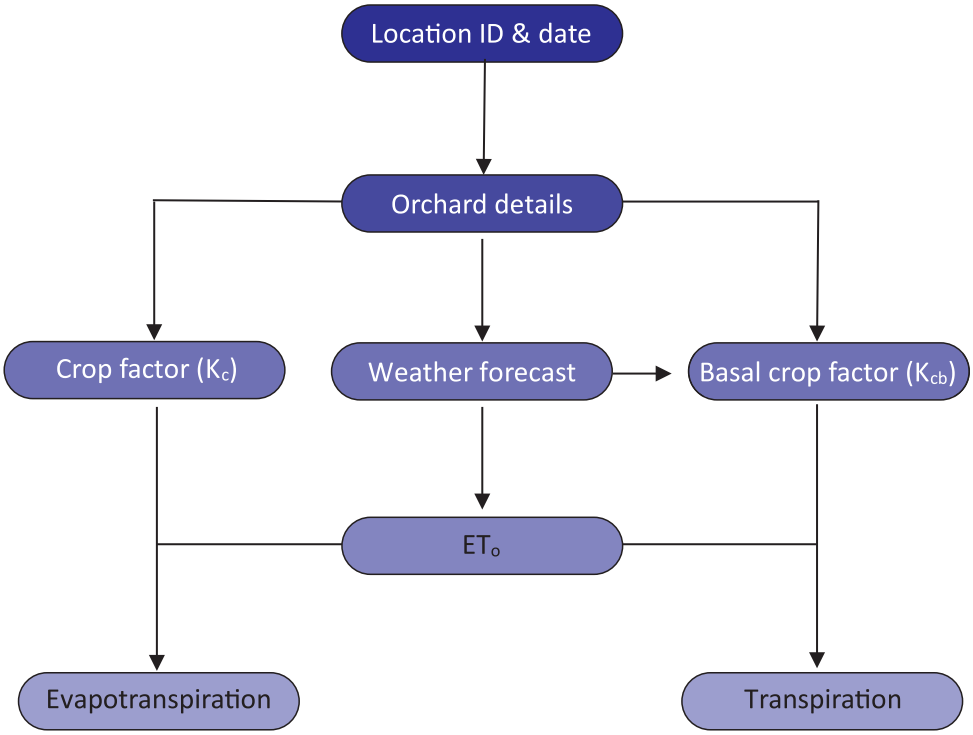


Figure 1. Schematic representation of the orchard water use Smartphone APP.

- Next the user decides how far ahead they want the water use estimates. It is important to note that the system restricts this choice to a maximum of seven days in advance as the accuracy of weather forecasts decreases the longer the forecasting period
- Once the landing page is fully populated, the user then runs the APP using the 'Get Estimates' button
- This action pulls in the necessary daily weather forecast data from an online source (www.darksky.net) providing the relevant weather variables (i.e. maximum and minimum temperature, maximum and minimum relative humidity, wind speed and solar irradiance);
- Calculations of the daily crop factors (K_{cb} & K_c), ET_o, transpiration and evapotranspiration (in mm/d) are then performed in the background
- The data is displayed as graphs or in tabular form
- In addition, a weekly summary of the outputs i.e. total ET_o, transpiration and evapotranspiration (in mm/week), and average crop factors is also generated

BACK TO TOP

Field testing the app

The performance of the app has been tested in collaboration with two farms in the Western Cape, one in the Koue Bokkeveld and the other in Villiersdorp during the 2019-20 growing season. The Koue Bokkeveld orchard was planted to mature Rosy Glow apples under microsprinkler irrigation. In Villiersdorp, data were collected in a mature Royal Gala apple orchard on V-trellis training system under drip irrigation. Data collected included the site microclimate, irrigation volumes, soil water content and tree transpiration (measured using the heat ratio method of monitoring sap flow).

The two farms were selected because they rely heavily on another tool for ET_o forecasting already in use in the industry (iLeaf) for irrigation decision making. The farm decided on the appropriate crop factors to use. Thus, we assessed the relative performance of the two tools in comparison with measured data. Validation of the app was performed as follows: every Monday morning the app was run for each test orchard for the week ahead (Monday to Sunday).

The information was immediately sent to the farm. The farm, in turn, sent back to the researchers their own irrigation forecasts for the week. The Orchard Water Use app and the farm's irrigation forecasts were then compared with the actual measured data. For example, Figure 2 shows a comparison of the forecast daily ET_o by the app and iLeaf against the actual measured data in Villiersdorp.

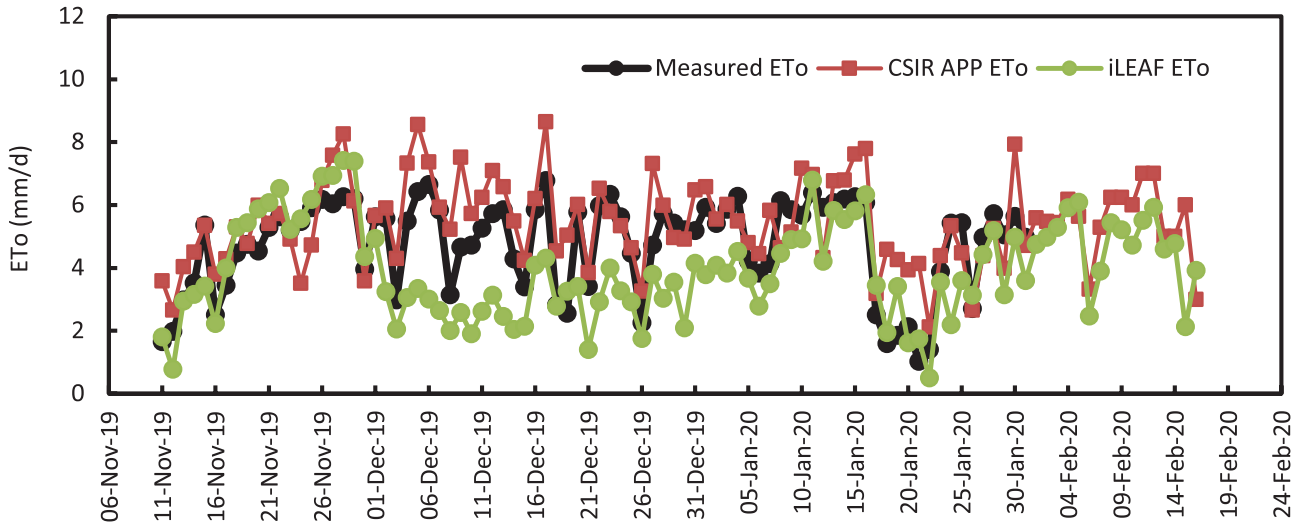


Figure 2. Comparison of the daily ET_o forecasts predicted using the APP (brown line) and iLeaf (green line) against the actual measured data (black line) in Villiersdorp.

A comparison of the actual weekly irrigation applied against that forecast by the APP and iLeaf ET_o in Villiersdorp are shown in Figure 3. The app's irrigation forecasts were within the same order of magnitude as iLeaf and the actual measured irrigation amount.

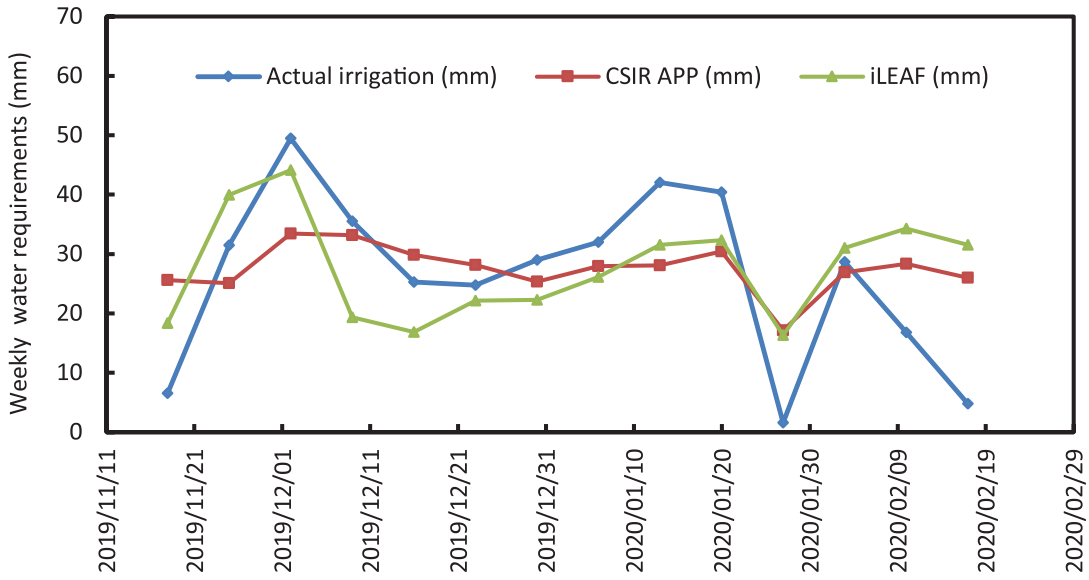
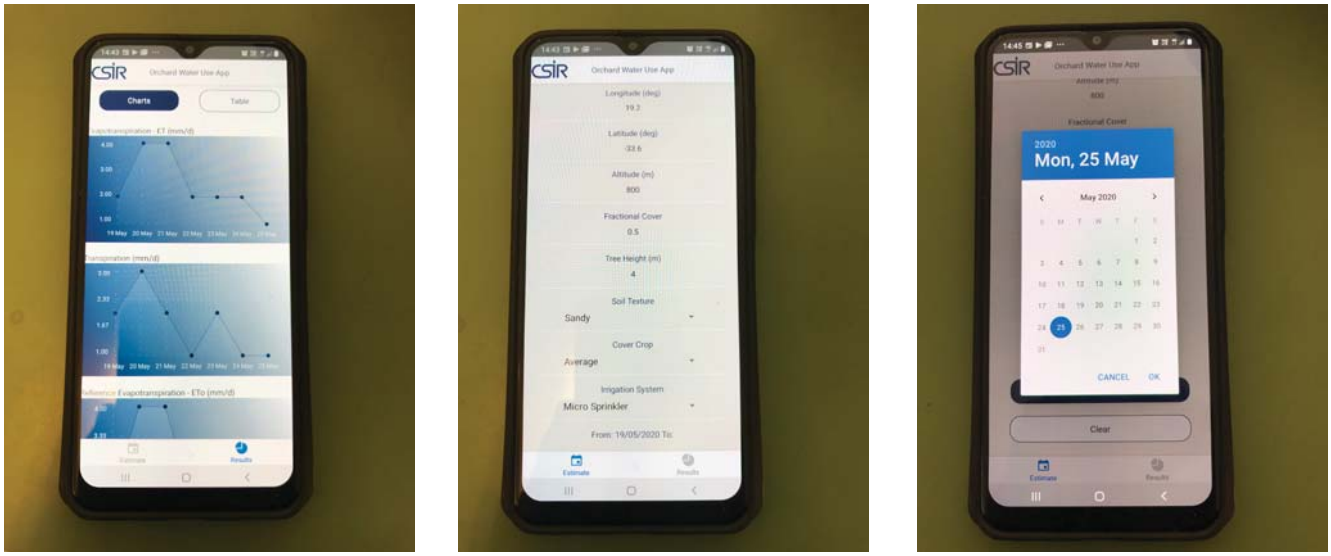


Figure 3. A comparison of the weekly irrigation forecasts determined using the APP and the farm's method against the actual applied irrigation in Villiersdorp.

BACK TO TOP



Courtesy CSIR

Screenshots showing the various phases of running the Orchard Water Use APP.

Next steps

Evaluation of the app using measured data for the period February to April 2020 was in progress at the time of writing. Detailed results of the study, specifically showing how the app's transpiration and orchard ETc estimates compare with the actual measurements will be presented in the final report of the project.

However, the performance of the app during the first half of the season at both sites was satisfactory and it compared well with observed ET_o and irrigation data although we did not show the Koue Bokkeveld site data. A free version of the Orchard Water Use app will be posted on the Google Play Store before October 2020. It is important to note that the current version of the app is designed for apple orchards only. Other tree crops may be added in future.

Acknowledgements: We acknowledge funding from the Water Research Commission (**project no. WRC K5 2819**) and the CSIR Parliamentary Grant (P1AHS01). We also wish to thank the two farms that have participated in the initial evaluation of the APP.

References

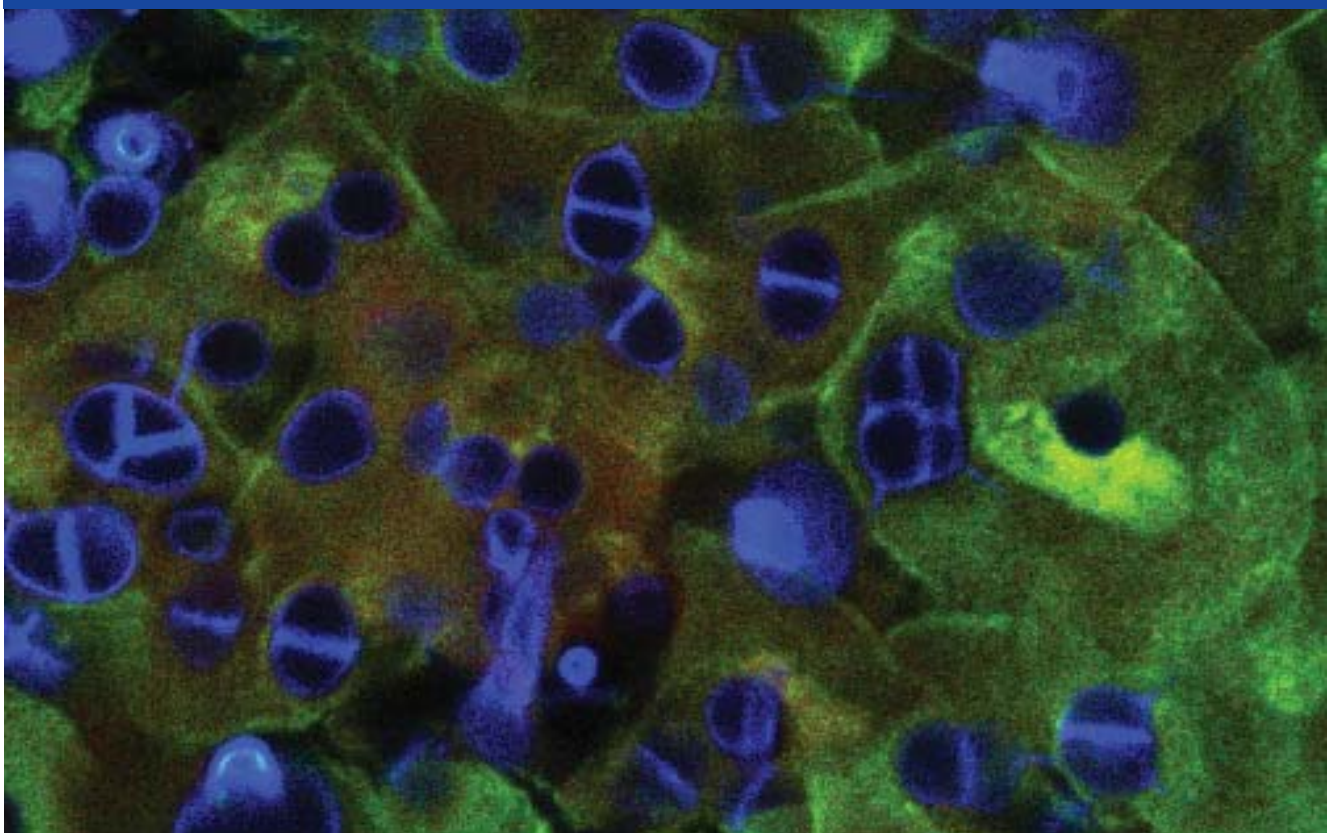
- Allen R., Pereira LS., Raes D., Smith M. 1998. Crop evapotranspiration. FAO, irrigation and drainage paper 56. Rome.
- Dzikiti S, Volschenk T., Midgley SJE., Lötze E., Taylor NJ., Gush MB., Ntshidi Z., Zirebwa SF., Doko Q., Schmeisser M., Jarmain C., Steyn WJ., Pienaar HH. 2018. Estimating the water requirements of high yielding and young apple orchards in the winter rainfall areas of South Africa using a dual source evapotranspiration model. Agricultural Water Management. 208: 152-162.
- Gush MB., Dzikiti S., van der Laan M., Steyn M., Manamathela S., Pienaar HH. 2019. Field quantification of the water footprint of an apple orchard, and extrapolation to watershed scale within a winter rainfall Mediterranean climate zone. Agricultural and Forest Meteorology. 271: 135-147.
- Midgley SJE., Dzikiti S., Volschenk T., Lötze E., Gush MB. 2019. Are water savings in apple orchards under shade netting an additional benefit? SAFRUIT JOURNAL DEC 2018 / JAN 2019
- Volschenk T., De Villiers J.F., Beukes O. 2003. The selection and calibration of a model for irrigation scheduling of deciduous fruit orchards. Water Research Commission, Pretoria, South Africa. Report no WRC 892.

BACK TO TOP

DISEASE RESEARCH

Diagnostics and aquatic emerging fungal diseases

History has shown that pandemics can have major impacts on populations and the environment. The current Covid-19 pandemic is turning the world upside down, and will undoubtedly leave its footprints on all sectors of life to some degree. So writes MR Greeff-Laubscher and C Weldon.



Laser scanning confocal micrograph of amphibian skin (green epidermal tissue) infected with Batrachochytrium dendrobatidis (blue fungal bodies).

The infection pathway and high infection rate of this causative virus affect our social lives, and even our behaviours are impacted and changed. A question we should be asking is if any of these adversities could have been avoided had we been more prepared? Or, even more fundamentally, is it at all possible to be prepared for dealing with the diagnosis of a pandemic?

What are the driving forces behind research in the field of emerging infectious diseases (EIDs) – is it engagement with current known diseases and their related strains, or is it lessons learnt from historic epizootics? In reality, it is incredibly difficult to prepare for EIDs, be it human or animal diseases, especially when the epidemiology and infection rates are not yet understood. This begs the question, how do we develop accurate and reliable diagnostic tools for EIDs if the infectious agent is not yet known? The current Covid-19 pandemic, caused by the infectious virus, SARS-CoV-2, is an example of how this zoonotic coronavirus became pandemic within just a few months. Infectious agents can include a variety of microbial organisms, including bacteria, viruses, fungal and fungal-like organisms.

BACK TO TOP

Over the past two decades, there has been an increase in fungal diseases both in plant and animal (aquatic and semi-aquatic) populations. A record number of fungal and fungal-like diseases have now known to cause mass mortalities and species extinctions. Some examples include ***Batrachochytrium dendrobatidis,*** the causative agent of amphibian chytridiomycosis; ***Aspergillus sydowii***, the causative agent of aspergillosis in marine coral; and ***Aphanomyces invadans*** and ***A. astaci*** causing epizootic ulcerative syndrome in fishes, and crayfish plague respectively.

In the face of unprecedented, rapid declines in global biodiversity, scientists have been investigating how ecosystems with altered biodiversity affect the provision of beneficial ecosystem services. Studies on Lime diseases, for instance, indicated that a greater diversity of hosts lower transmission risks to humans. One can deduct from this finding that a loss of biodiversity would likely result in an increase of infectious disease transmission to humans.

The impact of pandemics can be lowered with quick, reliable and accurate diagnostics. Once infected individuals have been diagnosed, management plans can be put in place to either control or eradicate the infectious agents. While population density and disease susceptibility are some of the major risk factors involved during disease outbreaks, another silent factor is asymptomatic individuals. During the absence of reliable diagnostics, the latter is often underestimated or remains undiagnosed within a population. This is especially true when diagnostic assays are dependent on clinical symptoms (in humans) or visible clinical signs (e.g. in animals).

Although it is referred to as a silent factor, we prefer to refer to it as ***ticking bombs*** because these individuals have the ability to infect other individuals in their environment, apparently unnoticed. If this would happen with a highly infectious disease, an epidemic can occur, resulting in high mortality rates in severely affected populations. To lower the effect of these ***ticking bombs*** on their populations, reliable diagnostic tools are required.

Most diagnostic protocols can be divided into three phases. These are: sampling, sample processing, and sample analysis. The saying "only as strong as the weakest link" is a good way to approach a diagnostic assay. If one of the steps is not reliable, the entire diagnostic assay becomes unreliable.

Validating each step of a diagnostic assay is therefore a prerequisite for achieving reliability. It bridges laboratory work and field application by assessing the application of a specific technique related to the intended use of that technique. The validation step truly reveals if an assay is good enough to perform to the anticipated outcome.

Validation of an assay can be time-consuming and is often neglected during the development of diagnostic (identification from a host) or detection (identification from environment) assays, especially when each step has to be validated. Using an unvalidated diagnostic assay lowers the confidence in the results. Such assays could either lead to the misinterpretation of negative results (false negatives) or an incorrect number of positive individuals (false positives) or sites reported, and therefore lead to inappropriate management of a pandemic.

The causative agent of the next animal pandemic and its impact on aquatic biodiversity is currently unknown to us; however in the midst of a changing climate it has been argued that emerging fungal infections will cause an enhanced abrasion of biodiversity, which spill over to human and ecosystem health. Just like certain bacteria and virus species, fungal and fungal-like organisms can be lethal to naïve species. ***Batrachochytrium dendrobatidis*** is a true panzootic, with a wide host range and the ability to survive outside the host. The global occurrence of this pathogen was facilitated by anthropogenic spread, which resulted in an estimated 90 amphibian species becoming extinct.

The first report of this pathogen on the African continent dates back to the early 1930s. Researchers are now busy using this infectious agent as a model to develop and validate the first two steps of a novel diagnostic assay, which includes field sampling and sample processing, based on environmental DNA technology. The environmental DNA technology will be used in conjunction with a targeted approach at first. This involves detecting DNA of a specific pathogen from water samples which will assist in early detection of future disease outbreaks, specifically in South African waters with its rich biodiversity (e.g. 140 odd amphibian species). In doing so, the first two steps of an assay would only require development and validation of one step, should an outbreak of a fungal or fungal-like species currently unknown to us occur.

In conclusion, the new detection assays that are being developed based on eDNA will hopefully assist not only in understanding the current fungal communities, but also assist in building a robust foundation database of host diversity in aquatic ecosystems. Above all and most importantly, this data will assist in predicting outbreaks and hopefully lower the impact of ***ticking bombs*** among our cherished biodiversity.

Ché Weldon

The Anchieta's ridged frog.

BACK TO TOP

Water KIDZ

Hail – Freaky force of nature

Hailstones come in various sizes.

Hail is one of the most amazing, and destructive, forms of precipitation we have in South Africa.

Hail usually occurs during summer thunderstorms. A hailstone begins as a small water drop or a round snow pellet in a cloud. The drop grows by collecting many cloud drops. The little drop is blown by a strong wind inside the cloud to where it meets with some extremely cold water drops. These supercooled drops are still liquid water even though the temperature is below freezing. When the little drop mixes with these extremely cold drops, they join, and the little drop has now become a hailstone.

The little hailstone is thrown up inside the cloud, still collecting other cold drops. The hailstone gets bigger and bigger until it goes to the top of the cloud. Then, because there is no more wind, it falls back down through the cloud. While it is falling it gets even bigger as it bangs into more supercooled drops. If it goes down very fast it can hit the earth at up to 144 kilometres per hour, bouncing like popcorn. Hail can only form in thunderstorm or Cumulonimbus clouds.

Most hailstones measure between 5 millimetres and 150 millimetres in diameter, but cricket ball-sized hailstones have been reported. Hailstones can be round or jagged. The size of hailstones depends on the strength and size of the updraught. Most of the time hailstones are smaller than 25 mm, which is about the size of a 10c piece. Large hailstones can do serious damage to crops, vehicles and buildings. Even small hail with strong winds can crush a field of wheat flat in a few minutes. It sometimes breaks windows, and can dent cars and roofs. Big hailstones can hurt and even kill small animals.

South Africa is prone to severe thunderstorms. The areas most prone to hail include areas that are adjacent to the Drakensberg mountains and other smaller mountain ranges. The eastern Free State, central and western parts of KwaZulu-Natal, the northern parts of the Eastern Cape, as well as parts of Mpumalanga therefore have the highest occurence of hail. Statistics show that there are, on average, six to eight hail days a year in parts of Lesotho, the eastern Free State, surrounding parts of KwaZulu-Natal, as well as parts of Mpumalanga.

BACK TO TOP

Hail can do severe damage to crops.

But South Africa is not the only country that receives hail. Certain parts of the world receive more hail than others. The approach of the summer monsoon season in India brings severe thunderstorms, often with tornadoes and hail. A particularly deadly hailstorm in Moradabad, India, in 1888, killed more than 250 people. China also experiences frequent hailstorms, as do parts of the Midwestern United States. In fact, the Great Plains region of the United States and Canada is called Hail Alley.

The occurrence of hail is very sporadic. For this reason, it is quite difficult to predict coming hailstorms far ahead of time. However, in the short term, weather tools such as radar and satellite technology can help predict the development and movement of hailstorms for about an hour ahead of time. This can give people enough time to move vehicles and animals to safety.

A hail-covered lawn following a thunderstorm.

Sources

- *https://study.com/academy/lesson/facts-about-hail-lesson-for-kids.html*
- *https://www.learningonlineblog.com/2019/05/09/hail-videos-for-kids/*
- *https://www.nationalgeographic.org/encyclopedia/hail/*
- *https://www.nationalgeographic.org/encyclopedia/hail/*
- *https://www.santam.co.za/about-us/media/agriculture/the-occurence-of-hail-and-hail-damage-in-south-africa/*

Water words

Cumulonimbus clouds: A type of cloud associated with thunderstorms and heavy precipitation

Precipitation: Any kind of water that comes down from the clouds

Updraught: Upward movement of air

A hailstone begins as a small water drop or a round snow pellet in a cloud, but can collect many layers before it falls to the ground.

BACK TO TOP

PONGOLAPOORT DAM – THE CONCRETE GIANT OF NORTHERN KWAZULU-NATAL

Located in northern KwaZulu-Natal close to the town of Jozini, Pongolapoort Dam is one of the largest dams in South Africa. Construction of this dam, commonly referred to as Lake Jozini, started in 1963. Until work started on the Gariep Dam in 1966, Pongolapoort was the largest dam under construction in South Africa. It is a medium thin, double curvature arch dam with a gradual transition towards a gravity thrust block on the left flank. It has a maximum height of 89 m and a crest length of 515 m.

The dam has a controlled and an uncontrolled spillway. The gross capacity of the reservoir is 2 500 million m^3, which is more than twice the mean annual runoff. The chute spillways have a combined capacity of 2 010 m^3 at high flood level. The thickness of the wall above the cushion is 18,3 m tapering to 8,2 m at the spillway and then flowing to 11 m to carry a double carriageway across it.

Work on the dam was on a 24-hour basis, requiring up to 764 m^3 of concrete a day. The aggregate came from a site 20 km upstream, some two million tons had been stockpiled at the start of the project. The high average air temperatures on the site provide a significant construction challenge. This was overcome by pre-cooling the aggregate with controlled amounts of crushed ice. Pongolapoort Dam was the first dam in South Africa where this artificial cooling method was used. Some 563 000 m^3 of concrete and rock went into the dam wall. Each vertical section is independent of the other. The gravity sections on the flanks induced blasting of some 500 000 t of rock. The dam was eventually completed in 1973.

BACK TO TOP

DEEPLY ROOTED IN SOUTH AFRICA WATER SOCIETY

www.wrc.org.za

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

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

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

FOLLOW US ON

WATER RESEARCH COMMISSION

THE POWER OF KNOWLEDGE TO THE PEOPLE