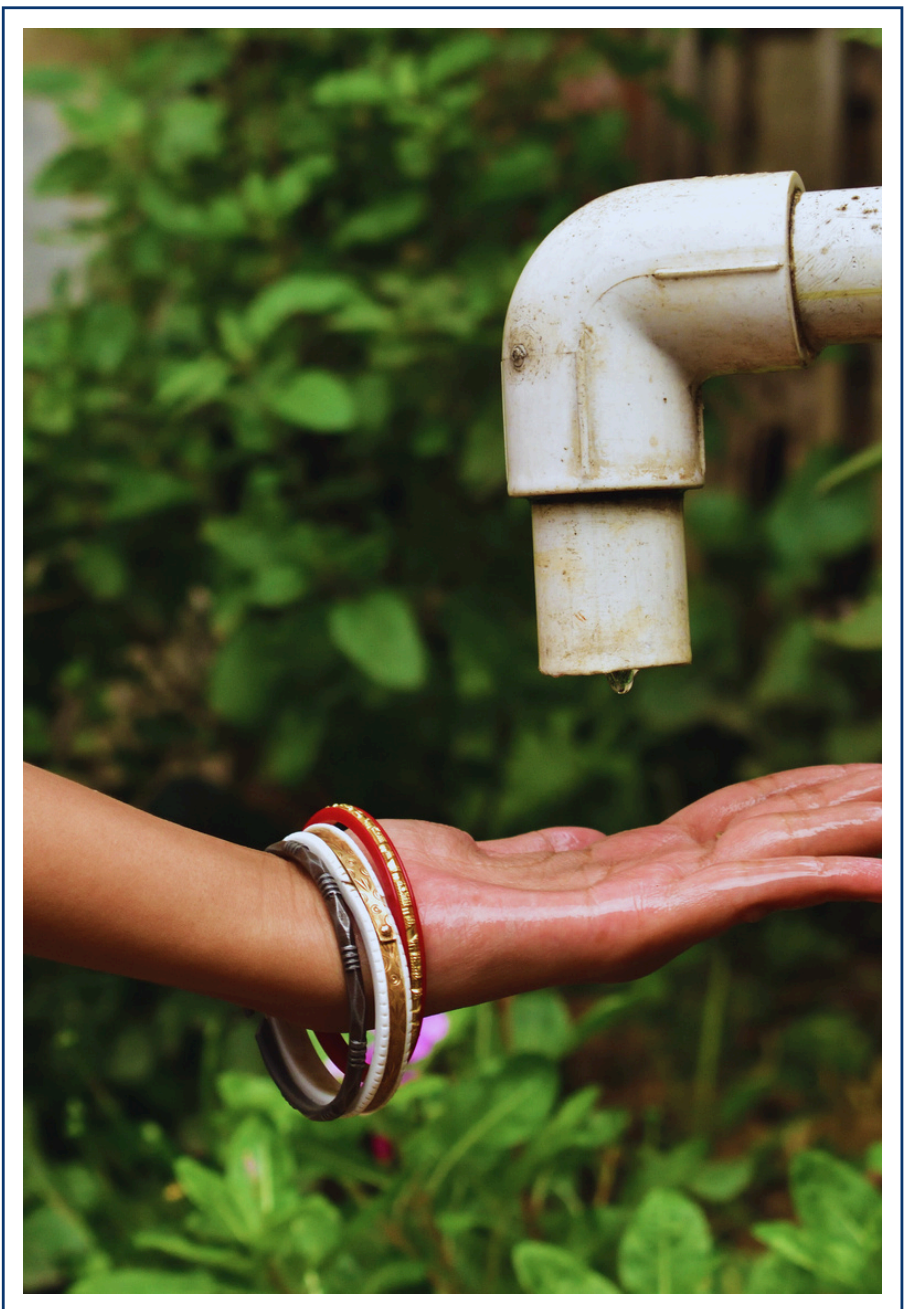


POSTGRAD RESEARCH BOOKLET 2024



RRIP

REORIENTING RESEARCH,
INNOVATION AND
PRACTICE

TO ADDRESS FUTURE WATER
CHALLENGES IN AFRICA



Research Overview



Researcher: Mamokitlane Korotsoane

Supervisor: Dr. Theo Harding, Department of Civil Engineering

Degree: MSc(Eng)

Research stage: Proposal

Affiliated research project: WRC Project - Evaluation and modelling of an integrated tannery wastewater treatment system used for resource recovery and process water re-use.

Title of Research Project: The Comparative Assessment of the Treatability and Biodegradability of Conventional Tannery Processing wastewater and Ecological Tannery Processing Wastewater

Research Aim: Tanneries produce one of the most obnoxious, pollutive, complex wastewaters due to the nature of the material (hides & skins) being processed and the chemicals used in the processing. The wastewaters are usually comprised of high concentrations of nitrogen, sulfate, organic matter, chromium and other ions, making it an extremely challenging industrial effluent to treat (Gallego-Molina et al., 2013). These wastewaters are difficult to treat to acceptable standards by municipal sewers or sewage treatment works currently available. Hence, unless cost prohibitive methods are used, the tannery wastewaters cannot meet the required discharge standards.

Moreover, industries, including tannery industries, are increasingly transitioning to the production of ecological or environmentally friendly products. The characteristics of wastewaters generated from the processes of producing environmentally friendly products differ from those produced from conventional production. Although existing wastewater treatment plants have been used to treat wastewater from traditional processes, the treatability of ecological production wastewater by these plants remains unclear.

Research Overview



Researcher: Ebrahim Behardien

Supervisor: A/Prof. Kevin Winter, Department of Environmental & Geographical Sciences

Degree: MSc

Research stage: Proposal

Title of Research Project: An investigation into the use of alternative insulating material for heat reduction in informally constructed housing.

Research aim:

The project is ongoing and continues the work from an Honours project. This project showed that alternative insulating material could reduce temperature by 5°C and control relative humidity. The Masters research seeks to expand the project to an informal settlement and monitor real-time temperatures and relative humidity in occupied informally constructed housing. The collected data from the informally constructed housing will then be compared to the data produced by experimental and control shacks with a model used to project future temperatures the occupants may be exposed to into 2040.

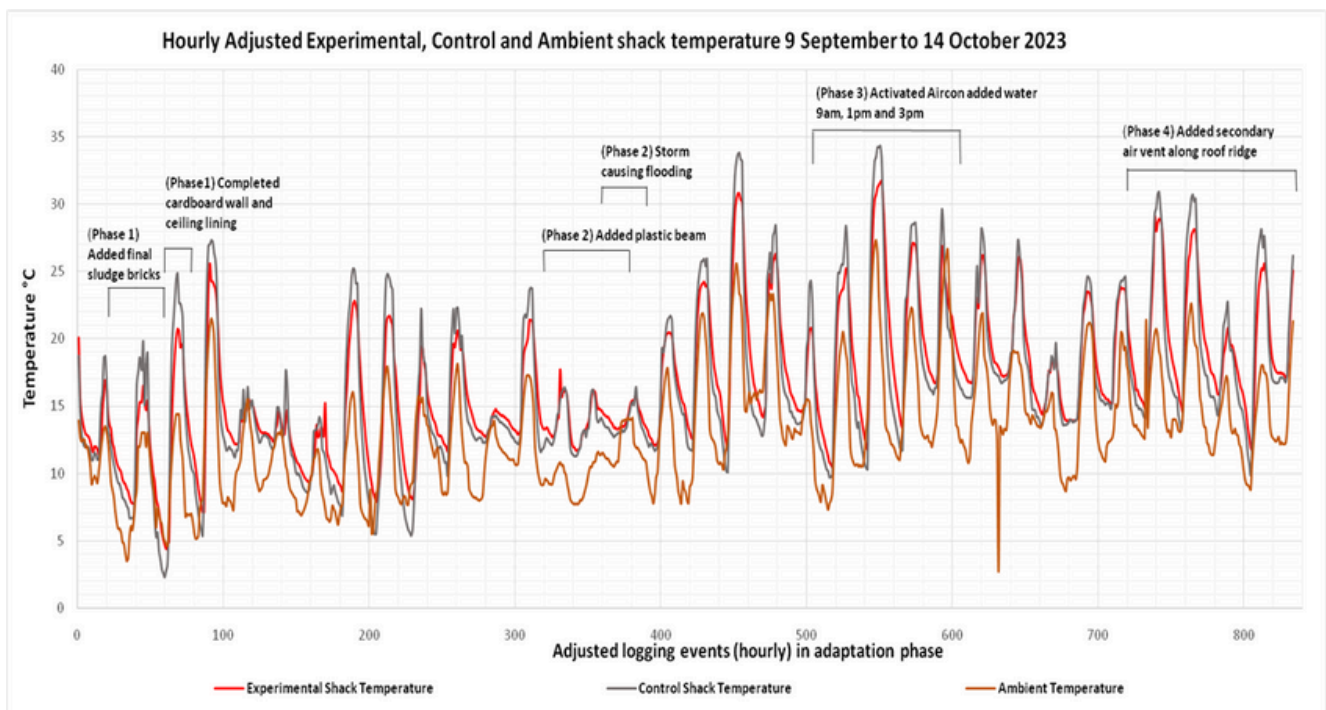


Figure 1: The hourly logged temperature for the experimental and control shack, including the ambient temperature.

Research Overview



Researcher: Minenhle Linda

Supervisor: Dr. Amber Abrams, Future Water Institute & Department of Civil Engineering

Degree: MA

Research stage: Proposal

Title of Research Project: A Comparative Study of Water Perception and Valuation in Giba Gorge and the downstream Umhlatuzana River

Research aim: This research aims to delve into the divergent valuation languages of water bodies, focusing on the contrast between the pristine and valued Giba Gorge Parkrun's waterfall and the neglected Umhlatuzana River, that it is in and goes downstream. The study will examine the ways in which people perceive, and assign value to these water bodies, as well as the socio-cultural, economic, and environmental factors contributing to these disparities.

Project outcomes:

- To understand local perceptions of water bodies and explore the cultural, recreational, and aesthetic values attached to Giba Gorge Parkrun's waterfall and the Umhlatuzana River.
- To understand the factors that contribute to the Giba Gorge Parkrun's waterfall being a tourist attraction while the Umhlatuzana River remains underappreciated and littered.
- To find out the economic benefits derived from the tourism in association with the waterfall and the environmental consequences of the neglect along the Umhlatuzana River.
- To find out the dynamics of existing policies and community engagement initiatives related to water management in the study areas.
- To identify opportunities for enhancing community involvement and promoting sustainable water practices.

Research Overview



Researcher: Max Baard

Supervisor: Prof. Martine Visser, School of Economics

Degree: MComm

Research stage: Proposal

Title of Research Project: Shared Waters, Shared Responsibilities: Investigating Urban Water Burden-Sharing Preferences in Johannesburg South Africa and Across the Global South.

Research aim: Climate change is exacerbating water insecurity challenges for many large cities across the Global South. As such, this research project aims to investigate what the preferences are for rules around sharing the burden of reducing consumption and paying for water services under different supply scenarios. This study builds on and will link to two earlier projects conducted with residents of Cape Town in 2021 and 2023. It aims to extend the research scope to address similar issues in other South African cities and, more broadly, in the Global South by replicating and expanding the experiment in Johannesburg. The objective is to investigate, using lab-in-the-field experiments, how beliefs, and policy preferences affect these equity preferences and notions of burden-sharing in the context of a city's residents' water consumption and saving behaviour in the face of future droughts.

This study aims to understand how the perception and preferences for burden-sharing varies under different water scarcity scenarios, including the impact of extreme weather conditions on water supply. Furthermore, this research will seek to investigate and understand how willingness to pay for infrastructure, whether man-made or ecological, varies based in socio-demographic factors and contextual heterogeneity. This approach will provide key insights into the multifaceted influences on water management strategies and present insights into equitable solutions and residents policy preferences for urban water crises.

Research Overview



Researcher: Moferefere Tlali

Supervisor: Dr. Theo Harding, Department of Civil Engineering

Degree: MSc(Eng)

Research stage: Proposal

Title of Research Project: Kinetic modelling describing the hydrolysis of tannery wastewater under biological methane production and biological sulphate reduction conditions.

Research aim: The era of industrialization has yielded substantial economic advantages for both developing and established nations (Mpofu et al., 2022). The leather industry has made a major contribution to the development of nations and the global economy among several emerging industries (Bhardwaj et al., 2023). Fortunately, South Africa is seeing a rise in the importance of their leather industries. According to SA report in (Department of trade and industry, 2016), the leather industry is a significant component of South Africa's manufacturing sector, attracting attention due to its role as a major employer and its potential to create job opportunities. However, tannery industries consume vast amounts of water which produce large volumes of effluents with a significant pollution burden. Approximately 20% of chemicals utilized in the tanning process are absorbed by the leather, while the remaining 80% are discharged as effluent (Humayra et al., 2023). In line with UN Sustainability Goals 2030 which recommend that industrial entities should practice water treatment methods that promote reuse of water and resource recovery to limit dependency on freshwater sources and limit waste generation. Anaerobic digestion (AD) is being recognised as a cost-effective alternative for reducing organic waste while simultaneously protecting the environment and generating renewable energy in underdeveloped countries (Priebe et al., 2016).

Despite the numerous advantages of anaerobic digestion (AD) in stabilising sludge and treating organic matter, the limited knowledge regarding AD failures has resulted in a gradual and cautious approach to modelling advancements. The models lack accurate calibration of intermediate bioprocesses, resulting in an inability to accurately simulate AD dynamics. In the absence of sufficient modelling of AD dynamics, the AD model is not suitable for start-up or failure analysis and not ensuring reliable outcomes from the simulation of the datasets to be generated to calibrate the methane production and also the influence of SRB activity in the AD.

Research Overview

	Recycled Water Supply	Drinking Water Supply	
	Moderate: noticeable with some effort to remove	None: No stain	Moderate: n to remove
	Slight discolour 	No colour 	Distinctly yell 
se to monthly	-R50	+R25	R0
ne	 Slight smell	 No smell	No
	Treat before discharge to sea	Discharge to sea without treatment	Treat before
	☐ Recycled Water Supply	☐ Drinking Water Supply	☐

Researcher: Cameron Andrews
Supervisor: Ms. Teboho Mofokeng, Department of Civil Engineering
Degree: MSc(Eng)
Research stage: Ongoing
Affiliated Research Project: WRC project - Feasibility of using seawater to flush toilets in the African context

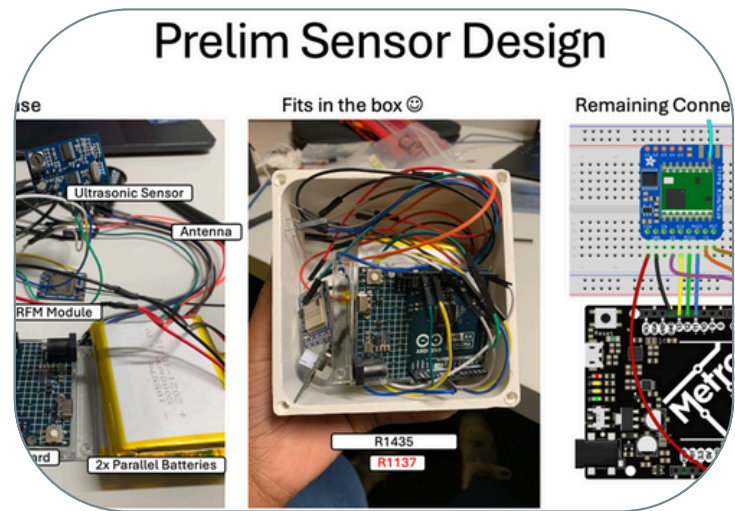
Title of Research Project: Using discrete choice experiment to determine the stated preference for alternative water sources to flush toilets

Abstract: Climate change has increased the frequency of droughts (Sousa et al., 2018). Water utilities often promote water conservation behaviour measures, such as multiple use flushing and timed showers, to limit water demand (Aina et al., 2023; Taing et al., 2019). However, if droughts continue unabated, water conservation is insufficient and seeking alternative water sources is essential to ensure a sustainable water supply. This study investigates the stated preference for using alternative water sources for toilet flushing and aligns it with the subtheme of social acceptance at an alternative water level.

This study uses a discrete choice experiment to determine the user’s stated preference for alternative water sources to flush toilets. Discrete choice experiments present individuals with multiple choices through choice sets to elicit users’ stated preferences. In this case, the choice sets consisted of three alternatives: seawater, recycled water, and drinking water, each of which was described by five attributes: stain, colour, cost, odour, and disposal. The discrete choice experiment began with a random utility model (RUM). The RUM produced a d-efficient 72 row design, which was then divided into 12 blocks, meaning each respondent will see six choice sets. Across the six choice sets, the arrangement of alternatives and attribute levels ensures that the individual is shown the optimum combination of choice sets to extract the user preferences.

Project outcomes:
This research aims to gather data that will help identify the preference for alternative water sources to flush toilets using a Hout Bay sample. Furthermore, the data will be able to explain the covariates that influence the individuals’ choices, through a Latent Class model. The data and results will go towards a full dissertation, publishable paper, and the WRC project report.

Research Overview



Researcher: Nompumelelo Mnisi

Supervisor: Dr. John Okedi, Department of Civil Engineering

Degree: MSc(Eng)

Research stage: Ongoing

Affiliated research project: Pathways to water resilient South African cities (PaWS).

Title of Project: Enhancing Hydrological Modeling through Data-Driven Approaches with novel Internet of Things (IoT) technology: A Case Study in Cape Town, South Africa

Abstract:

Located on the coast of South Africa with a water-scarce Mediterranean climate, Cape Town faces significant water resource challenges. IoT technology offers a compelling solution. Dense sensor networks enable real-time data collection, while their cost-effectiveness, remote accessibility, and scalability address the limitations of traditional methods. By leveraging IoT, SA can modernise its network, providing critical data for effective water management in the face of climate change and population growth.

This study investigates the potential for a low-cost IoT network to monitor the performance of a retrofitted stormwater pond in Mitchells Plain, Cape Town. It aims to evaluate the pond's infiltration capabilities, determine the contribution to Managed Aquifer Recharge (MAR) for sustainable Stormwater Harvesting (SWH) and evaluate real-time data collection and analysis methods accompanied by data-driven methods machine learning models and statistical approaches. The total cost of the IoT systems deployed was ZAR 12,067. The IoT system collects real-time data on flow, infiltration, storage, and water levels where the data is remotely accessible at a low cost, and with wide applications, thus improving decision-making to reclaim and reuse harvested groundwater.

Project outcomes:

- Research Dissertation
- Dataset (physical data and analysis incl. the model)
- Network Blueprint (guideline)
- PaWS Research/ Newsletter Paper (WP2)
- Future Water Presentation
- PaWS CoP Webinar Presentation

Research Overview



Researcher: Michael Fehrsen

Supervisor: A/Prof. Kirsty Carden, Future Water Institute & Department of Civil Engineering

Degree: MSc(Eng)

Research stage: Ongoing

Title of Research Project: Factors affecting the implementation of SuDS in City of Cape Town

Abstract: The natural water cycle is impacted by urbanisation through the introduction of impermeable surfaces, reducing infiltration into the ground and increasing surface runoff flows. The traditional approach to managing stormwater within urban areas has focussed on managing the quantity of water to prevent flooding to avoid damage to property and loss of life by directing it efficiently and quickly away from urban areas, with little regard for the impact of pollution carried by the stormwater on receiving water bodies. Cape Town's rivers and water bodies have been impacted and pollution levels may continue to increase, impacting communities and businesses.

Sustainable drainage systems (SuDS) are an alternative and more sustainable approach, that aims to copy natural processes to handle stormwater in order to reduce flows, reduce pollution, provide amenities, and preserve biodiversity. It is not well understood how effective the Management of Urban Stormwater policy, published by the City of Cape Town, has been in encouraging the implementation of SuDS and how these sites are performing, are monitored, and maintained. The CoCT recognises that SuDS are necessary to become a Water Sensitive City by 2040. Thus, there is a need for research to understand what the factors are that affect the implementation of SuDS in Cape Town to guide decisions, policies and guidelines around SuDS in Cape Town. The aim of this research is to identify these factors and recommend any changes to Impacts Policy.

Project outcomes:

- A thesis and journal paper to fulfil the requirements of a Master's in Civil Engineering by dissertation.
- Submission of site visit reports and a database of identified bioretention areas in Cape Town.
- Key recommendations for changes to CoCT's Stormwater Impacts Policy to facilitate dissemination of the research work.

Research Overview



Researcher: Jessica Reimers

Supervisor: Prof. Neil Armitage, Department of Civil Engineering

Degree: MSc (Eng)

Research stage: Proposal

Affiliated research project: Pathways to water resilient South African cities (PaWS).

Title of Research Project: Modelling and measuring the efficiency of retention ponds to remove stormwater pollutants

Research Aim: During periods of rainfall, various pollutants (e.g., sediments, nutrients, and metals) are washed into stormwater systems (Razguliaev et al., 2024). Downstream natural waterways receive these contaminants, causing health risks and environmental degradation (Yazdi et al., 2021). Sustainable Drainage Systems (SuDS), the stormwater fraction of Water Sensitive Urban Design (WSUD), have been established to combat the effects of urbanisation. Stormwater modelling is used regularly in urban water management to analyse the efficacy of proposed SuDS systems. Several stormwater software engines are currently available that incorporate an array of complex inputs and outputs while allowing a user-friendly interface (Urbonas, E. & Wre, 2007). High-resolution hydrological and hydraulic data is needed to mimic the conditions of real environments, but robust measurement methods are needed to achieve an acceptable model calibration. Retention ponds are a reputable strategy used in SuDS, and can be defined as attenuating devices for stormwater, storing water on a permanent basis. However, these units possess an ability to treat water naturally through physical, chemical, and biological processes (Yazdi et al., 2021). These devices can be modelled in software, such as Personnel Computer Stormwater Management Model (PCSWMM), as storage nodes and can be programmed to remove pollutants using treatment equations linked to a pond factor. However, there are several factors which play a role in the removal of pollutants in pond systems. Thus, treatment equations for retention ponds are severely lacking and difficult to find, explaining the strong need to develop them, particularly within the South African context.

The aim is to model the efficiency of the retention ponds found across three locations: Greenbay Estate (Gordon's Bay), Fynbos Estate (Parklands), and a park near Paddocks Shopping Centre in Milnerton. Reasonable treatment equations need to be developed to use in PCSWMM, a hydraulic and hydrological model, where key treatment parameters will be used to define the treatment.

Research Overview



Researcher: Zindzi Tendo

Supervisor (s): Dr. John Okedi, A/Prof. Kirsty Carden, Department of Civil Engineering and Future Water Institute

Degree: MSc

Research stage: Ongoing

Affiliated Research Project: Khusela Ikamva - UCT Sustainable Campus

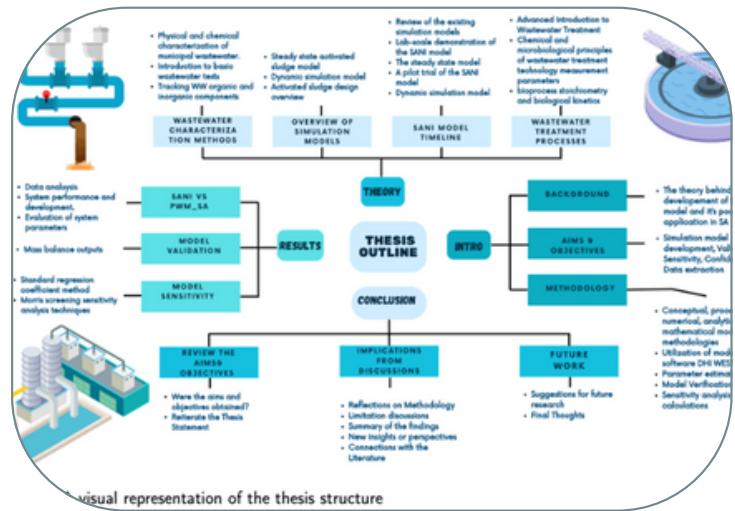
Title of Research Project: Development of a Risk Assessment tool for greywater, rainwater and stormwater, using UCT as a case study

Abstract: Over half a billion people are faced with the challenge of water scarcity (Zhang, Njebu & Xia, 2021). In an area such as Cape Town, South Africa which is semi-arid and urban, this situation is exacerbated. In response to the threat of water shortage, investigations were undertaken to assess water reuse potential as an alternative source of water supply. The water reuse potential sources included inter alia wastewater, rainwater, and stormwater. Studies showed that the integrated use of these alternatives at a large scale led to up to 69% in water savings (Ndeketeya & Dundu, 2019). For these alternatives to be implemented successfully, the associated risks and the management of these risks must be known. Therefore, there have been global and local studies on Risk Assessment frameworks that can be used for these alternatives. Internationally, the World Health Organisation developed the Quantitative Microbial Risk Assessment (QMRA) framework. QMRA provides a quantified risk analysis but is not easy to understand by all installers and users. Secondly, the reference pathogens used are not often tested in South Africa. In South Africa, there is a risk assessment framework for irrigation using greywater. This framework presents the risk qualitatively, as a range from Low to High, and provides appropriate Risk Management strategies depending on the level of risk. Despite its simplicity, it is only for greywater and does not give a detailed analysis of the Risk. There are also no tools that assess Risk for the integrated use of greywater, rainwater and stormwater for a context such as Cape Town. This research will therefore address the need for a simplified tool that quantitatively and qualitatively assesses Risk and recommends Risk Management strategies for greywater, rainwater and stormwater, that are tailored to a context like Cape Town.

Project outcomes:

A simplified Risk Assessment tool for greywater, stormwater and rainwater use.

Research Overview



Researcher: Hope Thendo Mudau

Supervisor: A/Prof. David Ikumi, Department of Civil Engineering

Degree: MSc

Research stage: Ongoing

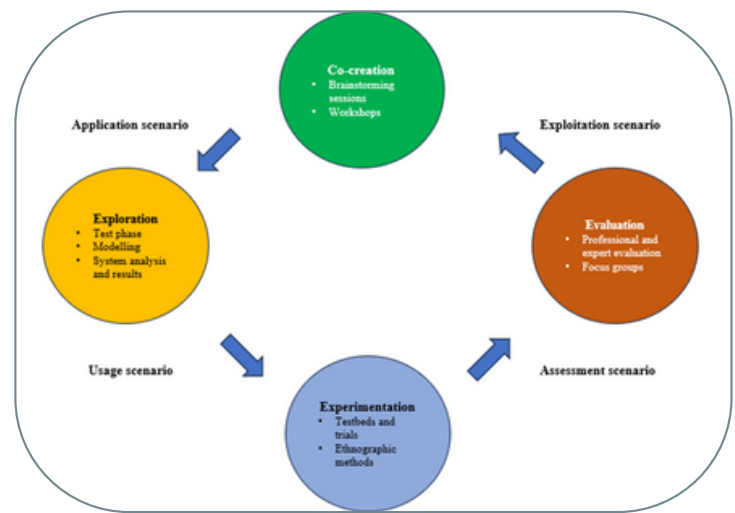
Title of Research Project: Calibration of the PWM_SA model against experimental data from the SANI saline sewage treatment system from the Hong Kong SANI pilot plant.

Abstract: In South Africa, the degradation of freshwater resources is an urgent issue driven by increasing pollution and the deterioration of river catchments. Projections from the 2018 National Water and Sanitation Master Plan indicate a critical water supply shortfall of 17% by 2030. Consequently, there is a pressing need to develop sustainable water management strategies. Notably, Hong Kong has successfully implemented alternative water supply methods, such as seawater toilet flushing (SWTF), since the 1950s, which produces saline sewage. This innovation led to the creation of the SANI process, a significant advancement in wastewater treatment. This project aims to calibrate the Plant Wide Model in South Africa (PWMSA) using experimental data from a SANI saline sewage treatment system, similar to the Hong Kong SANI pilot plant. Additionally, the research will investigate the feasibility of implementing a comprehensive system-wide model for monitoring and managing sulfur content in wastewater.

Project outcomes:

The outcomes are currently being pursued, and results have not yet been obtained but we are currently employing the identical model utilized for the SANI Pilot system in Hong Kong to conduct batch tests within the WEST® framework.

Research Overview



Researcher: Tariro Marekwa

Supervisor : Dr John Okedi, Department of Civil Engineering

Degree: MSc

Research stage: Write-up

Affiliated Research Project: Khusela Ikamva - UCT Sustainable Campus

Title of Research Project: Using a living lab approach to determine pathways towards a water sensitive campus – University of Cape Town as a case study

Abstract: Universities are increasingly identifying the benefits of incorporating water-sensitive practices in a campus setting, and among these, rainwater harvesting is the most adopted. To maximize the benefits of rainwater harvesting systems there is a need to quantify the extent to which these systems can reduce potable water demand. This study aims to evaluate the performance of an existing rainwater harvesting system at the University of Cape Town. A living lab was used to continuously monitor and collect data from the rainwater harvesting system over 12 months. A spreadsheet-based behavioural model was developed to assess the yield of the rainwater harvesting system. The viability of a water net zero scenario was also investigated through water quality testing and behavioural modelling under the effects of climatic changes. The concept of living labs was also further elaborated through a review of living lab case studies from across the world. Three campus living labs are analysed in this thesis using qualitative research methods. The research project focuses on the exploration phase of a living lab cycle aiming to understand the current status at the Hasso Plattner d-school.

Project outcomes:

- Evaluation of the rainwater harvesting system at Hasso Plattner d-school
- Understanding the effect of different climates on system performance
- Understanding what a living lab is
- Missed opportunities at the Hasso Plattner d-school
- Assessment of the water quality at Hasso Plattner d-school

Research Overview



Researcher: Imaan Ghoor

Supervisor: Prof. Martine Visser, School of Economics

Degree: Mcomm Economics

Research stage: Write-up

Title of Research Project: Fairness in Water Consumption Experiments: Understanding Burden-Sharing Preferences and Conservation Beliefs

Abstract: Climate change shifts are making the challenge of water insecurity a reality for many large cities in developing countries. This realisation has come to light in South Africa as one of its major cities, Cape Town, experienced its worst drought in four centuries. Although Cape Town recovered from the water crisis, the challenge of insufficient water supply is not over. Effective demand and supply-side management is essential for long-term water security. When designing policies that account for the burden-sharing of rights and responsibilities concerning water conservation, a deep understanding of the preferences for burden-sharing among residents is crucial. This study will use experimental techniques to elicit the burden-sharing preferences of Cape Town residents. It will investigate how beliefs, policy preferences, and the Cultural Theory of Risk affect these equity preferences and notions of burden-sharing in the context of a city's residents' water consumption and saving behaviour in the face of future droughts.

Project outcomes:

To assess the fairness perceptions of high and low-income households in the context of a future drought. Majority of respondents believe that high-income households consume more water. Participants favour a proportional reduction in water consumption amongst households. Whether participants endowment were randomly allocated or based on the neighbourhood they reside in, it made no difference.

Research Overview



Researcher: Ridah Perin

Supervisor: Dr. Amber Abrams, Future Water Institute & Department of Civil Engineering

Degree: MA

Research stage: Write-up

Affiliated Research Project: WRC Project - Towards a health vulnerability index for extreme weather events

Title of Research Project: Health Vulnerability in the context of extreme weather events; flooding and drought.

Abstract: This comparative ethnography analyses the challenges that have emerged in the attempt to develop an all-encompassing health vulnerability index (HVI) that can be applied to address vulnerabilities of communities susceptible to extreme weather events (EWEs) and how community resilience is mobilised and practiced within neighbourhoods of contrasting socioeconomic backgrounds, in Cape Town. This research aims to unpack the role that vulnerability and sustainability plays in activating degrees of personhood. How convivial relations are directly impacted and/or severed by the abruptness of an EWE. Most vulnerability assessments follow a particular template of design usually comprising of three concepts (Cutter et.al, 2009; 10). These are based around damage assessment, impact assessments or looking at the consequences of the natural stressor or hazard on a particular area or community and assessing exposure. These aspects have largely been used to emphasise the interaction of physical systems and the expected consequences on population elements. There is a lack of insight into how cultivated social environments play a role in how a community responds to an EWE.

This study aims to interrogate what outcomes people experience when an EWE takes place by observing how the selected communities mobilise before, during and after an EWE takes place. This research aims to further contextualise analytical limitations of vulnerability indexes (CoCT and civil society/self) that have been implemented to support community adaptation across diverse settings. Supplementing this would be a focus on how communities embrace each other's shortfalls of combating EWEs in order to develop "community resilience". This approach will be operationalised through the lens of observing people's experiences within selected settings to hammer home the need for considering whether socially cultivated perceptions is bound in a communities formulation of personhood and convivial relationships with others.

Research Overview



Researcher: Rachelle Schneuwly

Supervisor: A/Prof Kirsty Carden, Future Water Institute & Civil Engineering

Degree: MSc

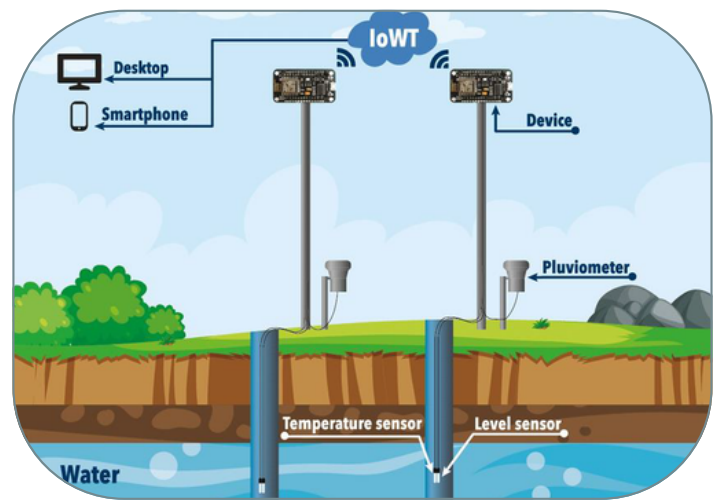
Research stage: Completed (thesis under review)

Affiliated Research Project: Pathways to water resilient South African Cities (PaWS)

Title of Research Project: Stormwater treatment during infiltration and its effect on shallow urban groundwater quality in the Cape Flats Aquifer: field study and soil-column experiments.

Abstract: This study formed part of larger transdisciplinary research where a stormwater detention pond in Mitchell's Plain, Cape Town was retrofitted with an infiltration swale. The study aimed to evaluate the potential for stormwater treatment during infiltration through the soil, and investigate whether infiltration could result in deterioration of groundwater quality in the underlying aquifer. Field research included monitoring stormwater and groundwater quality on site, and in the laboratory using large-scale soil column experiments. The field study showed that infiltration processes reduced concentrations of dissolved contaminants ammonium, phosphorus, aluminium, zinc, and total organic carbon, by 80 to 95% after accounting for dilution effects. Nitrate reduction was observed indicating that the organic carbon input from the stormwater may stimulate denitrification in the shallow infiltration area. Some localised and time restrained mobilisation of iron and manganese was found, however no deterioration in groundwater quality was found. Stormwater outflow showed improved water quality in comparison to incoming stormwater. Column experiments showed that 0.5 m of soil effectively retained P, Zn, Pb, Ni, Cr and Cu during infiltration of synthetic stormwater. Removal of total nitrogen, driven by denitrification, improved in the saturated zone. Denitrification during infiltration improved with addition of organic carbon to synthetic stormwater, however this also resulted in higher concentrations of geogenic contaminants arsenic, iron, and manganese in the column effluent - typical contaminants in a residential area. The concentrations used did not significantly influence the effluent concentrations of soil adsorbable contaminants (P, Zn, Pb, Ni, Cr and Cu) after infiltration through the soil or the concentration of total nitrogen in the saturated zone. Based on this research enhanced infiltration of stormwater from relatively small (neighbourhood scale) formal residential catchments are unlikely to pose a significant threat to groundwater quality. Stormwater with higher contaminant concentrations may be suitable for infiltration, however further research is required to determine the concentration limits and determining factors for suitability of a particular site.

Research Overview



Researcher: Miriam Arinaitwe

Supervisor: Dr. John Okedi, Department of Civil Engineering

Degree: PhD

Research stage: Proposal

Title of Research Project: Utilizing IoT in Assessing the Impacts of Climate Change on Groundwater recharge and Stormwater Patterns in the Cape Flats Area

Research Aim: Groundwater is a critical natural resource, particularly in regions with limited surface water availability, such as South Africa. In the Cape Flats Area, groundwater serves as a crucial water source for local communities and industries and is vital for maintaining the ecological balance. However, the sustainability of the Cape Flats Aquifer is threatened by challenges in groundwater recharge and stormwater management, exacerbated by climate change. These impacts on groundwater recharge and stormwater patterns are particularly concerning as they significantly affect water availability and quality for human consumption and agricultural use. This research aims to assess these impacts of climate change by employing a combination of field studies, IoT-based data collection, and integrated hydrological modeling to inform adaptive management strategies. We can better understand the interplay between climate change and groundwater recharge by gathering information on precipitation patterns, land use changes, and groundwater levels. Analyzing stormwater patterns will provide valuable insights into water flow dynamics and their influence on aquifer recharge. The research will also harness citizen science, engaging the local community in groundwater monitoring to enhance data collection and environmental stewardship. Stakeholder engagement, including local communities, governmental organizations, and water management authorities, will provide valuable perspectives and insights, informing effective adaptation and mitigation strategies.

Project outcomes:

- Comprehensive Assessment Report/ Thesis
- Deployment of IoT Sensors
- Integrated Hydrological Model
- Educational Materials and Workshops
- Establishment of Permanent Environmental Monitoring Infrastructure

Research Overview



Researcher: Lauren Grootboom

Supervisor: Dr. Amber Abrams, Future Water Institute & Department of Civil Engineering

Degree: PhD

Research stage: Proposal

Title of Research Project: Exploring the Indigenous Knowledge systems in rural and small town in South Africa as a tool to building and investing in the ecological infrastructure: Towards decolonising ecological infrastructure and water systems in South Africa

Research Aim: Ecological infrastructure has become an increasingly important component to South Africa's environmental ecosystems as they deliver imperative services to society as a nature based equivalent to build infrastructure . Ecological infrastructure centres the tangible asset base from which specific ecosystems services are derived as naturally functioning ecosystems which produce valuable goods and services to the community. These environmental includes building material, a source of renewable fuel, clean water, food and supports diversifying livelihoods while reducing poverty which remains at the centre of the basic requirements for livelihood sustainability in rural areas and small towns in South Africa. Due to rapid climate change shifts and a degradation of the ecosystems these resources have become sparse which has significantly been exacerbated in rural communities and small towns and causes further marginalisation and vulnerability in these spaces . This reality therefor requires a holistic approach to contextualising how the environmental changes, historical context, and socio – economic aspects of these communities contribute to the sustainability of ecological infrastructure of these spaces. This research therefor aims to centre how Indigenous Knowledge Systems employed by women in rural areas and small town contribute to the sustainability of Ecological Infrastructure and water management systems in South Africa.

Research Overview



Researcher: Lethabo Makgoba

Supervisors: Prof. Aqiel Dalvie, Dr. Amber Abrams, School of Public Health; Future Water Institute & Department of Civil Engineering

Degree: PhD

Research stage: Proposal

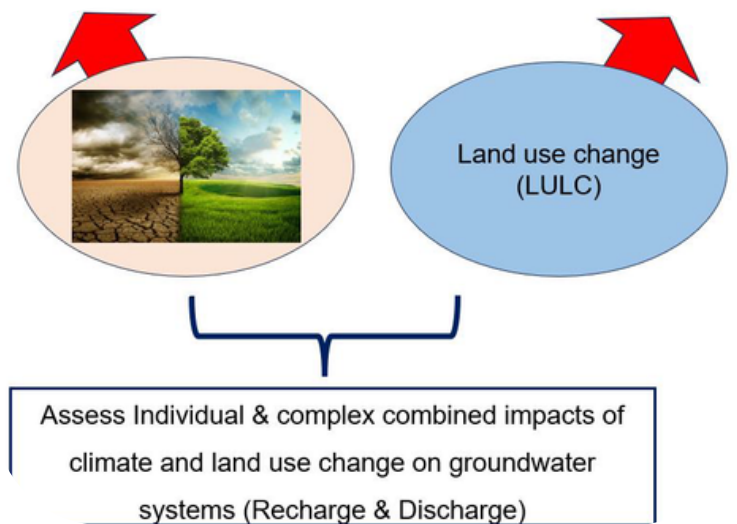
Title of Research Project: The Presence of Microplastics and Toxic Metals with Endocrine Disrupting Chemical Activities in Water Resources and their Health Risks in Africa and perceptions and knowledge of the health impacts of these chemicals and of interventions to improve water quality in relation to toxic metals in South Africa.

Research Aim: The study aims to explore the prevalence of microplastics and toxic metals with endocrine-disrupting chemical (EDC) activities in water resources across Africa, assessing their potential health risks. The study will integrate a comprehensive analysis of existing literature on the distribution and concentration of these contaminants and their documented effects on human health. Additionally, it will include qualitative surveys which will be conducted in South Africa to gauge stakeholder perceptions and knowledge regarding the health impacts of these chemicals. The surveys will also examine the effectiveness of current interventions aimed at improving water quality in relation to toxic metals. By synthesizing scientific data and stakeholder insights, this research seeks to identify gaps in knowledge, raise awareness, and inform policy recommendations for mitigating the health risks associated with microplastics and toxic metals in African water resources.

Project outcomes:

- Information on the types and concentrations of microplastics and toxic metals in African water bodies.
- An understanding of the EDC activities associated with these contaminants.
- A summary of health risks linked to exposure.
- Stakeholder perceptions and knowledge of the health impacts of these chemicals and of interventions to improve water quality in relation to toxic metals in South Africa
- Identification of research gaps and priorities for future studies.

Research Overview



Researcher: Hilja Ndakola

Supervisor: Dr. John Okedi, Department of Civil Engineering

Degree: PhD

Research stage: Ongoing

Title of Research Project: Assessing the impacts of Climate and Land Use change on groundwater recharge and discharge patterns: A case Study of Windhoek Aquifer, Namibia

Abstract: Groundwater resources are under threats from overuse, contamination, and the evolving climate and land-use patterns, posing significant risks. Climate change indirectly impacts groundwater through altered recharge processes, and long-term land use changes further contribute to these impacts. Despite recognizing individual climate and land use change's effects on groundwater, understanding their specific impacts on recharge and discharge patterns is lacking, necessitating local-scale research. This study focuses on Windhoek, Namibia, which partially depends on groundwater, and the water scarcity is exacerbated by changing precipitation, rising temperatures, and rapid population growth. The study aims to assess the impacts of both individual and combined climate and land use changes on groundwater recharge and discharge patterns, with a primary goal of understanding their relationships. This desktop study will use a modelling approach for the comprehensive assessment. The outcomes of this study will guide effective planning and adaptation strategies to ensure a resilient water supply for Windhoek and other communities and ecosystems.

Project outcomes:

Knowledge contribution of the research would be the approach to assess the complex combined impacts of climate and land use/land cover (LULC) change on groundwater recharge and discharge patterns. The study will focus on a localized-scale investigation, which allows for a more detailed understanding of the impacts of climate and LULC changes on groundwater recharge and discharge; and the relationship between climate change, LULC change and groundwater recharge and discharge. The long-term effects assessment of climate and LULC changes will provide valuable insights into the persistence and cumulative impacts on groundwater resources. This study will adopt an integrated modeling approach which will enable a more rigorous and systematic evaluation of the impacts.

Research Overview



Researcher: Zikhona Ngqula

Supervisor: Dr. Nikiwe Solomon, Department of Anthropology

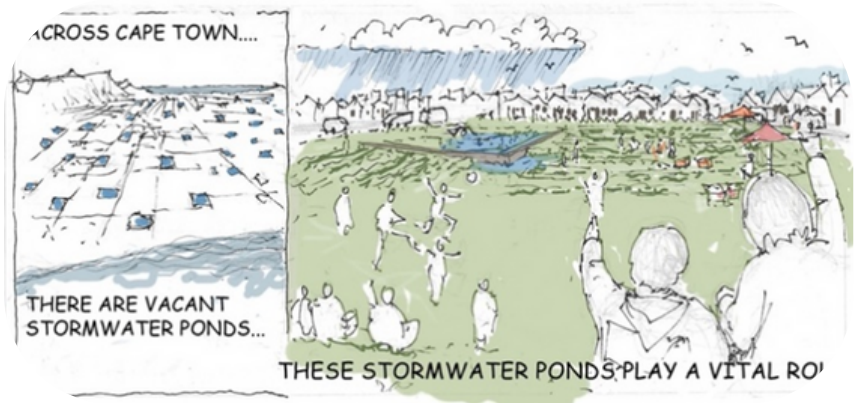
Degree: PhD

Research stage: Ongoing

Title of Research Project: Changing flows, water subjectivities and habitability of the Diep River Estuary in Milnerton, Cape Town

Research Aim: The current R5.2-billion construction upgrade of Potsdam Wastewater Treatment Plant (PWWTP) is the second largest infrastructure project undertaken by the City of Cape Town. This rehabilitation project is set to restore the heavily polluted Milnerton Lagoon to a healthier ecological state. Diep River estuary begins in the Riebeek Kasteel Mountains northeast of Malmesbury, flows approximately 65 kilometres southwest toward Cape Town. It eventually meets the sea (Atlantic Ocean) at Milnerton, approximately 5 kilometres north of the Port of Cape Town. Before entering the sea, the Diep River flows through numerous communities and surrounding towns, and through the Rietvlei wetland, Flamingo Vlei and the Milnerton Lagoon. The interest in this estuary is due to the geographical locations it passes through and the usage of the waterbody by multispecies communities, including humans, as it flows before meeting the sea. The proposed research seeks to explore the varied meanings and ways of relating to the estuary and its associated landscapes that shape how it flows and is governed. The proposed research aims to explore ways of relating to the Diep River Estuary, the varied meanings and relationships produced and how this shapes habitability for human and other-than-human species. The research will draw on transdisciplinary approaches including ethnographic approaches, archival research, document analysis and water sampling to understand the multiple networks that shape the landscape.

Research Overview



Researcher: Julia McLachlan

Supervisor (s): Dr. Kathryn Ewing, A/Prof. Kirsty Carden, School of Architecture, Planning and Geomatics; Future Water & Department of Civil Engineering

Degree: PhD

Research stage: Ongoing

Affiliated Research Project: Pathways to water resilient South African Cities (PaWS)

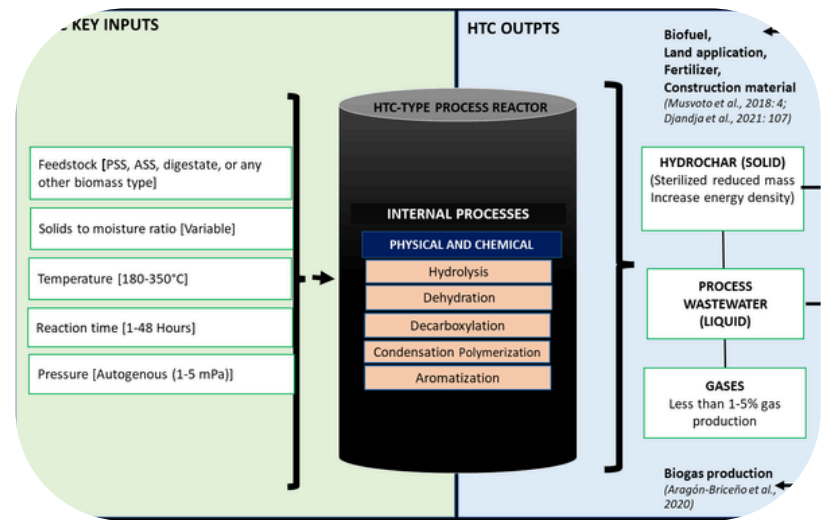
Title of Research Project: Accessing opportunity through storied Blue-Green space: Stormwater infrastructure as productive space, Cape Town

Abstract: Since a near Day Zero calamity, Cape Town's focus has shifted to achieving a Water Sensitive City vision. This vision includes inter alia, strategies that focus on stormwater as a resource: improving stormwater run-off quality using natural filtration systems; harvesting filtered stormwater to recharge groundwater supplies; repurposing stormwater for productive use; and converting portions of the existing stormwater infrastructure into public open spaces. Lending themselves to these strategies are the more than 800 stormwater ponds scattered across Cape Town, that currently provide only for flood attenuation. However, the ponds are often vacant, litter strewn and often perceived by local communities as unsafe for a variety of reasons. The research argues that water is central to our needs and should be integrated into settlements as part of a structural-spatial approach. To do this, the research proposes that, for the constitution of space, processes of both 'spacing' and 'synthesis' are necessary. Critically though, it is the 'synthesis' of space, through the processes of memory, perception and imagination, that needs to be explored in order to translate these stormwater ponds into blue-green productive spaces. Adopting a critical realist philosophical approach, the research uses Situational Analysis, applying it in part to the Pathways to water resilient South African cities Research project (PaWS) set in Mitchells Plain as a collaboration between University of Cape Town's Future Water and the University of Copenhagen. As part of the re-synthesis strategy, the research will also consider how socio-ecological memory can be developed as part of a Community of Practice in order to co-produce knowledge. Through this, it aims to develop a story of landscape systems that reveal the variety of opportunities that these blue-green spaces can provide for a variety of stakeholders.

Project outcomes:

Using Qualitative analysis (Situational Analysis) and employing visual materials, identify potential strategic landscape element interventions that can help to convert the perception of these ponds from mono-functional systems, perceived as empty land, into multi-functional space.

Research Overview



Researcher: Christina Mazivila

Supervisor: A/Prof. David Ikumi, Department of Civil Engineering

Degree: PhD

Research stage: Ongoing

Title of Research Project: The development of a mathematical model for an enhanced hydrothermal polymerization process for sludge treatment.

Abstract: In South Africa (SA), managing wastewater sludge (WWS) is a major challenge and constitutes a significant portion of treatment costs, ranging from 40-50%. As the population continues to grow, urbanization and industrialization are on the rise, leading to an expected increase in WWS production. This highlights the urgent need for sustainable and eco-friendly sludge treatment approaches. Amongst previous research projects funded by the Water Research Commission (WRC), the enhanced hydrothermal polymerisation (EHTP) process has been identified as one of the promising solutions capable of transforming the WWS into calorific-rich hydrochar. Hydrochar serves as an environmentally friendly renewable resource and can be used for applications like biofuel and fertilizers, among others. Despite previous experimental campaigns to test EHTP technology feasibility, there is currently no representative EHTP model that allows for realistic simulations and simplified workflow explanations. This project, funded by the WRC, seeks to develop a mathematical model that can serve a simulation tool for EHTP technology performance, supporting upscaling efforts. Taking a multi-disciplinary approach, the project will integrate the EHTP model into a plant-wide model (PWM), which includes primary sedimentation tanks (PST) and biological nutrient removal (BNR) activated sludge systems (ASS). The ultimate goal is to verify the feasibility of adopting this technology in the SA wastewater sector.

Research Overview



Researcher: Shalongo Angula

Supervisor: A/Prof. David Ikumi, Dr. John Okedi, Department of Civil Engineering

Degree: PhD

Research stage: Ongoing

Affiliated Research Project: WRC Project - Towards Data-Driven Digital-Twins for Integrated Wastewater Reclamation and Reuse

Title of Research Project: Towards Development of System-Wide Digital Twins for Water and Resource Recovery Facilities

Abstract: Advancements in the design and scope of Water and Resource Recovery Facilities (WRRFs), along with the emergence of new technologies, have led to a shift towards integrated modelling approaches rather than the traditional unit-based modelling approach. However, current WRRF models often underrepresent tertiary or advanced wastewater treatment processes, despite water being a significant output of WRRFs. This work aims to advance water treatment modelling within the context of system-wide WRRFs. The development of mechanistic models for ozone (O₃) and biological activated carbon (BAC) (O₃-BAC) systems is currently underway. To improve their performance, particularly for parameters not well predicted by the mechanistic models, these models will be hybridized by integrating data-driven techniques. Additionally, The water treatment models are being developed within the activated sludge modelling (ASM) framework to allow future integration of water treatment models with wastewater plantwide models (e.g., Plantwide Model South Africa – PWM_SA). Ultimately the integrated wastewater and water treatment model will also be extended with models for water resources (i.e., managed aquifer recharge), resulting in a system-wide model for wastewater reclamation and reuse. Another goal is to develop a system-wide WRRF digital twin framework using artificial intelligence (AI)-enabled data and machine learning (ML) techniques for automatic model calibration. The development of such engineering tools will be useful decision-support tools for future wastewater reclamation prospects.

Research Overview



Researcher (s) Name (s): Emily Nicklin

Supervisor (s): A/Prof. Kevin Winter, Environmental and Geographical Sciences

Degree: PhD

Research stage: Ongoing

Title of Research Project: Nature-based solutions for addressing the persistence and toxicity of emerging contaminants in highly polluted surface waters

Abstract: The Stiebeuel River catchment in Franschhoek, South Africa, is a peri-urban area challenged by increasing water scarcity and declining water quality. The Water Hub is a pilot-scale experimentation facility that uses nature-based solutions (NbS) to treat and reuse polluted surface water in the Stiebeuel catchment. This water typically contains high levels of organic matter, nutrients, sulphate and E. coli, originating from greywater runoff and inadequate sanitation facilities in nearby informal settlement. NbS were selected because they are decentralised, low-cost and low maintenance, thereby well-suited for resource-constrained settings like informal settlements, with unreliable access to consistent water and energy supplies. Previous research showed effective removal of key contaminants through constructed wetlands and biofilters but did not consider the potential effects of emerging contaminants (ECs) on human health. To address this research gap, this project investigates the uptake and accumulation of ECs in soil and vegetables. By examining the EC bioconcentration factors in leafy and root vegetables as indicators, the experiment aims to assess the risks associated with using EC-polluted surface waters for irrigation purposes. Comparing the NbS-treated and untreated surface waters offers insight into NbS application for mitigating risks associated with ECs for water reuse.

Project outcomes: Contributes to evidence on the presence and concentrations of ECs, particularly antiretroviral drugs (ARVs), in surface waters impacted by informal settlements. Establishes a robust protocol for monitoring ECs in surface waters and outlines the analytical techniques required for detection at trace levels in water, soil and vegetation samples. Assists in characterising contaminated surface waters by closely monitoring daily fluctuations in various water quality parameters. Advances understanding of alternative treatment options to address surface water pollution, and investigates treatment efficiency of biofiltration systems for removing ARVs from contaminated surface waters, thereby advancing knowledge on mitigating ARV contamination and its potential toxicity effects. Explores water reuse practices in agriculture, highlighting the critical role that NbS can play in facilitating circularity in water management. Risk assessment incorporates the bioconcentration factor of ARV drugs in the soil and crops, providing insights into the potential toxicity of ARV drugs and their persistence in the agricultural environment.

Research Overview



Researcher: Njabulo Thela

Supervisor: Prof. Dyllon Randall, Dr. Caitlin Courtney, Department of Civil Engineering

Degree: PhD

Research stage: Ongoing

Title of Research Project: The development of a pretreatment process to reduce reverse osmosis membrane fouling and scaling caused by acidified urine

Abstract: The global fertilizer industry faces a growing deficit in the key macronutrients, including nitrogen (N), phosphorus (P), and potassium (K), exacerbated by the finite nature of (P) reserves and the energy-intensive production of nitrogen fertilizers. Human urine, which contains significant quantities of these nutrients, presents an opportunity for recovery and recycling. This study explores the potential of using reverse osmosis (RO) to concentrate nutrients from acidified urine, addressing the challenges of membrane fouling and pharmaceutical compounds contamination. While direct human urine is limited by its high water content and logistical challenges, RO offers a promising alternative by efficiently recovering high concentrations of N, P, and K. The integration of nanofiltration (NF) to pretreat urine and improve RO performance has been explored in the past and found to result in significant urea losses, which accounts for the majority of (N) in urine. The study highlights the need for effective methods to mitigate organic fouling and scale formation on membranes, as well as strategies for removing or degrading PhACs to ensure the purity and safety of the resulting fertilizer product.

Project outcomes:

- This research aims to expand the understanding of membrane fouling during the process of concentrating acidified urine by analyzing the foulants that deposit onto RO membranes.
- This research aims to be the first to contribute knowledge to the understanding of how fouling/scaling precursor compounds, including urate ion, proteins, and microorganisms change when acidified urine is acidified; and by developing a process that can produce a liquid fertilizer with the three important nutrients urine using RO membranes.
- The study will add new knowledge on the effectiveness of hydrodynamic cavitation, uricase enzyme, cation resins, and microorganisms as pretreatment methods to reduce membrane fouling and scaling precursor compounds from acidified urine.
- Current RO treatment processes, where urine is stabilized with a base, are unable to recover all the three important fertilizer nutrients, NPK, from a single stream as most of the P in urine precipitates out during stabilization.

The successful development of an effective pretreatment process will make it feasible to concentrate acid stabilized urine and recover NPK in a single stream.

Research Overview



Researcher: Emma Horn

Supervisor (s): Prof. Dyllon Randall, Dr. Rob Huddy, Department of Civil Engineering & Faculty of Health Sciences

Degree: PhD

Research stage: Ongoing

Title of Research Project: Manufacturing bio-tiles using microbially induced calcium carbonate precipitation

Abstract: Bio-tiles are a biobased alternative to conventional tiles that utilise a promising technology called microbially induced calcium carbonate (CaCO_3) precipitation (MICP). This technology has low energy requirements and also sequesters carbon. Bio-tiles have been made in previous work using a submersion method, however, the process required additives such as 0.3 M magnesium chloride to achieve bio-tiles that meet international standards. The current study aimed to improve the bio-tile strength properties with CaCO_3 crystal seeding and a pumping method instead of the use of magnesium that also increases ionic strength. With this technique, cementation solution containing the required calcium and urea for the MICP reaction was pumped through a sealed mould in a series of programmed treatments. The highest concentration of ureolytic *Sporosarcina pasteurii* with an effective urease activity of 40 mmol NH_4 N/L·min was found to be most beneficial to the breaking strength of the bio-tiles, as were the shortest retention times of one hour between treatments. Seeding with CaCO_3 crystals offered significant benefit to the MICP process. Pre-seeding of the geotextiles was explored and the mass of seeds initially present on the geotextiles was found to have a direct improvement on the breaking strength of 21-82%, increasing with seed loading. There is potential for the benefits of the submersion and pumping techniques to be combined into another technique that is automated and more scalable, binder jet 3D printing.

Project outcomes:

Proof of concept that bio-tiles that meet international strength standards for ceramic tiles can be grown with MICP. Multiple techniques can be used to grow bio-tiles that meet the standards. Key parameters have a strong effect on bio-tile strength: bacteria activity, particle size, calcium and urea concentration, magnesium concentration, precipitation rate and seed loading.

Research Overview

Researcher: Joshua Matesun

Supervisor: A/Prof. David Ikumi, Civil Engineering

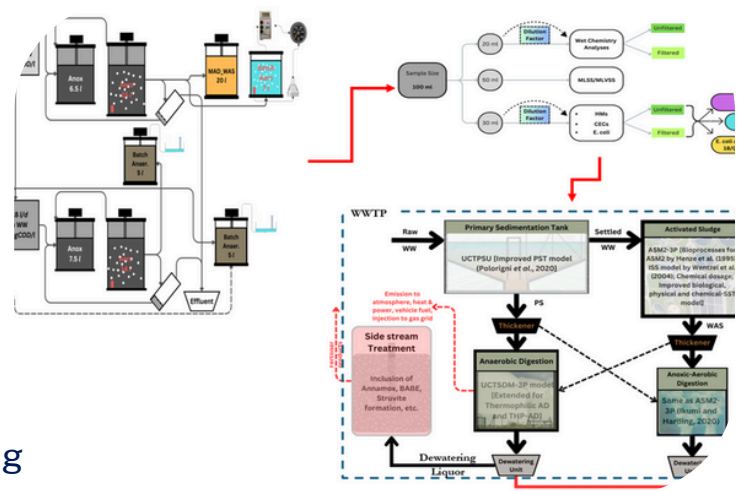
Degree: PhD

Research stage: Write-up

Title of Research Project: The development and calibration of mathematical models to track *Escherichia coli* and micropollutants of concern in a South African wastewater treatment plant

Abstract: Wastewater treatment plants (WWTP) must meet strict effluent discharge regulations to recover resources like water, energy, and nutrients. Mathematical modelling tools have been developed to aid in designing and assessing WWTP, simplifying the process, and evaluating different optimisation strategies (Marais et al., 1987; Gernaey et al., 2004). This study presents a comprehensive analytical framework that combines several methods to track *Escherichia coli* (*E. coli*) and target micropollutants of concern (MPC) in a South African wastewater treatment plant (WWTP). It aimed to examine the behaviour and fate of selected pollutants in Bellville Wastewater Treatment Works before, during, and after conventional treatment processes. Samples were collected for qualitative and quantitative studies of *E. coli*, eleven target metals (TM), and five emerging contaminants (ECs). Qualitative and quantitative data were processed and used to develop and calibrate an evaluative mathematical plantwide wastewater treatment model, which can track TM and CEC, linking the biological treatment unit controls to represent the conventional WWTP in full-scale plants. This rigorous method provides a comprehensive and flexible framework for enhancing MPC monitoring and modelling in WWTP in South Africa. This technique could also help WWTP operators and managers optimise their treatment processes, assess their compliance with effluent discharge regulations, and evaluate the potential for wastewater reuse. T

Project outcomes: Review paper on the limitations of wastewater treatment plants in removing micropollutants of concern and future directions; completed; MethodsX Manuscript; completed; Results on the behavioural changes of studied CECs and target metals in MLEs (separately treating raw and settled wastewater) and AD (separately treating primary sludge, and WAS from settled wastewater) systems; completed; *E. coli* in MLE and AD systems; completed; Behavioural changes of the CECs and metals under aerobic and anaerobic conditions – batch studies – (75% complete); CEC/Metal tracking model developments for MLE and AD systems – (20% complete); Model calibration – (not yet started)



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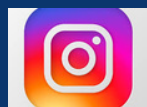
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