



1st Water-Gender-Social Vulnerability Symposium

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2-3 July 2026

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PROGRAMME

Provisional symposium programme			
Day 1	2 July 2026		
07:30-08:30	Registration		
08:30-08:45	Official opening Welcoming statement: Prof Ngubeni		
08:45-09:45	Plenary Keynote Address: Prof Grey Magaiza- UFS Centre for Gender and Africa Studies		
	<i>Special session: Water and Gender Inequality</i> Chair(s): Kefiloe and Sithembiso		
	<i>Presenter</i>	<i>Title</i>	<i>Abstr</i>
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10:00	Ngubane Nonhle	The Role of Women in Addressing Water Scarcity in the Rural Qwaqwa: Vulnerabilities, Resilience and Community-Based Solutions	4
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10:45	Mokoena Dineo & Dubazane Mhlengeni	Exploring the perspectives of young people on poor water supply in rural communities through participatory approach: a case study of Qwaqwa, Phuthaditjhaba	5
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	Presenter	Title	Abstr
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	Special session: Health and Sanitation		
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	Presenter	Title	Abstr
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KEYNOTE PRESENTATION

Thursday 2 July 2026

Liquid Inequality and Contestations of Thirst: Water Poverty, Human Security and the Spatialities of Civic Unrest.

Prof Grey Magaiza

This address advances the concept of liquid inequality to explain how water insecurity in the Global South is produced and sustained through historically embedded structures of power, uneven development, and socio-spatial exclusion. Moving beyond conventional explanations that attribute water crises to scarcity, climate variability, population growth, or governance inefficiencies, the presentation argues that water poverty is fundamentally a manifestation of development injustice. Liquid inequality is a nascent concept which refers to the unequal distribution of water resources, infrastructure, services, and water-related opportunities, reflecting broader inequalities in citizenship, recognition, and access to development. As such, water is not merely a resource under pressure but a political terrain through which power, privilege, and exclusion are negotiated and contested.

Drawing on an integrative interdisciplinary theoretical continuum rooted in Political Ecology, Water Justice, Spatial Justice, and Human Security perspectives, I examine how colonial legacies, neoliberal governance reforms, infrastructure violence, and climate vulnerabilities converge to produce differentiated experiences of thirst across the Global South. While some communities enjoy secure and reliable access to water, others, like Qwaqwa, remain trapped in conditions of chronic deprivation despite being located in resource-rich water tower spatialities. This paradox reveals that water insecurity is less a crisis of hydrology than a crisis of political economy, infrastructure violence and uneven development. The consequences extend beyond access to water itself, undermining multiple human development indicators, including gender equality, livelihoods, food security, public health, social reproduction, and human dignity. Against this backdrop, the presentation reconceptualises civic unrest not as a breakdown of order but as a form of political agency through which marginalised populations challenge liquid inequality and assert claims to justice, citizenship, and development. Contestations of thirst are therefore interpreted as struggles over recognition, belonging, and the right to equitable futures. By foregrounding liquid inequality as both a condition and consequence of structural exclusion, the presentation calls for a transformative shift from technocratic water management towards development pathways grounded in redistribution, participation, human security, and water justice. In doing so, it positions water as a critical lens through which to interrogate contemporary inequalities and contested development trajectories in the Global South.

Keywords: Liquid Inequality, Unrest spatialities, Human Security and water poverty.



Prof Grey Magaiza is the Deputy Director of the Centre for Gender and Africa Studies (CGAS). His research focuses on rural livelihoods, poverty and inequality, social entrepreneurship, governance, and sustainability, particularly within Southern African contexts. Prof Magaiza adopts an interdisciplinary approach, combining sociology, development studies, and policy analysis. He has produced over 30 scholarly publications, addressing issues such as informal economies, youth development, and community resilience. A central theme in his work is community empowerment, advocating for participatory, locally driven development. His academic philosophy emphasises strong partnerships between universities and communities to generate practical, inclusive solutions to development challenges.

Session 1-Water and Gender Inequality

Akukhiwa Amanzi Ntambama: Water Insecurity, Intersectionality, and the Constitutional Burden of Black Women and Girls in South Africa.

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Water insecurity in post-apartheid South Africa is not a neutral development failure — it has a face, and that face is Black and female. Despite the constitutional promise of access to water enshrined in Section 27, the lived reality of millions of Black women and girls in rural and peri-urban communities tells a starkly different story. This paper examines water insecurity not merely as a service delivery shortcoming but as a compounded constitutional violation, one whose weight is distributed along deeply unequal lines of race, gender, class, and geography. Using Kimberlé Crenshaw's intersectionality framework as its theoretical anchor, the paper demonstrates that Sections 9, 10, and 27 of the Constitution are not violated in isolation but simultaneously and structurally, in ways that existing legal frameworks have yet to adequately name or redress. At the heart of this violation lies a system of deeply entrenched gender stereotypes that assign water collection exclusively to women and girls, presenting subjugation as culture and duty as nature. This assignment is so normalised that it escapes legal scrutiny, yet it constitutes a daily erosion of the rights to equality and dignity. For the Black girl child, the consequences are particularly far-reaching. She wakes before school to fetch water. She misses class when the source is far. Her development, her education, and her future are quietly circumscribed by a burden that the law does not see and the state does not count. What apartheid-era spatial planning began — by deliberately locating Black communities far from adequate infrastructure — the post-apartheid state has not sufficiently corrected, making water insecurity a continuation of racialised injustice as much as it is a gendered one. Yet the burden carried by Black girls extends beyond time and physical labour. Across generations, Black mothers have warned their daughters: *akukhiwa amanzi ntambama*, *akudlulwa emobeni ntambama* — water is not fetched in the evening, one does not pass by the river at dusk. This unwritten rule, alive in households across rural South Africa, is not cultural colour or poetic caution. It is a survival code, passed down in direct response to the rape and murder of girls at water points after dark. That Black girls must negotiate their constitutional right to water around the threat of gender-based violence reveals precisely where the state's failure to deliver safe infrastructure and its failure to protect women and girls collapse into a single, compounded harm — one that simultaneously violates Sections 12, 27, and 10 of the Constitution. This paper argues that speaking honestly about water insecurity demands a feminist constitutional jurisprudence, one that moves beyond the abstract standard of progressive realisation to confront the racialised, gendered, and classed reality of who suffers most when the state fails. Redress cannot be limited to pipes and taps. It must reckon with stereotypes, with danger, and with the dignity of girls whose right to water has never been truly free. In doing so, this paper seeks to bring legal scholarship into direct conversation with lived realities, answering the symposium's call to make research speak to the communities it concerns most.

Keywords: *water insecurity, intersectionality, constitutional rights, Black women, girl child, gender-based violence, dignity, feminist jurisprudence, Section 27, rural South Africa*

Water Scarcity as a Gendered Crisis: Reinforcing Inequality and Social Vulnerability in rural Lesotho

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Environmental degradation and climate-induced resource scarcity are inherently gendered phenomena that disproportionately worsen the socio-economic vulnerabilities of marginalised women in developing rural economies. While Lesotho operates as a major regional water exporter transferring billions of litres annually to South Africa, severe domestic infrastructure gaps and recurring El Niño shocks transform localised water shortages into a profound gender crisis. This paper utilises a Feminist Political Ecology (FPE) to examine how chronic water scarcity reinforces structural inequality within the drought-prone Mafeteng district. Employing a mixed-methods research approach, this study analyses primary data collected across six rural villages using a combination of interviews, focus group discussions, and questionnaires. The empirical findings reveal that acute depletion of local water tables forces female residents to absorb severe time poverty averaging up to four hours daily in water procurement, which systematically undermines female educational attainment and disrupts home-based micro-enterprises. Furthermore, the study highlights critical physical risks, showing how long distances and heavy water containers cause severe back pain, body injuries, and extreme physical exhaustion, while trips to unprotected wells increase exposure to gender-based violence (GBV). Ultimately, this paper critiques the historical exclusion of women from local hydro-governance and argues that addressing Lesotho's climate vulnerabilities requires a structural shift from passive community participation to gender-responsive water infrastructure and policy management.

Keywords: water scarcity, gender inequality, climate stress, social vulnerability, Feminist Political Ecology, Mafeteng District, Lesotho.

Exploring The Challenges of Water Scarcity and Its Impact on Women in Rural Communities in Qwaqwa.

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Water scarcity in South Africa is an escalating phenomenon that presents challenges in rural communities. This issue has also been experienced by the community of Qwaqwa, Phuthaditjhaba (Free State). These communities rely heavily on water resources to sustain their livelihood. The study aims to explore the challenges of water scarcity and its impact on women in Qwaqwa. Water scarcity contributes to socio-economic issues, gender roles in water collection. This study examines the gender roles, highlight the power dynamics and identify the causes of water scarcity. In understanding the impact of water scarcity, the literature conducted, allowed for a further understanding of the experiences women have on the issue of water scarcity. The Feminist Political Ecology theory was employed for this study because it shows how women in Qwaqwa are affected by water scarcity due to lack of resources, and the socio-cultural norm exerted on them. This study shows that women face limited opportunities to participate in the economy, face inequalities by exclusion in decision making processes, are often expected to travel long distances to fetch water, and heavy burden is placed on them as they are expected to do a lot of work. This study recommends investment in water infrastructure that is easily accessible to relieve the burden placed on women, secondly the establishment of water management strategies that will allow for management and maintenance of water infrastructure to ensure sustainable access to safe and reliable water, it further promote the implementation of gender policies for the inclusion of women in the economy and decision making processes, ensuring their participation is fully recognized and there is social justice, no gender inequality.

Keywords: water scarcity, rural communities, gender inequality, women, water management.

The Role of Women in Addressing Water Scarcity in the Rural Qwaqwa: Vulnerabilities, Resilience and Community-Based Solutions

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This study explores the role of women in addressing water scarcity in Qwaqwa, a region in South Africa, Free State province that has long struggled with access to water because of poor infrastructure, poor governance and climate change. Despite women playing a crucial role in household water management, their voices are often unheard and excluded from water governance decision-making processes. The study explores how women's experiences, coping mechanisms and contributions to community-based water solutions are influenced by social and cultural norms. Using a qualitative approach grounded in ecofeminist theory, the study focuses on the lived experiences of women in Qwaqwa. Fifteen women from different socio-economic backgrounds were selected using purposive sampling. Semi-structured interviews, non-participants observations and focus group discussions were used to collect data, which will be analysed using thematic analysis. The findings will offer a gendered perspective on water scarcity, illuminating the ways how women deal with day-to-day water challenges and the strategies they use to help their families and communities. This study intends to contribute to gender-dimensions and inclusive water governance practices. It also contributes to the literature on ecofeminism and sustainable development, particularly in South Africa's under-explored rural communities.

Key words: Water Scarcity, Ecofeminism, Community based-water management, Women Roles.

Exploring the perspectives of young people on poor water supply in rural communities through participatory approach: a case study of QwaQwa, Phuthaditjhaba.

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Access to clean water is recognised as a fundamental human right. However, many rural communities in South Africa continue to face persistent challenges in securing reliable water supply. This study examined how young people aged 18 to 35 years in Phuthaditjhaba (Qwaqwa) employ participatory approaches to address the challenges posed by water scarcity. Anchored in a qualitative research approach, the study collected data through semi-structured interviews and focus group discussions. The findings reveal that young people are acutely aware of the inadequate water supply in their community. The study further established that water scarcity significantly undermines education, local businesses, and public health, thereby disrupting the daily lives and priorities of community members. The study recommends that the local municipality improve communication with residents regarding water shortages and service delivery. It further emphasises the urgent need for programmes that empower young people with knowledge and skills in water conservation. Additionally, the study advocates for meaningful collaboration between youth and local municipality officials to develop sustainable, context-specific solutions to the water crisis in Qwaqwa.

Keywords: water scarcity, youth participation, participatory approaches, service delivery, Qwaqwa, Phuthaditjhaba

Resilience in Scarcity: Women's Adaptive Strategies in Water-Insecure Umlazi

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Water scarcity in Umlazi has become a persistent and critical challenge, driven by infrastructure failure, vandalism, and the municipality's inability to meet growing community demand. This shortage has far-reaching implications for sanitation, health, and overall community wellbeing. While water insecurity affects all residents, its burden is disproportionately borne by women, who are socially and culturally positioned as primary caregivers and household managers. These gendered expectations require women to ensure food preparation, hygiene, and domestic stability, even under conditions of limited or no water access. In response, women often undertake physically and socially risky efforts to secure water, exposing themselves to health hazards, safety concerns, and economic strain. These conditions perpetuate cycles of poverty, physical and emotional exhaustion, and declining wellbeing. Despite these challenges, women in Umlazi demonstrate agency by developing adaptive strategies to navigate periods of water scarcity. However, such strategies are frequently overlooked in existing literature, which tends to prioritise technical and infrastructural analyses over gendered experiences. This study adopts a qualitative approach to examine water scarcity as a driver of gender inequality in Umlazi, with a specific focus on the coping and management strategies employed by women. Data are generated through a systematic review and analysed thematically. Preliminary findings indicate that women utilise rainwater harvesting, community-based communication platforms such as WhatsApp groups, and hydro social timekeeping practices to manage water access. Additionally, indigenous and low-cost purification methods, such as the use of moringa seeds, are employed to improve water quality. By foregrounding women's lived experiences and adaptive practices, this study contributes to a more nuanced understanding of water insecurity and highlights the need for gender-responsive approaches in policy and community development interventions.

Keywords: Water scarcity, water insecurity, indigenous knowledge, community development, lived experiences, gender inequality.

Women's adaptation strategies to climate-induced water, sanitation, and hygiene (WASH) challenges in Nompumelelo peri-urban community, Eastern Cape, South Africa

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Climate change is increasingly exacerbating water insecurity and intensifying water, sanitation, and hygiene (WASH) challenges in vulnerable communities across South Africa. Peri-urban settlements are particularly affected due to a combination of rapid population growth, inadequate infrastructure, poor service delivery, and socio-economic inequalities. Informal settlements are among the most vulnerable environments because they often experience limited access to reliable water supply, inadequate sanitation facilities, insecure housing, and weak service delivery systems. Nompumelelo, a peri-urban informal settlement in the Eastern Cape Province, exemplifies these challenges and therefore provides an important context for examining the intersection of climate change and WASH vulnerability. In this community, climate-related stressors, particularly droughts and erratic rainfall patterns, place additional pressure on already strained WASH systems. Women are disproportionately affected by these challenges because they are primarily responsible for household water collection, sanitation management, caregiving, and maintaining household hygiene. Despite growing research on climate change and WASH, limited attention has been given to understanding the adaptation strategies women employ to cope with climate-induced WASH challenges in informal peri-urban settlements. The study seeks to investigate the range of adaptation strategies employed by women, examine factors influencing their adaptation decisions, and explore the effectiveness and limitations of these strategies in the informal peri-urban Nompumelelo community, enhancing household resilience. A mixed-methods case study design will be employed to generate both quantitative and qualitative data. Quantitative data will be collected through structured household surveys and analyzed using descriptive and inferential statistical techniques, while qualitative data gathered through key informant interviews and focus group discussions will be analyzed using thematic analysis. The study is anticipated to contribute to the growing body of knowledge on gender, climate change adaptation, and WASH governance by providing context-specific evidence from a peri-urban informal settlement in South Africa. Furthermore, the findings are expected to inform the development of gender-responsive climate adaptation policies, inclusive water governance frameworks, and community-based interventions to strengthen resilience and improve WASH service delivery for vulnerable populations.

Keywords: Climate change adaptation, women, water insecurity, WASH, peri-urban communities, informal settlements, resilience, Eastern Cape.

Session 2-Water and Social Unrest

Spring Water Usage: Community Perceptions, Practices and Knowledge in Rural Communities of Qwaqwa, Eastern Free State, South Africa

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Springwater is a source of drinking water for many rural communities in South Africa, particularly in areas affected by water scarcity and inadequate municipal water infrastructure. However, concerns regarding Springwater quality, environmental sustainability, and consumption of polluted water have become increasingly important public health issues. This study investigated community perceptions, knowledge and access to spring water, conservation practices, and potential environmental health risks associated with spring water use in Leratong and Tseki rural communities in Qwaqwa, Eastern Free State. A mixed-methods approach was employed, using structured questionnaires administered to 43 participants from the Tseki and Monontsha communities. The findings revealed that most respondents relied on spring water sources, springs, for domestic use due to an unreliable water supply. Although the majority of participants perceived spring water as safe for human consumption, some respondents reported experiencing water-related illnesses such as diarrhoea and stomach aches. Water conservation practices included rainwater harvesting, water reuse, and boiling water before consumption, while cultural beliefs and traditional practices also influenced spring water management and conservation behaviours. Water scarcity, inadequate infrastructure, insufficient environmental awareness programmes, and limited institutional support were identified as key challenges affecting sustainable spring water use. Community members expressed a strong need for educational campaigns, improved infrastructure, and enhanced support to ensure safe and sustainable access to water. The findings contribute to the growing body of knowledge on spring water governance, environmental sustainability, and public health in rural South African communities and emphasise the need for integrated water management strategies that integrate local community perspectives and support from different institutions.

Keywords: Spring water, Rural communities, knowledge, practices, perceptions

Lived experience of nurses working in healthcare clinics that are experiencing water scarcity, in Maluti-A-Phofung district, Free State Province, South Africa

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Nursing has faced numerous challenges, but water scarcity was not one of them. Water scarcity has become a global public health issue. Water shortages in South Africa negatively impact nursing and patient care. Additionally, nurses are experiencing the effects of it firsthand. This study aimed to explore and describe the lived experiences of nurses working in healthcare facilities that are experiencing water scarcity in the Maluti-A-Phofung municipality, Free State Province. Participatory Action Research (PAR) was employed, including 14 nurses from ten clinics. Nurses were selected from clinics in Maluti-A-Phofung District Municipality, Free State, South Africa, using purposive sampling. All nurses had in-depth face-to-face interviews conducted. After transcribing and inductively analysing audio recordings, four themes emerged. Themes emerged: 1) Compromised hygiene practices, 2) Disease outbreaks, 3) Patient denied access to care, 4) Compromised nurses and patient's safety and dignity. This study found that nurses in clinics with water scarcity are confronted with hygiene challenges, infringements of human rights, and psychological distress due to a lack of managerial support and municipality services. This study also suggests more research on the development of strategies to inform infection prevention and control policy for nurses in water-scarce healthcare facilities to improve patient care and hygiene practices in the facilities experiencing water-scarcity.

Keywords: nurses, lived experience, clinic, water scarcity.

Daily Resilience of Qwaqwa Residents and Concealed Adversities Amid the Water Crisis

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Qwaqwa residents have experienced water shortages for decades due to several factors, including ecological issues, but mainly exacerbated by municipal maladministration, corruption, and poor service delivery. Over the years, the water crisis has remained an ongoing social issue in predominantly rural areas of South Africa, such as Qwaqwa. Qwaqwa has been experiencing a persistent water crisis, forcing residents to adapt and adopt various strategies to remain resilient. However, being resilient to the water crisis means being prepared to face other recurring adversities associated with it. Understanding the water crisis in Qwaqwa highlights the importance of resilience. The concept of resilience is common across various fields; however, it remains underexplored in understanding the water crisis, particularly in the context of rural Qwaqwa. This study is guided by the theoretical foundations of resilience, which is understood as the ability to withstand shocks and recover, depending on residents' capacity to adapt to the water crisis. Qualitative research was adopted to examine how Qwaqwa residents practice resilience amid the water crisis. This research involved semi-structured interviews and observations with 13 participants from five villages in Qwaqwa, recruited through purposive sampling. The key findings reveal that, for Qwaqwa residents, resilience to the water crisis is a necessity, not just something to be implemented during an emergency. Being resilient to the water crisis means being prepared to withstand other adversities that arise from adapting to it. This includes relying on private solutions, such as purchasing water, due to the lack of reliable government and municipal interventions, thereby increasing their household financial burden. This means that resilience to the water crisis does not eliminate household vulnerabilities; it perpetuates them. The contribution of this research is that it has linked the adaptation strategies that Qwaqwa residents relied on to the concept of resilience. It also goes beyond understanding that resilience to the water crisis does not only reflect the capacity to withstand and survive the crisis, but also to unlock other hidden adversities by strategically adapting to it.

Keywords: Resilience, Water Crisis, Residents, Adaptation, Adversity, Qwaqwa

Reimagining social service responses to disaster-induced housing loss: harnessing *ubudlelane*

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Disasters, including heavy rainfall and flooding, frequently result in devastating consequences for disadvantaged communities, particularly through the loss of housing as a critical form of shelter. Notably, the role of social services professionals in disaster response often remains largely unrecognised; however, it is fundamentally central to addressing the challenges faced by victims, grounded in the professions' foundational pillars of support, empowerment, and resilience-building. This conceptual paper examines how social service professionals could apply the philosophy of *ubudlelane* to enhance responses and interventions during disaster crises. In the aftermath of disasters, *ubudlelane* has the potential to situate social service interventions within human-centred responses that bolster disaster preparedness by reinforcing existing community networks and enhancing local capacities to confront future crises. The paper contextualises this perspective through the *Ubudlelane*-disaster response framework, which enables social services not only to address immediate material and emotional needs but also to cultivate long-term social cohesion and sustainable recovery. Furthermore, the paper highlights practical strategies to co-develop culturally responsive disaster interventions. Ultimately, the application of the *ubudlelane* philosophy in disaster social services professionals contributes to Afrocentric, context-specific, and community-driven approaches that empower disadvantaged communities to rebuild not only their homes but also the social fabric essential for resilience and well-being.

Key words: *Ubudlelane*, disasters, social services, housing loss, community practice, community resilience, collective recovery, vulnerability

Exploring the perceptions of youth on water, poverty and social unrest: The case study of Tseki Township in Maluti-a-Phofung

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Democratic South Africa continues to experience violent service delivery protests concentrated in poor communities, where service delivery failures are more pronounced. Access to basic services such as clean water remains a persistent challenge, in townships where poverty, and unemployment continue to undermine livelihoods. This paper explores young people's perceptions of violent service delivery protests in Tseki Township. The study was conducted in the hinterlands of Maluti-a-Phofung within the Thabo Mofutsanyane District in the Free State Province. Rooted in the interpretivist paradigm, this study employed a qualitative research design. Participants were drawn from youth, aged between 18-35 years. The findings of the study reveal that, perceived municipal unresponsiveness, failure to deliver basic services, and poverty drove people to violent protests. Addressing the persistent violent service delivery protests in Tseki Township requires improved governance, community participation, and equitable resource allocation. Improving access to reliable water may potentially help reduce social unrests as violent protests are perceived as a mechanism by participants that often enables young people to draw attention of municipal authorities and communicate service delivery grievances.

Keywords: Maluti-a-Phofung, Poverty, Social unrest, Violent service delivery protests, Water insecurity, Youth perceptions

Climate Change and Water insecurity: concerns for global and national unrest

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Climate change has emerged as one of the most pressing environmental and developmental challenges of the 21st century, especially due to its impact on water resources. Water is a key adaptation challenge to climate change. And as such, the notion of water security has metamorphosed into water insecurity due to water scarcity. Climate change is increasingly recognized as a major driver of water insecurity, posing significant challenges to social stability, economic development, and national security worldwide. Such concerns emanate not only from humanitarian risks that affect governments. However, environmental issues also embody political and security risks that are of great concern to government's stability. It is therefore important to pay attention to the relationship between environmental issues and security concerns, including the well-being of people. Climate change poses a significant threat to security by worsening existing vulnerabilities, potentially leading to increased competition over scarce resources thus causing social unrest, conflict and mass migrations, particularly in already fragile regions or states due its impact on food security. While climate change doesn't directly cause tensions, it can act as a threat multiplier, exacerbating existing vulnerabilities and tensions, making them more likely to erupt into conflict. Rising global temperatures are altering precipitation patterns, intensifying droughts and floods, accelerating glacier melt, and increasing the frequency of extreme weather events. These changes disrupt the availability, quality, and reliability of freshwater resources, particularly in regions already experiencing water stress. As demand for water continues to grow due to population expansion, urbanization, and agricultural intensification, climate-induced pressures are widening the gap between water supply and demand. Current trends indicate that water scarcity is affecting billions of people, with vulnerable populations in developing countries facing disproportionate impacts. Reduced access to safe water threatens food security, public health, energy production, and livelihoods, increasing the risk of poverty and displacement. Water insecurity can also exacerbate existing social, political, and economic tensions, contributing to local conflicts and, in some cases, transboundary disputes over shared water resources. Climate change can have national and broader geopolitical implications. At the national level, inadequate water governance, aging infrastructure, and unequal distribution of resources further intensify vulnerability to climate-related shocks. Globally, concerns are growing that persistent water stress may fuel migration, undermine state capacity, and heighten the potential for unrest in fragile regions. Addressing these challenges requires integrated water resource management, climate adaptation strategies, investment in resilient infrastructure, and strengthened international cooperation. Sustainable policies that promote equitable access to water and enhance adaptive capacity are essential for reducing the risks of conflict and ensuring long-term environmental and societal stability. Climate change and water insecurity therefore represent interconnected challenges with profound implications for global and national peace and security.

Keywords: climate change. Water scarcity. Food insecurity. Social unrest.

KEYNOTE PRESENTATION

Friday 3 July 2026

From Water Scarcity to Health Security: Harnessing Genomics and Wastewater Surveillance for a Resilient Future

Prof Martin M. Nyaga

Water scarcity is increasingly recognized not only as an environmental and socioeconomic challenge but also as a critical determinant of human health. Climate change, population growth, urbanization, and increasing pressure on water resources are altering the relationship between water availability, sanitation, and infectious disease transmission. As communities experience reduced access to safe water and compromised sanitation systems, the risk of exposure to waterborne pathogens, emerging infectious diseases, and antimicrobial resistance (AMR) continues to rise. Addressing these interconnected challenges requires innovative approaches that integrate environmental monitoring, genomic technologies, and public health intelligence. In this keynote, we will explore how genomic technologies and wastewater-based epidemiology are transforming disease surveillance by enabling early detection, monitoring, and characterization of pathogens circulating within communities. Through advances in next-generation sequencing, metagenomics, and bioinformatics, wastewater can be used as a powerful source of population-level health intelligence, providing insights into gastroenteric viruses, emerging pathogens, and AMR trends before they translate into large-scale outbreaks. Drawing from experiences in infectious disease genomics, enteric virus surveillance, One Health research, and genomic capacity development, this talk will highlight the importance of integrating environmental, human, and animal health data to build resilient public health systems. The role of genomic surveillance infrastructure, including initiatives at the University of the Free State Next Generation Sequencing Unit, will be discussed as a foundation for strengthening regional preparedness and innovation. Ultimately, every water system carries a biological story. The ability to decode these signals through genomics offers an unprecedented opportunity to strengthen water security, improve sanitation strategies, and safeguard health in the face of climate change and emerging infectious disease threats.



Prof Martin Munene Nyaga is a full Professor and the Head of the University of the Free State-Next Generation Sequencing (UFS-NGS) Unit. His research interests utilise genomics surveillance on Vaccine Preventable Diseases (VPD), particularly pre- and post-vaccination of enteric and respiratory viruses' surveillance at whole genome level with the aim of providing technical guidance and support to develop a continental VPD road map and implementation strategy for enhancing priority genomics surveillance in Africa. He is the team lead for studies on metagenomics of gut and respiratory virome in the UFS-NGS Unit to establish the role played by the gut and respiratory virome in young children over time to effect normal and metabolic disorders that may influence a child's healthy growth or impact medical conditions such as obesity. Prof Nyaga is a NRF B-rated researcher. He has disseminated over 150 peer-reviewed articles in international journals and scientific conferences and supervised over 40 postgraduate students.

Session 1- Health and Sanitation

Effects of Elevated Temperatures on Pyrethroid Efficacy, Cytochrome P450 Activity and kdr Resistance in *Culex* Mosquito Larvae

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Many rural and peri-urban communities in Thabo Mofutsanyane District face water related challenges such as unreliable and scarce water supply. The unavailability of water promotes unhygienic water storage practices and the formation of standing water bodies. Standing water bodies create favourable breeding habitats for mosquitoes and increases the risk of vector-borne diseases such as malaria, dengue fever and zika virus. Climate change accelerates these challenges through rising temperatures and altered rainfall patterns. Mosquito population dynamics and vector interventions are negatively impacted. Pyrethroids are the cornerstone of mosquito population control. Their efficacy is seemingly declining due to the development of insecticide resistance. This study aims to look into the relationship between elevated temperatures, pyrethroid efficacy, cytochrome P450 and kdr resistance in *Culex* mosquito larvae. Second to fourth instar larvae collected from standing water bodies in Harrismith will be exposed to deltamethrin and alpha-cypermethrin under three temperature conditions (18°C, 23°C and 28°C). Insecticide susceptibility will be assessed using mortality assays and LC₅₀ values. Cytochrome P450 activity will be quantified using spectrophotometer while DNA extraction and PCR will be used to detect kdr mutations associated with pyrethroids resistance. The findings of this study will contribute towards developing improved vector control strategies. Moreover, public health interventions will have a greater understanding of how to protect vulnerable communities facing water related health challenges.

Keywords – *Culex* mosquitoes, Climate change, Cytochrome P450, Insecticide resistance, Kdr mutations

Assessment of water quality and associated human health risks in major rivers of the Namahadi catchment

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Aquatic pollution is a global concern affecting aquatic environments and human health. However, little attention has been given to headwaters, particularly in the Qwaqwa region. This study assessed the water quality status and health risk associated with river water use in the Namahadi catchment. Water samples were collected seasonally upstream and midstream at Mphukojwane, Namahadi, Metsi-Matsho Rivers, and downstream at Elands River. Physicochemical parameters (pH, total dissolved solids, and electrical conductivity) were measured *in situ* using a Bante900P portable multimeter, and chemical analysis for As, Cu, Al, Ca, Fe, Mn, Mg, Sr, and Zn was performed using Inductively Coupled Plasma–Optical Emission Spectroscopy. Fe and Al were consistently above the World Health Organisation’s prescribed thresholds. Human health risk assessment revealed that the Average Daily Dose (ADD) for Cu was frequently above the respective dermal Reference Dose (RfD). For the ingestion route, ADD estimates for Mn, Cu and Sr exceeded the RfD. Hazard Quotient values for Cu were consistently above the limit, while Mn and Sr were occasionally above the threshold (HQ >1), highlighting the possibility of cancer and non-cancer risks for people depending on these rivers for water. Water quality index values indicated that overall water quality in the catchment is poor (WQI > 100), whereas all upstream sites maintained excellent water quality status (WQI < 50). River pollution in the study area arises from wastewater discharges, land-use activities, and anthropogenic sources. River water from mid- to downstream must be properly treated before being used for domestic and agricultural purposes.

Keywords: Carcinogenic and non-carcinogenic risk, Water pollution, Potentially toxic elements, River water, Seasonal variations

Environmental impact and risk assessment of pristine vs aged, engineered nanomaterials (ENMs) from commercial cosmetic UV-filters: towards better innovation and implementation of safe and sustainable by design (SSbD) of ENMs

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Engineered nanomaterials (ENMs) are widely used in various fields of nanotechnology, including cosmetics and personal care products. Market demand increases the use of these ENMs, making them more available to the environment as they are likely to be released throughout their life cycle. This has resulted in nanotechnology being one of the anthropogenic sources of emerging water pollutants. However, little is known concerning their ageing, behaviour, and ecotoxicological effects in aquatic ecosystems. Therefore, this study aimed to quantify and characterise pristine vs aged nTiO₂ treated with SiO₂ and then experimentally assess their toxicity in three freshwater organisms: *Raphidocelis subcapitata*, *Daphnia magna*, *Spirodela punctata*. TEM-EDX analysis showed no altered physicochemical properties of nTiO₂, including particle size and morphology, confirmed by the manufacturer (Merck Eusolex®). The concentrations of nTiO₂ samples (0.2, 1, & 5%) and Si-coating ions were confirmed using ICP-OES analysis. For *Daphnia* immobilisation and plant growth rates, the effects were concentration-dependent for both nTiO₂ and Si-ions. In most cases, aged ENMs exhibited higher toxicity than pristine ENMs, and material coating ions were the least toxic for daphnids. Variation in microalgal growth rate was observed, with effective concentrations either inhibiting or stimulating growth above acceptable levels (>20%). It can be concluded that preparing nTiO₂ samples at a lower percentage can help reduce environmental hazard effects, while considering the intended application. Ageing the materials is crucial to get a sense of what is happening in the real world because ENMs undergo ageing in the natural environment, and what is available in the environment are residues of materials after ageing processes.

Keywords: Material ageing, Nanoparticles, quantitative characterisation, multispecies toxicology

Understanding water quality and microbial risks in unmonitored water bodies around Qwaqwa

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Many rural communities are faced with unreliable water supply. Forcing residents to rely on unmonitored water bodies for domestic use. These water bodies may contain waterborne pathogens, including enteric parasites and bacteria associated with gastrointestinal infections. In 2024, a study was conducted to investigate the presence of the enteric parasites, *Cryptosporidium* and *Giardia*, in selected water bodies in Qwaqwa. Sixteen water samples were collected from four sites and analysed for physicochemical parameters (temperature, turbidity, salinity, and pH) and the molecular presence of the target parasites using polymerase chain reaction (PCR). Turbidity levels exceeded recommended freshwater guidelines at all sites (80–160 NTU), while temperature, salinity, and pH remained within acceptable ranges. Despite environmental conditions that may support parasite survival, neither *Cryptosporidium* nor *Giardia* DNA was detected in any of the samples. However, enteric bacteria were detected in the same water sources from a parallel study, suggesting faecal contamination and indicating that the absence of these parasites does not necessarily imply microbiologically safe water. Building on these findings, the current study expands the scope of investigation by assessing a broader range of enteric pathogens in an increased number of water bodies across Qwaqwa. Water samples will be analysed for physicochemical parameters, metal content, coliform abundance, and selected enteric bacterial and parasitic pathogens. Molecular techniques will be used to determine pathogen occurrence and distribution, contributing to a more comprehensive understanding of microbial water quality and associated health risks in the region.

Keywords: *Cryptosporidium*, enteric pathogens, *Giardia*, physicochemical parameters, Qwaqwa, water quality.

Water and Sanitation Policy: A Retrospective Analysis of Effectiveness, Barriers, and Reform Needs

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This study evaluates the effectiveness of water and sanitation policies in addressing the critical challenges of water access and sanitation. Using a mixed -methods approach, including qualitative interviews and quantitative analysis of the national datasets, the research aims to identify the policy's strengths and weaknesses, assess implementation barriers, and recommend improvements. The focus of the research will be centered around Lesotho and related water&sanitation policies, especially the 2007 Lesotho Water and Sanitation Policy (LWSP), as a case study in an attempt to provide sustainable lessons for the Thabo Mofutsanyane District Municipality. The research highlights the critical need for cooperative policy frameworks to water and sanitation issues for 'human security'. The findings reveal significant disparities in access to clean water and sanitation between the urban and rural areas, with only approximately 40% of rural residents enjoying reliable water services. Additionally, climate change and inadequate infrastructure maintenance emerged as critical obstacles to achieving policy goals. Eventually, the research concludes that despite progress, urgent reforms are necessary to enhance stakeholder engagement and resource allocation, aligning the LWSP more effectively with the Sustainable Development Goals (SDG 6). The comprehensive policy analysis underscores the need for collaborative strategies and adaptive governance to ensure equitable water access.

Keywords: Water and sanitation, Policy framework, Water and Sanitation Policy, Retrospective Analysis, Climate Change.

Diversity and habitat preferences of freshwater snails in Qwaqwa and their associated helminth infections

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Helminth infections transmitted by snail hosts have a significant impact on both human and animal health. Qwaqwa, a region situated in the eastern Free State province of South Africa, is understudied in this context. A foundational study identified six genera of nematodes infecting livestock in Qwaqwa, Kestell, and Harrismith, with *Haemonchus* being the most dominant. However, there were no records of trematode infections such as *Fasciola* and *Schistosoma*, raising important questions: were these parasites genuinely absent, or had they been overlooked due to limited research on the snail populations that serve as intermediate hosts? With that study now over two decades old, updated data were needed. The study aimed to identify the snail species found in the Phuthaditjhaba area and evaluate their potential to harbour helminth infections using both morphological and molecular techniques. The research was motivated by the growing concern over waterborne parasitic diseases in Phuthaditjhaba communities and the lack of recent data on local snail vectors. A total of 268 of freshwater and terrestrial snails were collected from seven sampling sites. Environmental factors such as proximity to water bodies, vegetation, and human activity were recorded for each site. Morphological identification revealed the presence of genera such as *Radix*, *Galba*, *Bulinus*, *Succinea*, and *Oxychilus*. Molecular screening using PCR targeted the CO1 and 18S genes to detect snail and helminth DNA. *Radix* was the most abundant genus, primarily found in muddy areas, while *Bulinus* was scarce, with only one specimen collected from one site. PCR analysis detected trematode DNA in *Radix* (4/4) and *Vallonia* spp. (1/1), and nematode DNA in 5 of 24 terrestrial snail samples. This study provided updated insights into snail diversity, habitat preferences, and their associations with helminth infections in Qwaqwa, highlighting potential risks for disease transmission and the importance of continued ecological and molecular monitoring.

Key words: *Galba*, helminth infections, morphology, Phuthaditjhaba, *Radix*, snail hosts

Session 2- Innovation and Technology

Improving wastewater treatment using fungi: Evaluating mycofiltration as a potential add-on tool for underperforming wastewater treatment plants in South Africa

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Clean surface water is essential for ecological and human health, yet many wastewater treatment plants (WWTPs) struggle to remove harmful metals before releasing the effluent into water bodies. This study evaluated mycofiltration, a low-cost biotechnology using living fungal threads, i.e., mycelia of the oyster mushroom (*Pleurotus ostreatus*), as a potential complementary polishing step to improve metal removal beyond conventional treatment. Wastewater samples collected before and after treatment by a local WWTP were analysed for selected metals. The treatment plant performed poorly, with most metals passing through largely unchanged. Mycofiltration of the wastewater samples achieved 99% removal of phosphorus and approximately 50% removal of mercury, lead, and potassium. Mycofiltration, however, could not remove heavy metals such chromium and cadmium. Overall wastewater quality was measured using a standardised quality scoring index, where lower scores indicate better quality. Wastewater quality improved slightly from 527 after conventional treatment by the plant to 473-482 after mycofiltration. The present study demonstrated how mycofiltration could be an innovative and cost-effective (i.e., no major capital investment) add-on to WWTP infrastructure and/ or for application at specific industries e.g., where there is significant phosphorus or mercury release. Mycofiltration potentially offers a practical pathway for municipalities to enhance regulatory compliance and reduce ecological and human health risk in effluent-receiving waters.

Keywords: mycoremediation, wastewater quality, heavy metals, Agenda2063, Green Drop.

Qwaqwa Campus Water Optimisation Strategy for 2026 - 2027

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The Qwaqwa Campus of the University of the Free State is increasingly vulnerable to unreliable municipal water supply, posing significant risks to student accommodation, academic continuity, compliance with health and sanitation, and overall institutional operations. Existing mitigation measures, including bulk water storage reservoirs, borehole utilisation, and rainwater harvesting, are no longer sufficient to meet rising demand and declining supply reliability. In response to this pressing issue, University Estates developed a 'Water Optimisation Strategy' that sets out a structured, multi-source approach to enhance water security and transition Qwaqwa Campus toward a more resilient and partially self-sustaining water system. The strategic objective of the strategy is to reduce potable water demand, diversify supply sources, and optimise existing infrastructure through a phased implementation programme. Key interventions include immediate demand reduction measures (such as waterless urinals, low-flow fixtures, and controlled shower systems), optimisation of existing boreholes and expansion of potable water storage capacity. Medium to long-term initiatives include focussing on implementing grey water reuse systems in residences, exploring the feasibility for developing wastewater treatment infrastructure in collaboration with academic departments, enhancing the use of natural water sources such as on-campus dams and additional boreholes, and capturing and reusing stormwater. In addition, targeted irrigation strategies for sports fields and waterless landscaping will further reduce reliance on potable water. The strategy adopts a phased implementation approach, prioritising high-impact, low-cost interventions in the short term, followed by infrastructure development and system integration over the medium to long term. This ensures early gains in water savings while building the foundation for sustainable, long-term water resilience. From a strategic perspective, the implementation of this plan will significantly strengthen Qwaqwa Campus's operational resilience, reduce long-term cost exposure, and ensure compliance with national water regulations such as the National Water Act. It also aligns with global sustainability frameworks, including the United Nations Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation). Beyond operational benefits, the strategy creates opportunities for research, innovation, and academic integration, positioning the University as a leader in sustainable campus management. The introduction of water monitoring systems, performance tracking, and stakeholder engagement programmes will further ensure that these interventions will have a sustained impact. Collectively, this water optimisation strategy provides a practical and forward-looking roadmap to secure continuous water availability, support institutional growth, and embed sustainability at the core of Qwaqwa Campus operations.

Keywords: Water Security, Sustainable Development, Potable Water, Grey Water Reuse, Demand Reduction Technologies

Augmented photocatalytic degradation of antibiotics in a solid-liquid interfacial system using Ag-TiO₂-laced graphene oxide sponge

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There are inherent flaws in using pristine nano-photocatalysts for aqueous organic contaminants photo-degradation such as fast electron-hole recombination rates, low photon harvesting, large band gap, difficulty in separating nano-sized photocatalysts from aqueous solution after degradation, and poor reusability. These have led to the search for photo-degradation catalysts that suppress these flaws. Thus, pristine TiO₂ nano-photocatalysts was doped with Ag ion to yield Ag-TiO₂ which was then evenly laced on graphene oxide sponge (GOS) to obtain a final composite product (Ag-TiO-GOS). The Ag-TiO-GOS was extensively characterized and employed in the photo-degradation of ciprofloxacin (CPF) and tetracycline (TC). The Ag-TiO-GOS exhibited enhanced physicochemical and optical properties including lowered agglomeration of Ag-TiO₂, high surface area and pore diameter compared to the GOS, lowered band gap, and enhanced photon absorption compared to TiO₂ and Ag-TiO₂, as well as high adsorption of antibiotics onto the GOS. The experimental CPF and TC degradation data showed that these improved properties worked in tandem to enhance the photo-degradation with maximal efficiencies of ≈ 90 and 100%, respectively, at optimum conditions including photon harvesting, pH of 7, concentration (≈ 7.3 mg/L), and an average photon irradiation time of 200 min. These maximal efficiencies ($\geq 90\%$) were comparatively far higher than those of the Ag-doped-TiO₂ and TiO₂ recorded at ≈ 32 and 22%, respectively. The initial Ag-TiO-GOS enhanced efficiencies for CPF and TC were retained even after 4 reuse cycles; hence, the Ag-TiO-GOS demonstrated excellent reusability with high efficiency. Application of the Ag-TiO-GOS composite may be practically feasible in real water treatment due to its easy handling, easy removal from treated water, easy washing and reuse, and consistent efficiency over several reuse cycles. This may be especially so for the degradation of low concentrations of both TC and CPF which are common in most environmental water sources.

Keywords: Antibiotics, Graphene oxide sponge, TiO₂, Water treatment, Graphene oxide-photocatalyst composite

Utilising MODIS for Snowmelt Runoff Analysis in the ORASECOM Basin - A Case Study of Senqu Catchment, Lesotho

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Snow is the main form of precipitation in Lesotho during the winter season (April-July), but limited knowledge of snow hydrology hinders proper planning of water allocation for water managers in Lesotho. This problem is compounded by limited snow data, due to non-functional meteorological stations located throughout the country's mountainous terrain. This study aims to assess the amount of water contributed by snowmelt water equivalent (SWE) to the Senqu River. Cloud-free MODIS (Terra/Aqua) MOD09A1 images were downloaded for the winter snow packing period (April-July) and the melting seasons (August – September) for the years 2013-2017. The snow cover areas were mapped using the MOD09A1 MODIS satellite images. The study area was subdivided into different elevation zones of 500m increment intervals. Three conditions should be obtained to map snow cover areas such as, Normalised Difference Snow Index (NDSI) with a threshold reflectance value $\geq 40\%$. Band-4 should have a reflectance value $> 10\%$ whilst Band -2 should have a reflectance $> 11\%$. SRTM DEM (1arc-second, 30m) was used to extract the catchment characteristics such as elevation zones and hypsometric curve using ILIWS 3.31 academic GIS software package. The river discharges were modelled using the Snowmelt Runoff Model (SRM). In-situ meteorological data in the form of average daily temperatures, precipitation and river discharge were used as inputs into the SRM model. The model was calibrated using datasets from the time-period 2000 and validated by 2013-2014. 2015-2017 dataset was used to substantiate the model performance. The performances were assessed through percentage volume difference (DV) and coefficient of determination (R²). The MODIS images were able to show an estimated hit accuracy of about 90% for snow cover mapping as observed from the observer's records book at different meteorological stations. Snow cover area mapping results indicated that as much as 90% spatial cover can be achieved as shown for the 27th of July 2016 incident. The model results showed that as much as of the runoff was the contribution by snowmelt water equivalent during the year 2016 snowmelt season contrary to that of (2015) and (2017). The difference between 2016 contribution and the rest was thought to be because the slow-melting massive snowpack received in 2016, which was more than 4m in depth, the situation last seen in 2006. 2016 results were obtained by a model performance of R² of 93% and Dv of 56% while 2015 R² was 96% and Dv = -0.253% and finally 2017 model performance was R² = 93% and Dv = 0, 6%.

Keywords: Snowmelt, Snow cover areas, Snowmelt water equivalent, SRM, MOD09A1

GO/ZrP as an effective adsorbent for Pb (II) ions removal from water: preparation, adsorption behaviour, and equilibrium studies.

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Contaminated water, especially with heavy metals like lead (Pb (II)), poses significant risks to both ecosystems and human health. This study explores effective materials for removing Pb (II) ions from water, focusing on graphene oxide (GO)-based nanocomposites known for their high adsorption capacity. Zirconium phosphate (ZrP) was grafted onto GO to form GO/ZrP nanocomposite as a potential adsorbent. Scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), Thermogravimetric analysis (TGA), and Inductively coupled plasma optical emission spectroscopy (ICP-OES) were used to study the morphology, thermal degradation and stability, and the adsorption of lead contaminant from water. According to FTIR, XRD, and SEM, a plenty of oxygen-containing functional groups were attached to expandable graphite, and ZrP was successfully grafted onto GO to enhance its Pb (II) ions removal efficiency. ICP-OES results showed that the ZrP-modified GO indeed outperformed pristine GO in removing Pb (II) ions, achieving the maximum removal across all tested parameters. Regarding the adsorption isotherm models, the correlation coefficient (R^2) and the slope ($1/n$) revealed that the experimental data of GO/ZrP nanocomposite fit the Freundlich over the Langmuir isotherm model and favours the adsorption of Pb (II) ions on a heterogeneous surface. The results indicate that the excellent adsorption properties of GO, coupled with ZrP, which has good ion exchange capabilities, drive the effective removal of Pb (II) from contaminated water. TGA revealed that the thermal stability of GO was enhanced by ZrP.

Keywords: contaminated water; heavy metals; graphene oxide; zirconium phosphate; adsorption

Availability, accessibility and use of weather and climate information services for water-related decision-making in South Africa

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Water resource management in South Africa is increasingly challenged by climate variability and extreme weather events, including droughts, floods, and prolonged dry spells. Effective weather and climate information services can support proactive planning and risk management within the water sector. However, limited information exists regarding the availability, accessibility, and use of these services among water-sector stakeholders. This study assesses the availability, accessibility and use of weather and climate information services among stakeholders involved in water resource management across South Africa. An online survey was developed, tested and circulated to multiple stakeholders involved in the water sector across the country. Data collected were compiled in a Microsoft Excel spreadsheet and underwent a data quality process to detect and eliminate incomplete, erroneous and suspicious data. After the data quality process, a total of 40 questionnaires with high-quality data were reserved for further data analysis using the Statistical Package for the Social Sciences (SPSS) version 23.0. Descriptive statistics and frequency analysis were used to analyse data. Preliminary findings indicate that weather and climate information are widely recognised as important for decision-making. However, differences exist in accessibility, frequency of use, preferred information products, and stakeholder capacity to interpret and apply forecasts. Key challenges include unreliability, lack of tailored and local-specific climate services, and difficulty in understanding, decoding and use of supplied information for decision-making. This study recommends that the co-production of tailored and location-specific climate services, accompanied by capacity-building initiatives are among the key strategies needed to overcome these barriers limiting the use of climate services in the water sector. The findings of this study are expected to contribute to the ongoing efforts of the Agricultural Research Council to develop a web-based application that host weather and climate indices that are crucial for decision-making in the water and agricultural sectors (<https://github.com/climindex/hydroclimsa>).

Keywords: Climate Adaptation, Climate services, Climate Variability, Decision support systems, Water resource management

Linking Ageing Infrastructure and Settlement Dynamics to River Water Degradation: Rapid Assessment Protocols and Mycofiltration Solutions from Qwaqwa

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Over the past decade, research conducted by the Ecotoxicology Research Group at the University of the Free State has systematically investigated the deterioration of surface water quality in the Qwaqwa region, revealing a consistent pattern linking anthropogenic pressures, ageing infrastructure, and ecological risk. Early work demonstrated that wastewater treatment plants (WWTPs) in the Maluti-a-Phofung municipality are often ineffective in removing heavy metals, with negligible differences between influent and effluent concentrations and measurable downstream contamination in receiving the rivers. This infrastructural inefficiency, compounded by rapid urbanisation, the expansion of informal settlements, and inadequate waste management, has contributed to the long-term degradation of river systems in the region. Subsequent studies expanded this understanding through integrated chemical and ecotoxicological assessments, identifying elevated concentrations of metals in both water and sediments, frequently exceeding ecological and domestic guideline thresholds. Advanced monitoring approaches that combined physicochemical analyses with in vitro bioassays further revealed complex pollutant mixtures, including organic micropollutants linked to human health dynamics, and demonstrated that no sampling sites in regional headwaters are free from anthropogenic impacts. This body of work continues to contribute to the development of rapid, cost-effective water quality assessment protocols integrating novel bioindicators approaches suitable for resource-limited contexts. Complementing diagnostic efforts, emerging research within the group has explored nature-based remediation strategies, notably mycofiltration, as a scalable intervention to reduce contaminant loads and help restore ecosystem integrity. Collectively, these studies establish Qwaqwa as a critical case study of how infrastructure obsolescence and settlement dynamics intersect to impair freshwater systems. They further demonstrate the potential of integrated monitoring frameworks and low-cost biotechnological solutions to inform adaptive water management. The continued application of these approaches holds significant promise for improving water security, public health, and ecological resilience in Qwaqwa and comparable semi-urban African catchments.