# BOOK OF ABSTRACTS

## NAS 2025


www.ufs.ac.za

*Inspiring excellence, transforming lives through quality, impact, and care.*

VISION 130
*Renew and Reimagine for 2034*

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS
NATURAL AND AGRICULTURAL SCIENCES

# Table of Contents

## RHODIUM (I) COMPLEXES AS GREENER MODEL CATALYST FOR HOMOGENEOUS CATALYSIS

**Lerato Bosman, Alice Brink & Dumisani Kama**
Department of Chemistry, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

Catalysis plays an important role in numerous stages of petroleum refinement and fuel production, with one of the major energy sources globally being crude oil for fuels and further production of a variety of chemicals. However, synthesis of highly selective catalysts still poses a significant challenge in most of these processes. Methanol carbonylation is one of the major homogeneously catalysed processes for the production of the acetic acid. With the oxidative addition of methyl iodide being the rate determining step in this catalytic process; the selectivity of the catalyst in favour of the desired product may be achieved by varying the ligand system of said catalyst as well as the reaction conditions. The selectivity for acetic acid production with rhodium-based catalysts in a homogeneous medium is roughly 99%. Catalytic rhodium systems activity and selectivity are vastly improved by phosphine ligands leading to favourable results under milder conditions. Rhodium(I) complexes, [Rh(N,O)(CO)PR3] (R= Ph, Cy), coordinated to Schiff-base ligands with various phosphine ligands coordinated to the metal centre are hereby reported. An extensive structural characterisation of the complexes followed by the kinetic study using UV/Vis, infrared and nuclear magnetic resonance spectroscopy are reported. The influence of halogens (F, Cl, Br) on the paraposition of the Schiff base ligand on the methyl iodide oxidative addition to the rhodium(I) carbonyl with triphenylphosphine (PPh3) ligands are also reported. A structural crystallographic study showed the manifestation of pseudo-dimeric metal-metal interactions in the bromo substituted complex with a Rh-Rh distance of 3.3743(6) Å. The iodomethane oxidative addition to the rhodium(I) complex with the bromine para-positioned Schiff-base suggested rhodium (III) alkyl species as the final product, with the rate constant, k1, of 0.0127(6) M-1 s-1. Finally, the study found that the rate of reaction increased with the increasing electronegativity of the halogen substituent.

**Keywords**: rhodium, schiff base, catalysis, carbonylation

**Poster Sessions**

---

## THE SYNTHESIS AND CHARACTERISATION OF CYCLODEXTRIN METAL ORGANIC FRAMEWORKS (CDMOFS) - FOCUSING ON PARTICLE SIZE REDUCTION

**Sokhana Gawe & E.H.G. Langner**
Department of Chemistry, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

Metal-organic frameworks (MOFs) have emerged as trailblazing materials in recent decades, owing to their highly tuneable porosity, high thermal and chemical stability and ease of chemical functionalisation. Cyclodextrins (CDs), naturally occurring materials derived from the enzymatic decomposition of starch, are porous, crystalline, non-hygroscopic compounds with a truncated cone

shape. Utilising CDs as organic ligands has given rise to a biocompatible subclass of MOFs known as CD-MOFs that present minimal material-associated risks for drug delivery applications. Reducing the particle size of CD-MOFs is crucial for their effectiveness in drug delivery applications, as smaller particles can enhance cellular uptake and improve bioavailability. Additionally, nanoscale MOFs offer better control over drug release rates and can easily penetrate biological barriers. In this study, we investigated the effects of different synthesis parameters on the crystal size, surface area, thermal stability, morphology, and drug-loading capacity of CDMOFs. Dynamic Light Scattering (DLS) and Transmission Electron Microscopy (TEM) were employed to assess particle morphology and size distribution. By varying ultrasound power levels and synthesis duration, we achieved significant particle size reduction – from approximately 240.5 nm for a-CD-MOF 200W-5min to around 77.4 nm for a-CD-MOF 500W-5min. Thermo-Gravimetric Analysis (TGA) revealed a single-step decomposition and thermal stability above 200$^{o}$C across all synthesised samples. The reduced particle sizes are anticipated to result in increased surface area and enhanced drug-loading capacity.

**Acknowledgements**

This work was financially supported by the National Research Foundation of South Africa.

**Keywords**: MOFs, CD-MOFs, synthesis, particle size control

**Poster Sessions**

---

## BIOSYNTHESIS OF SILVER NANOPARTICLES AND THEIR APPLICATIONS

**Neliswa Kunene, Anke Wilhelm, Elizabeth Erasmus & Marietjie Schutte-Smith**

Department of Chemistry, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

Nanotechnology is revolutionising many scientific fields with novel applications in medical science, environmental science, and materials science. Of its many applications, silver nanoparticles (AgNPs) are of particular interest due to their antimicrobial, anticancer, and diagnostic effects. Green synthesis of AgNPs using plant extracts has emerged as a non-toxic, eco-friendly alternative to conventional chemical approaches with the promise of a novel non-toxic, environmentally friendly approach by utilising phytochemicals as inherent reducing and stabilising agents. In this study, the green synthesis of silver nanoparticles using aqueous extracts of three South African plants namely *Aspalathus linearis* (rooibos), *Burkea africana*, and *Strelitzia reginae*, is investigated. Phytochemical analysis of the extracts confirmed the presence of bioactive compounds such as flavonoids, phenolics, and tannins responsible for the synthesis of nanoparticles. The biosynthesised AgNPs were characterised by Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS) as nanoparticles of varied shape and size, with elemental confirmation of silver. Further characterisation using infrared (IR) spectroscopy, Transmission Electron Microscopy (TEM) and UV-Visible spectrophotometry is underway. Successful synthesis of AgNPs using these local plants confirms that they are viable substitutes for more studied species. As an alternative to traditional methods, the process is environmentally less demanding using unexploited local biodiversity. The research contributes to a growing body of work in advocating green nanotechnology and expanding the phytochemical studies of South African plants used in synthesising nanoparticles. The results of this research hold great promise for biomedical applications, especially in cervical cancer diagnosis and toxicity assessment. This work enables the development of low-cost, sustainable nanomaterials with practical therapeutic and diagnostic applications, advancing toward the greater goals of nanomedicine with accessibility and environmental friendliness.

**Acknowledgements**

To Marietjie, Anke and Elizabeth: Need I say more? Thank you for your unwavering support and guidance. You all truly have a gift for this work and to the study of science. I am immensely indebted to you for the motivation and mentorship that brought me this far. To the NAS Faculty at the University of the Free State, the Department of Chemistry, and the Nanoscience bursary: Ngiyabonga for your contribution and foundational support in my pursuit to becoming the first MSc graduate in my family.

**Keywords**: Green synthesis, silver nanoparticles (AgNPs), South African medicinal plants, phytochemicals, biomedical applications

**Poster Sessions**

---

# DESIGN AND TAILORED BIODEGRADABLE COMPOSITES FOR 3D PRINTING OF MEDICAL DEVICE APPLICATIONS

**M.D. Maphakisa[1], J.P. Mofokeng[1] & O.J. Botlhoko[1]**

[1]Department of Chemistry, University of the Free State, Phuthaditjhaba, South Africa

[2]Department of Chemistry, University of Johannesburg, Auckland Park, South Africa

## ABSTRACT

Medical plastic devices transformed the medical industry due to their cost efficiency, lightweight nature, durability, and sterilizability. However, due to their single use, they produce a large amount of waste, which ends up as an environmental and aquatic pollutant. Accumulating medical plastic waste from petroleum-based polymers has sparked an interest in using biodegradable polymers to develop sustainable, short shelf-life medical devices, including testing kits. This project aims to reduce plastic pollution by producing biodegradable 3D-printed disposable medical devices using polylactic acid (PLA), thermoplastic starch (TPS), and polycaprolactone (PCL) blends and composites with sisal fiber (SF). From Differential scanning calorimetry (DSC), PCL and TPS in PLA acted as plasticisers by shifting the Tcc and Tm to lower temperatures and reducing the degree of crystallinity of PLA chains. SF enhanced the formation of perfect crystals by increasing the crystallisation and melting temperatures of PLA and PCL. The presence of SF seemed to have recovered the thermal stability of PLA and PCL, as their Td was slightly increased for all the composites. The tensile properties of the blends were reduced with the addition of PCL and TPS to PLA, while the elongation at break increased. The incorporation of SF improved the tensile properties but reduced the extensibility of the composites. The FTIR revealed no chemical interaction between the components of the blends. Blending PLA with TPS and PCL effectively improved the brittleness of PLA. At the same time, incorporation of SF perfected the crystals formed and enhanced the rigidity of the blends.

Keywords: Biodegradation, Polylactic acid, 3D-Printing, Characterisation

**Poster Sessions**

---

# IMPROVING NIGHT-TIME ROAD SAFETY USING $SRAL_2O_4:EU^{2+}$ FOR GLOW-IN-THE-DARK

**Lethabile Masiu[1], Mart-Mari Duvenhage[1] & Mubarak Yagoub[2]**
[1]Department of Physics, University of the Free State, Bloemfontein, South Africa
[2]Department of Physics, University of Johannesburg, Auckland Park, South Africa

## ABSTRACT

Unmarked and poorly illuminated roads significantly contribute to night-time traffic accidents, particularly in rural and underdeveloped areas with limited or no street lighting infrastructure. The lack of visible road markings reduces driver awareness and increases the risk of collisions, posing serious danger to both motorists and pedestrians. Despite lower traffic volumes at night, global traffic statistics indicate a disproportionately high rate of fatal accidents during these hours. To address this challenge, this study investigates the use of phosphorescent material – specifically strontium aluminate doped with europium $SrAl_2O_4:Eu^{2+}$ – as a sustainable solution for enhancing night-time road visibility. $SrAl_2O_4:Eu^{2+}$ was synthesised using the solid-state reaction method due to its simplicity, cost-effectiveness, and suitability for large-scale production. X-ray diffraction (XRD) confirmed the formation of a monoclinic crystal structure, while photoluminescence (PL) analysis identified the most effective luminescent composition. UV-Vis spectroscopy revealed a host lattice band gap of 5.22 eV. Scanning electron microscopy (SEM) provided morphological detail, and both energy-dispersive X-ray spectroscopy (EDS) and time-of-flight secondary ion mass spectrometry (TOF-SIMS) confirmed the successful distribution of dopant elements. Although the human eye is most sensitive to green light under bright conditions, it shifts toward blue-green wavelengths in low-light (scotopic) environments, which aligns with the emission profile of $SrAl_2O_4:Eu^{2+}$ This makes the material well-suited for dark settings. Based on these results, the material shows promise for integration into road markings and signage, potentially improving visibility and reducing accident rates in poorly lit areas. The study supports the development of low-energy, high-impact solutions for safer and more sustainable transportation infrastructure.

**Acknowledgements**
Mart-Mari Duvenhage and Mubarak Yagoub (helpful weekly discussions). CSIR (Funder of the project), UFS

**Keywords**: Road-Markings, Luminescence, Phosphorescence

**Session 6**

---

# BIOSYNTHESIS OF GOLD NANOPARTICLES AND THEIR APPLICATIONS

**Katleho K. Mathapo, Anke A. Wilhelm, Elizabeth E. Erasmus & Marietjie M. Schutte-Smith**
Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

In the present study, gold nanoparticles were synthesised using aqueous extracts from South African indigenous plants (*Strelitzia reginae*, *Aspalathus linearis* (rooibos), and *Burkea africana*). The plant material extracts are rich in diverse phytochemicals that possess important antibacterial, anticancer, antioxidative stress, and antiviral properties. The biomolecules present in plant extracts serve as both reducing and capping agent facilitating the reduction of Au 3+ to Au 0 and resulting in the formation of AuNPs. Some traditional health practitioners use the plants to cure diseases caused by bacterial pathogens. Thus, the aim of the study is to conduct a phytochemical investigation of the plant extracts, perform toxicity screenings with the aid of zebrafish larvae and synthesise gold nanoparticles using the

plant extracts as they might be good candidates for the therapeutic intervention of cancer. The ground dried plants were extracted with ultra-pure water for 24 hours at room temperature. For synthesis of gold nanoparticles, parameters such as HAuCl4 (1 mM) in a 6:4 ratio to the plant extracts at different pH values (4, 6, 7, 8) were assessed. Thin layer-chromatography was used to profile aqueous plant extracts with the aim to investigate the phytochemicals present in each plant. Scanning Electron Microscopy (SEM) was used to study the size, shape and morphology of the nanoparticles. Scanning Electron Microscopy (SEM) images of the synthesised gold nanoparticles indicated that they are spherical in shape, with size ranging from 50 to 200 nm. Further characterisation using Transmission Electron Microscopy (TEM), UV-Visible spectroscopy and Infrared (IR) spectroscopy is still underway. AuNPs were synthesised successfully using local plants extracts that contain bioactive compounds. The research contributes to the growing field of green chemistry and holds a great promise for water treatment and biomedical applications, especially in dye degradation and cervical cancer diagnosis.

**Acknowledgements**

My sincere gratitude is expressed to Prof Anke Wilhelm, Prof Marietjie Schutte-Smith and Prof Elizabeth Erasmus for their invaluable contribution and guidance. I thank the entire organic chemistry division for providing me with the necessary tools to make progress with my project. I would like to extend my gratitude to the Nanoscience programme for financial support.

**Keywords**: gold nanoparticles, phytochemicals, South African medicinal plants, antibacterial

**Poster Sessions**

---

# BLUE-EMITTING LANTHANIDE FREE $Ca_2YZr_2Al_3O_{12}:Bi^{3+}$ PHOSPHORS FOR LIGHT-EMITTING DIODES APPLICATIONS

**Thandi E. Mazibuko, David E Motaung & Hendrik C. Swart**

Department of Physics, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

White light-emitting diodes (WLEDs) have emerged as a superior lighting technology due to their numerous advantages, such as ecological friendliness, extended lifetimes, and low power consumption. WLEDs are typically fabricated using a combination of yellow $Y_3Al_5O_{12}:Ce^{3+}$ ($YAG:Ce^{3+}$) layers on the surface of the blue InGaN LED chip. However, health effects such as sleep disorders can result from the high emission intensity and narrow full width at half maxima of blue LED chips. Creating warm white light from the combination of near ultraviolet (n-UV) chips with red, blue, and green phosphors can solve this problem. Therefore, phosphors excited by n-UV chips have attracted more attention recently. However, most studies have focused on lanthanide-activated systems, which are often an expensive resource, making them less desirable for commercialisation. Thus, it is necessary to develop lanthanide-free $Bi^{3+}$-activated blue phosphors for WLEDs. $Bi^{3+}$ ions have the advantages of absorption in the n-UV region, little reabsorption, environmental friendliness, and low cost compared to $Eu^{2+}/Ce^{3+}$. Blue-emitting $Bi^{3+}$-activated phosphors $Ca_2Y_{1-x}Zr_2Al_3O_{12}:xBi^{3+}$ ($CYZA:xBi^{3+}$) were synthesised using the high-temperature solid-state method. The undoped and doped samples were found to crystallise to a garnet-type cubic structure, Ia3(-)d space group, proving that doping did not significantly alter the crystal structure. The undoped sample exhibits a wide band gap of 5.68 eV, ideal for ion incorporation. $CYZA:xBi^{3+}$ phosphors emitted blue light peaking at 399 nm and 450 nm when excited at 312 nm and 367 nm. The highest emission intensity was observed in the $CYZA:4\%Bi^{3+}$ sample sintered at 1400°C for 5 hours, after which concentration quenching occurred. Due to the efficient excitation in the n-UV region and the strong blue emission, $CYZA:xBi^{3+}$ would be a potential blue phosphor for n-UV pumped LEDs.

**Acknowledgements**

This work is based on the research supported by the South African Research Chairs Initiative of the Department of Science and Technology and the National Research Foundation of South Africa.

**Keywords**: lanthanide-free, blue-emitting, wLEDs, garnet-type phosphor

**Session 6**

---

# FLAMMABILITY PERFORMANCE OF PLA/PCL BLEND WITH EXPANDABLE GRAPHITE AND VERMICULITE

**Mfiso E. Mngomezulu[1], Adriaan S. Luyt[2] & Maya J. John[3,4]**

[1]Department of Chemistry, University of the Free State, Phuthaditjhaba, South Africa
[2]Center for Advanced Materials, Qatar University, Doha, Qatar
[3]Bioplastics and Biocomposites Platform, CSIR, Pretoria
[4]Department of Textile Science, Nelson Mandela University, Gqeberha, South Africa

## ABSTRACT

Due to growing global sustainability concerns on the use of petroleum-based polymers and halogen-based flame retardants, the use of biodegradable polymers and natural flame retardants is a viable solution. This work aims to investigate the effect of vermiculite (VMT) and expandable graphite (EG) as eco-friendly flame retardant system for polylactic acid/poly(e-caprolactone) (PLA/PCL) blend. The PLA-PCL/VMT/EG composites were prepared via melt-mixing method using the Brabender-Plastograph. The thermal stability and flammability properties of flame retarded PLA/PCL blend were respectively studied via simultaneous thermogravimetric analysis-Fourier transform infrared spectroscopy (TGA-FTIR), and cone calorimetry. Additionally, the char morphology was characterised using scanning electron microscopy (SEM). Although the incorporation of EG into PLA/PCL/VMT blend composites showed reduced onset temperature of thermal degradation, but both the thermal stability and char residue were improved to about 6.6% and 29.1%, respectively. The flammability test results revealed that there was synergy between VMT and exfoliated EG which formed a stable protective intumescent char layer on the surface of the composites. This was confirmed from the reduced peak heat release rate (pHRR) by 32.9, 55.4 and 76.3% at various EG loadings. The formed char layer favoured the extinguishing of the flame, separated oxygen from the burning materials and hindered the combustible gases from feeding the flame, thus lowered the degree of burning of volatile gases. From the smoke emission behaviour of PLA/PCL/VMT-EG, the results indicated reduced total smoke release (TSR) (~47.4 – 61.4%) and specific extinction area (SEA) (~32.3 – 51.6%) at 10 – 15wt.% EG loadings hinting that EG acted as effective smoke suppressant. The formation of intumescent char layer was indeed confirmed by SEM analysis of char residue from cone calorimetry tests. Thus, the fabricated eco-friendly flame retarded PLA/PCL/VMT-EG materials have the potential to reduce the loss of lives and casualty in a real fire.

**Acknowledgements**

The authors would like to acknowledge the financial support by the National Research Foundation (NRF) and Professional Development Programme (PDP). Acknowledgements are further extended to fellow colleagues and researchers (Mr Steve A Chapple and Dr Valencia N Jacobs) for their undivided attention and support.

**Keywords**: flammability, poly (lactic acid), poly (e-caprolactone), expandable graphite, vermiculite

**Session 6**

---

# DUAL-MODE LUMINESCENT COLOUR-TUNABLE $BaYF_5:Yb^{3+,}$ $Tb^{3+}$, $Eu^{3+}$ NANOPHOSPHORS FOR MULTI-SPECTRAL ANTICOUNTERFEITING APPLICATIONS

**Govind B. Nair, Hendrik C. Swart, Lucas J. B. Erasmus & Sumedha Tamboli**
Department of Physics, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Counterfeiting poses a major threat to the economic growth of a country and leads to heavy financial losses and security risks. Several industries such as pharmaceuticals, electronics, currency systems and fashion are affected by counterfeiters and measures must be adopted to safeguard their authenticity and product integrity. Traditional security features such as barcodes, holograms, watermarks or quick response (QR) codes can be easily mimicked or bypassed with advanced technology. However, light-based information cannot be easily duplicated, and it can be decoded only under certain specific photonic excitations. Luminescent materials offer hidden and more secure verification using their upconversion (UC) and downshifting (DS) modes. UC process converts high-energy photons into low-energy photons, whereas the DS process does the vice versa. By implementing both of these modes on a luminescent material, dualchannel security features can be unlocked. In this study, dual-mode luminescent $BaYF_5:Yb^{3+}$, $Tb^{3+}$, $Eu^{3+}$ nanophosphors were synthesised using a microwave-assisted hydrothermal method. These nanophosphors exhibited colour-tunable fluorescence when excited either by 360 nm near-ultraviolet (NUV) rays or 980 nm near-infrared (NIR) rays. The phase purity of the phosphors was confirmed from the X-ray powder diffraction (XRPD) patterns, whereas the high-resolution transmission electron microscopy (HR-TEM) images confirmed the spherical particle morphology of the nanophosphors with their size varying between 15-22 nm. The doping concentrations of $Tb^{3+}$ and $Yb^{3+}$ ions were optimised based on their photoluminescence (PL) spectra. By keeping the doping levels of $Yb^{3+}$ and $Tb^{3+}$ ions fixed, the $Eu^{3+}$ concentration was varied in the $BaYF_5$ host to achieve the colour tuning from green to red. For demonstrations of the applicability of these nanophosphors for anticounterfeiting, security inks were successfully prepared using $BaYF_5$:Yb3+, $Tb^{3+}$, $Eu^{3+}$ nanophosphors. By exploring the colour-tuning and dual-mode luminescence features, different patterns were produced on currency notes and paper using these inks.

**Acknowledgements**
This research is supported by the South African Research Chairs Initiative of the Department of Science and Technology and National Research Foundation of South Africa (Grant 84415). The PL system used is supported by the rental pool programme of the National Laser Centre (NLC) and funded by the National Research Foundation of South Africa (Grant EQP14080486021, 93214). The financial assistance from the University of the Free State is highly recognised.

**Keywords**: Anticounterfeiting, dual-mode luminescence, nanophosphors, colour-tuning

**Session 6**

---

# AB INITIO AND MULTICHANNEL RRKM COMPUTATIONS OF RATE CONSTANTS FOR HYDROCARBON RADICALS REACTING WITH $O_2$

**Kgalaletso Otukile[1], Cameron Matthews[1], Lyudmila Moskaleva[1], Ramakhrishnan Raghunathan[2], Sabyasachi Chakrborty[2] & Saurabh Kandpal[2]**

[1]Department of Chemistry, University of the Free State, Bloemfontein, South Africa
[2]Tata Institute of Fundamental Research, Hyderabad, India

**ABSTRACT**

Using a combination of electronic-structure theory, variational transition-state theory, and multichannel Rice-Ramsperger-Kassel-Marcus (RRKM) theory, we have theoretically studied the kinetics of the reactions of the hydrocarbon radicals (R = ethyl, isopropyl, isobutyl, tertbutyl, neopentyl, cyclohexyl, cyclohexenyl, and cyclohexadienyl) with molecular oxygen over wide ranges of temperature and pressure. The formation and decomposition of alkylperoxy ($RO_2$) and hydroalkylperoxy (QOOH) radicals play an important role in the reaction between R and O2. In low temperature combustion processes (T < 1200 K), these radical intermediates are crucial for chain propagation. For the RO2 decomposition, concerted OOH elimination reactions are preferred over isomerisation reactions for all the systems, except for isobutyl and neopentyl systems which have barrier heights (kcal/mol) for isomerisation and concerted OOH elimination (in parenthesis) channels of 30.4 (31.6) and 24.7 (66.9), respectively. For the QOOH dissociation, cyclic ether + OH formation is favoured over the alkene + OOH formation for all the systems, except for cyclohexadienyl system which has the barrier heights of 9.5 kcal/mol and 22.6 kcal/mol, respectively, for the alkene + OOH formation and cyclic ether + OH formation. Multichannel RRKM computations of the ethyl and isopropyl reactions with $O_2$ reveal three distinct kinetic regimes across the temperature range: low, intermediate, and high. The close agreement between the calculated and available experimental rate constants for the ethyl and isopropyl systems support their uses as prototypes for complex R + $O_2$ reactions.

**Acknowledgements**

The authors acknowledge the support of the National Research Foundation (NRF) of South Africa, the Department of Science and Technology (DST) of India, and the Centre for High-Performance Computing (CHPC), South Africa.

**Keywords**: combustion, kinetics, mechanism, radical

**Poster Sessions and Session 6**

---

# SYNTHESIS OF GRAPHENE OXIDE (GO), ZIRCONIUM OXIDE (ZRP) AND GO/ZRP NANOCOMPOSITES AS HEAVY METAL IONS ADSORBENTS IN WATER

**Lebohang Seromo[1], Julia Puseletso Mofokeng[1] & Nagi Greesh[2]**
[1]Department of Chemistry, University of the Free State, Phuthaditjhaba, South
[2]Libyan Advanced Center for Chemical Analysis, Tripoli, Libya

**ABSTRACT**

Contaminated water, especially by heavy metals, has a harmful impact on all living organisms and ecosystems. Lead (Pb) is among the deadliest heavy metal contaminants and removing it from water has been challenging to ensure clean drinking water for living organisms. This study seeks to find effective materials and methods for removing Pb contaminants in water. Graphene oxide (GO) and zirconium phosphate (ZrP) have been synthesised using modified Hummer's and precipitation methods, respectively. That was followed by the preparation of GO/ZrP nanocomposite using a simple solution-based method, and its morphology and structural properties have been characterised using Scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), and X-ray diffraction (XRD). Their effectiveness in adsorption of the lead contaminant will be conducted using atomic absorption spectroscopy (AAS). According to FTIR, XRD, and SEM, expandable graphite

oxidation to GO succeeded. This was confirmed by the development of the oxygen-containing functional groups from FTIR, and the increase in its interlayer spacing as per SEM and XRD's calculated d-spacing (from 0.3420 to 0.9074 nm). FTIR also revealed that the phosphate groups were attached to the zirconium (IV) chloride, and the resultant ZrP was grafted onto the GO to form GO/ZrP nanocomposite. The prepared nanocomposites will finally be incorporated into the biodegradable polymer blends to form polymer blends nanocomposites with potential use in the fabrication of membranes used in water purification via the adsorption process.

**Acknowledgements**

I would like to give an extent of gratitude to my supervisor, Prof J.P. Mofokeng, and my co-supervisor, Dr N. Greesh, for their enormous help and support they provided since the beginning of the study. I would also like to thank the National Research Foundation (NRF) and the Sasol Inzalo Foundation (SAIF)for their financial support.

**Keywords**: contaminated water, heavy metals, graphene oxide, zirconium phosphate

**Session 6**

# A MACHINE LEARNING APPROACH TO FLOOD SUSCEPTIBILITY MODELLING: CASE STUDY OF KWA-ZULU NATAL PROVINCE, SOUTH AFRICA

**Sodiq A. Alimi**
Department of Geology, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Frequent loss of lives and property due to flooding in urban and rural areas of KwaZulu-Natal (KZN), South Africa, highlights the urgent need for effective flood mitigation strategies. A flood susceptibility map can help identify high-risk zones and guide informed planning and development to reduce flood impacts. This study aims to generate a flood susceptibility map for KZN using a Geographic Information System (GIS)-based machine learning approach. Nine key flood-influencing factors were used as predictors: rainfall, soil type, lithology, distance to streams, drainage density, elevation, slope, land use/land cover, and the normalised difference vegetation index (NDVI). A dataset of 250 recorded flood locations was divided into training and testing sets in an 80:20 ratio. The Random Forest (RF) algorithm was chosen for its robustness in handling multiple variables and identifying patterns across datasets. To enhance model performance, hyperparameter tuning was applied with the following settings: mtry = 2, ntree = 1000, random state = 42, and stratification enabled. The resulting flood susceptibility map demonstrated high performance, achieving accuracy, precision, F1 score, and AUC values of 0.94, 0.96, 0.91, and 0.97, respectively. High susceptibility zones were primarily located near the coastline, characterised by low elevation and high rainfall. The study emphasises the urgent need for targeted flood mitigation policies in these coastal areas. Machine learning-based flood prediction offers a rapid, accurate, and cost-effective solution for mapping flood risk and can be extended to other flood-prone regions in South Africa. The outcomes of this study provide valuable insights for researchers, planners, and policymakers aiming to prevent and reduce the impact of flooding in vulnerable areas.

**Keywords**: Durban, flood risk, Ilembe, eThekwini

**Session 10B**

---

# ASSESSING THE DATA QUALITY OF ERA5 DATASETS IN RELATION TO SUMMER TEMPERATURE INDICES OVER SOUTH AFRICA: 1979-2023

**Nicolle Loader[1,2], Adriaan van Der Walt[1,3], Ramontsheng Rapolaki[1,4] & Sarah Roffe[1,5]**
[1]Department of Geography, University of the Free State, Bloemfontein, South Africa
[2]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa
[3]Afromontane Research Unit, University of the Free State, Bloemfontein, South Africa
[4]South Africa Marine Research Unit, South African Weather Service, Cape Town, South Africa
[5]Agrometeorology Division, Agricultural Research Council – Natural Resources and Engineering, Pretoria, South Africa

## ABSTRACT

Global surface temperatures have increased by ~1.07°C since 1970, primarily due to human-induced greenhouse gas emissions, leading to more frequent and intense above-normal temperature events, including heatwaves. In South Africa, maximum and minimum temperatures have risen significantly since 1960, alongside notable increases in the frequency, intensity, and duration of above-normal

temperature events. These trends pose serious risks to agriculture and water resources, contributing to growing food insecurity and water shortages. This study assesses the quality of reanalysis temperature data across South Africa from 1979 to 2023. Daily maximum temperature data from 3-4 South African Weather Services (SAWS) stations per province were compared with the freely available ERA5, ERA5-Land, and AgERA5 reanalysis products from 1979-2023. A selection of ET-SCCI temperature indices relevant to climate-sensitive sectors (e.g. Txge30, TXge35, TX90t, and SU) was calculated and statistically evaluated using the Mann-Whitney U test and Spearman's correlation. Preliminary results indicate strong alignment between reanalysis and station data; however, further analysis is needed to confirm these findings across different climate zones. This study lays important groundwork for improving the accuracy of temperature monitoring and supports informed adaptation planning to address urgent climate risks in South Africa's agricultural and water management sectors.

**Keywords**: ERA5, Temperature indices, ET-SCCI, SAWS

**Session 10B**

---

# RESPONSE OF SOIL QUALITY INDICATORS TO SIMULATED RANGELAND CONDITIONS AND SEASONAL VARIATIONS IN THE SEMI-ARID CENTRAL SOUTH AFRICA

**Palo Loke, Dirk Marx, Elmarie Kotzé & Johan van Tol**
Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Rangelands provide the cheapest source of livestock feed and play a crucial role in terrestrial carbon (C) cycling due to their extensive geographic coverage. This also applies in South Africa, where commercial livestock farming is the dominant rangeland management system that contributes significantly to national animal production. However, poor management and climate are depleting soil resources. This is particularly pronounced in arid and semi-arid regions, which are characterised by slow vegetation and soil organic matter (SOM) turnover due to hot-dry climates. This study investigated effects of simulated rangeland conditions and seasons on soil quality indicators within the top 10 cm of a sandy loam Acrisols. Field measurements and soil sampling were conducted seasonally across five rangeland conditions: good, moderate, poor, bare and cultivated. Samples were analysed for bulk density (BD), SOM, soil C, nitrogen (N), active carbon (AC), microbial biomass (MB), phosphorus (P), exchangeable base cations (K, Ca, Mg, and Na), cation exchange capacity (CEC), penetrometer resistance (PR), soil temperature (ST), and infiltration rate (IR). Bare and cultivated plots consistently exhibited higher PR and ST but lower IR compared to the good, moderate and poor conditions throughout the year. Regardless of seasonal variations, significant losses averaging to 22–80% of SOM, SOC, TN, AC and MB were recorded in the bare and cultivated plots. Soil pH, K, Ca, Mg, and CEC followed similar trends, except for P, which was higher in bare and cultivated plots during spring. In winter, P levels in cultivated plots were comparable to those in good and moderate conditions but remained higher than in bare and poor plots. Principal Component Analysis identified soils in good, moderate and poor conditions as healthier than those in bare and cultivated plots, suggesting that maintaining vegetation cover has the potential to improve soil quality in semi-arid rangelands amidst seasonal fluctuations.

Keywords: seasonal variability, semi-arid climate, simulated rangeland conditions, soil quality

**Session 10A**

---

# THE EFFECTS OF PLANTING GEOMETRY AND IRRIGATION REGIMES ON PIGEON PEA (*CAJANUS CAJAN*) PERFORMANCE IN SEMI-ARID ENVIRONMENT

**S. Manzini[1,2], W.A. Tesfuhuney[1], Z.A. Bello[2,3]**

[1]Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa
[2]Agricultural Research Council- Grain Crops, Potchefstroom, South Africa
[3]Climate Global Change Centre, University of Limpopo, Polokwane, South Africa

## ABSTRACT

Pigeon pea is an underutilised legume crop in South Africa known for its drought tolerance and nitrogen-fixation capabilities. It also has the potential to improve soil fertility and structure, ensure food security, and it can be a source of income for small-scale farmers. Small-scale farmers face challenges in optimising pigeon pea productivity, including inefficient planting geometries, inadequate irrigation, and limited knowledge of resource-use strategies. This study evaluated how different irrigation and planting geometry practices affect pigeon pea growth, development, water productivity, and radiation use efficiency in a semi-arid climate. The experiment was arranged in a randomised complete block design (RCBD) with split-plot restrictions across four blocks and three treatments: irrigation (main treatment), cultivars (ICEAP 86012 and ICEAP 00604), and planting geometry (45 cm x 28cm, 60cm x 21cm, and 75 cm x 17 cm). Plant height, leaf area, dry matter accumulation, and light interception were measured starting six weeks after emergence, with subsequent measurements at 7 to10-day intervals until maturity. Morphological traits were recorded throughout the plant's developmental stages. The different planting geometries showed significant effects on radiation interception and final yield. Under full irrigation, narrow rows intercepted more radiation than wide rows, resulting in a higher leaf area index. The differing canopy structures of the two cultivars under various irrigation regimes affected radiation reaching the soil surface. Plants with full irrigation in wide rows with narrow plant spacing achieved a higher yield (3.2 t/ha) than narrow rows with wide plant spacing (2.5 t/ha) due to reduced competition for water and radiation resources. However, the common planting geometry has a recorded yield of 5.1 t/ha in full irrigation, and the yield differs under partly and rainfed conditions. The RUE interaction between the different treatment indicated an insignificant difference at the p= 0.05. The ICEAP 00604 cultivar, with less branching, performed better under rainfed conditions, while the more vigorously branching ICEAP 86012 cultivar yielded higher with supplementary irrigation. Pigeon pea productivity can be improved by adjusting row and plant spacing under different irrigation regimes based on specific cultivar characteristics, enhancing resource-use efficiency in semi-arid environments.

**Keywords**: planting geometry, radiation interception, radiation use, underutilised crop, yield

**Session 10A**

# CLIMATE-DRIVEN SHIFTS IN THE RANGE OF SELECTED INVASIVE ALIEN PLANTS IN SOUTH AFRICA

**Achamyeleh G. Mengistu[1], Abraham S. Steyn[1], Weldemichael A. Tesfuhuney[1] & Yali E. Woyessa[2]**

[1]Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa

[2]Department of Civil Engineering, Central University of Technology, Free State, Bloemfontein, South Africa

## ABSTRACT

Invasive alien plants are among the leading causes of native biodiversity loss worldwide. Understanding their dynamics under changing climate conditions is therefore essential. This study aimed to assess the potential distribution of two major invasive alien species – *Prosopis* spp. and *Acacia mearnsii* – under current and future climate scenarios across South Africa. Species distribution modelling was conducted using the Maximum Entropy (MaxEnt) approach, incorporating occurrence data from the Global Biodiversity Information Facility (GBIF) and bioclimatic variables from the WorldClim database. Model performance, evaluated using the Area Under the Curve (AUC), showed strong predictive accuracy: 0.76 (training) and 0.77 (testing) for *Prosopis* spp., and 0.91 (training) and 0.89 (testing) for *A. mearnsii*. Under current climate conditions, *Prosopis* spp. was predicted to occupy 93.8% of South Africa's land area, whereas *A. mearnsii* was limited to 9.7%. Future projections revealed divergent patterns: *A. mearnsii* is projected to experience a significant reduction in suitable habitat – up to 75% by the late century under high-emission scenarios. In contrast, *Prosopis* spp. showed inconsistent trends across general circulation models (GCMs) and socioeconomic scenarios (SSPs), with both expansion and contraction projected depending on scenario combinations. Temperature seasonality and precipitation emerged as key drivers for Prosopis spp., while *A. mearnsii* was more influenced by cold-temperature variables. These findings highlight the differential climate sensitivity of IAPs and underscore the urgency of developing species-specific, climate-informed management strategies. In particular, immediate action is warranted to contain the spread of *Prosopis* spp., given its vast current suitability and aggressive expansion potential. Conversely, the anticipated decline of *A. mearnsii* may present opportunities to re-evaluate its control and economic utilisation. This study provides critical insights for policymakers, conservationists, and land managers working to mitigate the ecological and economic impacts of invasive plants under future climate conditions.

**Keywords**: MaxEnt model, climate change, South Africa, potential distribution, invasive alien plants

**Poster Sessions**

---

# TESTING VARIOUS MULCHES AS A CLIMATE CHANGE ADAPTATION STRATEGY ON A CABBAGE (*BRASSICA OLERACEA* L. VAR *CAPITATA*) AND GREEN PEPPER (*CAPSICUM ANNUM*) CROP

**Ntebaleng A. Mokotla, Gesine Coetzer, & Stephan Steyn**

Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Mulching is a widely recognised agronomic practice that helps conserve soil moisture, regulate soil temperature, and improve crop productivity. Its role has become increasingly important under the growing threat of climate variability. However, limited research has been conducted to assess the comparative effects of different mulch types on vegetable crops under controlled seasonal conditions, particularly in semi-arid regions. This study aimed to evaluate the impact of various mulches on crop growth, yield, soil temperature, and water use efficiency for cabbage (*Brassica oleracea* L. var. *capitata*)

and green pepper (*Capsicum annuum*), grown under glasshouse conditions at the University of the Free State, Bloemfontein, South Africa. Three pot trials were conducted using a completely randomised block design: two for cabbage in autumn (2022) and winter (2023), and one for green pepper in summer (2023/2024). Six mulch treatments were applied: bare soil (control), bark chips, black plastic, clear plastic, pebbles, and maize stubbles (introduced in 2023). Results indicated that mulching significantly influenced crop performance and soil properties, with variations observed across seasons and crop types. For cabbage, bark chips and pebbles enhanced plant height and fresh head mass in both seasons, while black plastic performed best during winter. For green pepper, bark chips, black plastic, and pebbles improved fruit yield but were associated with elevated soil temperatures. Clear plastic showed the highest water use efficiency. Maize stubbles performed poorly for both crops across all parameters. A consistent relationship between soil temperature and yield across all trials emphasised the critical role of mulch type in microclimate regulation. Overall, the findings suggest that mulching can serve as an effective climate-smart strategy in vegetable production by improving crop resilience, conserving water, and optimising growing conditions. Further field-based research across different agroecological zones is recommended to validate these results under natural conditions.

**Acknowledgements**

The authors would like to thank Mrs Lize Henning for organising glasshouse space, pots and soil, and Miss Nozi Radebe for assistance with instrumentation, both from the Department of Soil, Crop and Climate Sciences.

Keywords: complete randomised block design, greenhouse, microclimate manipulation, sustainable agriculture

**Session 10A**

---

# HYDROGEOCHEMICAL ANALYSIS OF CLIMATE CHANGE IMPACTS ON GROUNDWATER IN THE NORTHEASTERN UPPER KAROO HYDROGEOLOGICAL REGION, SOUTH AFRICA

**Ouma Ngoepe[1,2], Amy Allwright[3], Paul Lourens[2] & Robert Hansen[4]**

[1]Institute for Groundwater Studies, University of the Free State, Bloemfontein, South Africa
[2]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa
[3] Department of Earth Sciences, Stellenbosch University, Stellenbosch, South Africa
[4]Department of Geology, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Climate change is increasingly altering the natural systems, with groundwater resources amongst the most vulnerable to the long-term influence of temperature and precipitation patterns. Amid the growing climate variability, this research project aims to explore how the long-term impact of climate change trends influences the groundwater hydrogeochemistry. To assess the influence of climate change on groundwater hydrogeochemistry, the study utilised the historical hydrogeochemical data (1993- 2023) from the six monitoring stations within the Northeastern Upper Karoo hydrogeological region. Climate data of the same period, focusing on the annual precipitation and temperature trends, were analysed to determine the correlation with groundwater changes. The groundwater hydrogeochemical analysis focused on key physicochemical parameters such as pH, EC, TDS, TAL, Cl- , K+ , Na+, F-, NO3-, Mg2+, Ca2+, and SO42+. The hydrogeochemical approaches (Piper, GIBBS, PHREEQC, and SAR), geospatial tools (QGIS), and statistical analyses (correlation and WQI) were used to understand groundwater hydrogeochemistry. In addition, general circulation models were employed to establish the projected climate change trends (2024 - 2044), for insight into the potential future change in groundwater. The study has completed the analysis of groundwater hydrogeochemistry, showing trends across the stations. The hydrogeochemical results revealed that the groundwater across the study area is

predominantly classified as Ca- HCO3 and Na- HCO3 types, shaped by the evaporation-precipitation hydrogeochemical mechanism. A distinct host spring station, Aliwal North station, stands out from the rest of the stations, with elevated concentrations of F, Cl, Na, and EC, suggesting local geochemical or geothermal influence. The station also presented high SAR values, making the groundwater unsuitable for drinking, and a very poor WQI. While this component has been completed, the quantification of climate change impacts is still underway. However, preliminary climate data indicate high ion concentrations during hotter years, suggesting potential climate-driven influence on hydrogeochemistry.

**Acknowledgements**

I extend my sincere gratitude to my supervisors, Dr. Amy Allwright, Dr. Paul Lourens and Dr. Robert Hansen, for their exceptional mentorship and support. Their expertise and guidance were invaluable in this research. Their constructive feedback and encouragement sharpened my thinking, refined my work and pushed me to achieve excellence. It was truly enriching to work with them on a project that integrates different specialties in the Earth Sciences field. For the academic panel from the Institute for Groundwater Studies, I am grateful for their constructive feedback during the project progress presentations. I am especially thankful to the Council for Geosciences, for funding my studies and supporting my academic journey. I also acknowledge the Department of Water and Sanitation (DWS) and South African Weather Services for providing me with data from their archives, which significantly contributed to my research project. I also would like to acknowledge my fellow science students and my colleagues for their contributions and collaborative efforts which enriched my work. Special thanks to: Dr Mariana Erasmus, for granting me access to the equipment and resources at the Centre for Mineral Biogeochemistry and for her understanding as I balance work and studies; Dr Megan Purchase and Nicolle Loader, for their invaluable assistance in generating maps and navigating different software; Febé Van Vuuren, for her guidance in creating geospatial distribution maps and understanding the geospatial analysis; Dr Adriaan van der Walt and Dr Sarah Roffe, for assisting me with climate change modelling; and Wendy Mhaleni, for working together and ensuring we stayed on track with the critical aspects of our research projects. Lastly, I am appreciative of my family, for their wise counsel, unwavering prayers and support.

Keywords: groundwater, hydrogeochemistry, climate change, Northeastern upper Karoo hydrogeological region, general circulation model

**Poster Sessions**

---

# ROOT TRANSCRIPTOME ANALYSIS OF A DROUGHT-TOLERANT SORGHUM GENOTYPE UNDER DROUGHT STRESS

**Samkelisiwe Ngwenya[1], Amanda Beylefeld[2], Dirk Z.H. Swanevelder[2] & Rudo Ngara[1]**

[1]Department of Plant Sciences, University of the Free State, Phuthaditjhaba, South Africa

[2]Agricultural Research Council Biotechnology Platform, Onderstepoort, South Africa

## ABSTRACT

Crop productivity is negatively affected by drought stress worldwide. With the ongoing predictions of climate change and global warming, more severe drought episodes are imminent. As such, global food security is under threat, and there is a need to develop more drought-resilient crops to meet the global food demand. Such initiatives require a thorough understanding of plant drought responses. In this study, we explored changes in the root transcriptome of a drought-tolerant sorghum variety under drought stress to understand gene regulatory mechanisms under water-limiting conditions. We used sorghum because of its wide genetic diversity and natural drought-tolerant trait. Sorghum seeds were germinated and grown in potting soil in a growth chamber for three weeks under well-watered conditions. Then, plants were divided into a well-watered control group and a drought treatment group, where watering was withheld for 15 days. Leaf relative water content, chlorophyll content, and soil moisture content measurements were conducted to assess the extent of water limitation in the

drought-stressed plants relative to the controls. Root total RNA was then extracted and sent frozen in dry ice to the Agricultural Research Council, Biotechnology Platform, and Core Facility, Pretoria, South Africa, for RNA sequencing on the MGI platform. Following data cleanup processes, 1772 differentially expressed genes ($p < 0.05$) were identified in this sorghum genotype in response to drought stress. Of these genes, 717 were up-regulated while 1055 were down-regulated. This drought-tolerant sorghum genotype exhibited a significant expression of genes involved in osmotic adjustment, antioxidant activity, and stress signal transduction, possibly illustrating some of the key processes in drought response. Further bioinformatic analyses of the RNA-seq data are underway, as we continue exploring the regulatory and metabolic pathways modulated in sorghum under drought. Such information could be used in genetic improvement programs to improve crops' drought resilience and food security.

**Keywords**: sorghum, drought stress, root, transcriptome, drought tolerance

**Poster Sessions**

---

# FROM DEVELOPMENT SITE TO SCIENTIFIC DATA: UNLOCKING CLIMATE ARCHIVES IN LEPHALALE, SOUTH AFRICA

**Marthie E. Niemand[1], Frank H. Neumann[2], Stephan M. Woodborne[3,4]**

[1]Centre for Environmental Management, University of the Free State, Bloemfontein, South Africa
[2]Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa
[3]iThemba LABS, University of the Witwatersrand, Johannesburg, South Africa
[4]Mammal Research Institute, University of Pretoria, Pretoria, South Africa

## ABSTRACT

Vegetation clearing is a widespread consequence of development, with particularly long-lasting impacts in arid landscapes, where the footprint may remain visible for decades. However, the removal of trees presents a rare scientific opportunity: their wood preserves a valuable record of past environmental conditions. Longterm palaeoclimate data can serve as benchmarks for restoration efforts, indicate ecological variability in terrestrial habitats and help quantify ecosystem resilience to a changing climate. In this study we demonstrate the potential to develop a climate chronology from two trees harvested during a pipeline construction near Lephalale, South Africa. Stem discs were collected from *Vachellia erioloba* and *Senegalia burkei* trees and the longest radii were prepared for stable carbon isotope analysis using standardised methods. Radiocarbon dating of multiple aliquots along the radii provided chronological constraints for the stable isotope record. Both chronologies were calibrated against local short-term (<50 years) instrumental records to assess environmental forcing in the region. The trees, aged between 400 and 600 years, extend the local climate record by several centuries. This research highlights a unique opportunity when mature trees are identified during Environmental Impact Assessments and subsequently removed during development: they can either be used as firewood or contribute to southern Africa's limited climate archives. Palaeoclimate data extracted from these trees provide practical mitigation measures for developments where trees are earmarked for removal.

**Keywords**: Environmental impact assessment dendroclimatology stable carbon isotopes radiocarbon dating trees

**Session 10B**

---

# SOUTH AFRICAN COMMERCIAL LIVESTOCK FARMERS' ADAPTATION AND COPING STRATEGIES FOR AGRICULTURAL DROUGHT

**Yonas T. Bahta[1], Frikkie M. Maré[2] & Stephen A.N. Nyaki[1]**

[1]Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa

[2]Red Meat Producers' Organisation, Pretoria, South Africa

## ABSTRACT

To achieve the SDGs 13 of taking urgent action to combat climate change and its impact, SDGs 2 of ending hunger and poverty, and the African Union CAADP Strategy and Action Plan: 2026-2035 of ending hunger and intensifying sustainable food production, agro-industrialisation, and trade need to enhance farmers coping and adaptation strategies for shocks. Agricultural drought has remarkably affected the economies of many sub-Saharan African countries, especially South Africa, in the recent past and still poses a challenge to commercial livestock farming. Understanding the adaptive and coping mechanisms and their determinants is pertinent to informing future preparedness for agricultural drought. This study analyses data from 123 commercial livestock farmers using a multivariate probit model to examine determining factors for the choice of adaptation and coping strategies. The results revealed that livestock management strategies, including the adoption of drought-resilient breeds, feedbanks, and herd size reduction, are the most preferred adaptive strategies, followed by conservation agriculture. Reducing animal numbers and feed management were the most preferred drought coping strategies. The choice of adaptive and coping strategies was mainly influenced by livestock farmers' experience with past droughts, farmers' age, the strength of social networks, asset size, and market accessibility. The study advocates for integrated policy, managerial, and social interventions that enhance infrastructure to support market access, improve access to asset-backed financing, strengthen both horizontal (farmer-to-farmer) and vertical (cooperatives) networking, promote conservation agriculture, and ensure water security. These measures aim to bolster the short-term and long-term adaptive capacities, coping strategies, and resilience of livestock farmers in the face of agricultural drought.

**Keywords**: Preparedness, livestock management strategies, feed banks, social networks, market accessibility

**Session 10A**

# Conserving our Biodiversity

## DEVELOPMENT AND VALIDATION OF A LEOPARD STR PANEL FOR USE IN LEGAL AND ILLEGAL TRADE CASES IN SOUTH AFRICA

**Megan C. Fisher[1], Karen Ehlers[1] & Marli de Bruyn[2]**
[1] Department of Genetics, University of the Free State, Bloemfontein, South Africa
[2] South African National Biodiversity Institute, Pretoria, South Africa

### ABSTRACT

It is a known fact that wildlife crime is a very lucrative business with profits reaching well into the billions annually, making it one of the largest international criminal activities after human and narcotics trafficking. These crimes include poaching, illegal specimen trade, hunting and many more illegal activities that threaten our country's biodiversity. The illegal leopard trade is a well-developed, organised crime. Their skin and bones are used for decorative ornaments and clothes, luxury meat and cultural regalia. Currently, in South Africa, the only leopard population database to exist is at the South African National Biodiversity Institute (SANBI) and contains DNA profiles from previous casework through the years. STR marker sets in these profiles have been adapted throughout time, but no quality control evaluation has been done. Similarly, although SANBI performs many forensic wildlife tests on the leopard species, an improved and validated STR panel will benefit and aid law enforcement in catching and prosecuting perpetrators who engage in these crimes. The primary aim of this study is the evaluation and quality control of the existing leopard database and to validate an STR panel that will produce reliable and conclusive results for legal proceedings. Here we show how the current database was updated with a developed allelic ladder, and the STR panel was modified to include the most polymorphic and heterozygous STR loci. The STR panel was validated by testing the sensitivity, reliability and accuracy. Research involving leopards is very limited, and it leaves a big gap. With the help of a database that currently exists at SANBI, this type of study will ultimately enhance and strengthen confidence in the sustainability of South African biodiversity resources.

**Acknowledgements**
South African National Biodiversity Institute (SANBI)

**Keywords**: STR loci, wildlife crime, STR panel

**Poster Sessions and Session 5**

---

## INVESTIGATING OPPORTUNITIES AND CHALLENGES FOR SUSTAINABLE ECO-TOURISM DEVELOPMENT IN MALUTI-A-PHOFUNG

**Sebabaco I Itholeng, Melissa Hansen, Ntebohiseng Sekhele & Solomon Zondo**
Department of Geography, University of the Free State, Phuthaditjhaba, South Africa

### ABSTRACT

The tourism industry is a rapidly growing and significant economic sector globally, particularly in the developing countries. However, the industry in developing countries faces challenges like insecurity, poor resource management, and under-tourism due to historical issues. In South Africa, prior to 1994,

tourism operations and consumption were dominated by white minority group. During apartheid, mobility and access to homelands were challenging and restricted, which limited possible tourism opportunities particularly in rural areas. Unfortunately, even in the post-apartheid era, South Africa's former homeland continues to experience neglect, with limited investments of tourism development. This study aims to assess the key factors contributing to poor tourism development in Qwaqwa and explore sustainable tourism practices that involve all relevant stakeholders. Using Stakeholder Theory and Capital Theory as guiding frameworks, the study will identify important tourism stakeholders and examine how available resources can be utilised to support sustainable tourism development. The study will employ a qualitative research approach, using purposive sampling to select participants. Data will be collected through unstructured interviews with key informants, including operators and tourists as well as open ended questionnaires to understand the local community perspectives on nature-based tourism. Qualitative field observations will be conducted in the study area where tourist activities are taking place. The collected data will be analysed using thematic analysis. The results will highlight the significant role eco-tourism can play in promoting local economic development, environmental conservation and community empowerment in the former homeland of Maluti-a-Phofung. Furthermore, the study is expected to elucidate infrastructural factor like transport networks, accommodation, and service delivery that are paramount in tourism and tourism development. Moreover, the study is expected to highlight the importance of different stakeholders in developing and promoting sustainable ecotourism in Qwaqwa.

**Acknowledgements**

I would like to express my sincere gratitude to my supervisor Dr Melissa Hansen as well as my co-supervisors Ntebohiseng Sekhele and Solomon Zondo for their invaluable guidance, support and insightful contributions that has significantly enriched this study.

**Keywords**: Eco-tourism, Sustainable tourism development, Qwaqwa, community development

**Poster Sessions and Session 5**

---

## SCAT-TERED CLUES: USING DUNG TO DECODE KUDU DEMOGRAPHICS

**Ruan Jacobs[1], M.G. Du Plessis[1], B.K. Reilly[1], F. Zachos1,[2] & Prof. J.P. Grobler[1]**

[1]Departmet of Genetics, University of the Free State, Bloemfontein, South Africa

[2]Natural History Museum of Vienna, Vienna, Austria

### ABSTRACT

Accurate estimates of population size, density, and demographics are key to wildlife population management. Censuses are traditionally performed using direct counts, including aerial surveys (manned and unmanned), camera trapping, manned vehicle counts, community counts, and physical mark-recapture, amongst others. Although widely accepted, these methods still present inherent biases. Large mammal studies conducted on various North American deer species have validated the use of eDNA and noninvasive genetic sampling (GNIS) as a supplementation to conventional methods. GNIS is an alternative method used to indirectly sample populations without direct physical interaction and minimal observation, and is becoming a popular alternative for rare, elusive, and threatened or endangered species. However, the implementation of GNIS coupled with mark-recapture has not been assessed for larger, more common species in the southern hemisphere. This proof-of-concept study evaluated the use of non-invasive genetic sampling and mark-recapture on a large, enclosed greater kudu (Tragelaphus strepsiceros) population located within Doornkloof Nature Reserve in the Northern Cape. Scat samples were randomly collected from predetermined transects within the reserve. This technique estimated the population size at 161 individual kudus (SD of 18.33), with a density of 174

individuals/100km2, while also providing useful genetic diversity and relatedness data for future management. Our results align with previous findings on similar ungulate studies in the northern hemisphere, and supports the inclusion of GNIS and mark-recapture as supplementary methods for population census, density, and demographics, especially for cryptic and elusive species.

**Acknowledgements**

I would like to extend my gratitude to the Doornkloof Nature Reserve team for always having us and working alongside us to collect samples and keep the buffalos away! Also, to all my supervisors for your constant support and guidance.

**Keywords**: Genetics, kudu, census, eDNA

**Session 5**

---

# INTEGRATING EVOLUTIONARY CONSTRAINTS INTO CONSERVATION: DIETARY ADAPTATION AND MORPHOLOGICAL LIMITS IN RUMINANTS

**Chanel Lewis & Daryl Codron**

Department of Zoology and Entomology, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Effective conservation in a changing world demands an understanding of the evolutionary constraints that shape species' ecological roles. In ruminants, key morphophysiological traits – particularly in craniodental anatomy and rumen anatomy – can constrain dietary niches and limit ecological flexibility. To understand these constraints, we aim to resolve the mechanisms underlying non-linear relationships between form and function. We tested for non-linearity in relationships between species' natural diets and 25 different craniodental traits across 32 ruminant species, by comparing goodness-of-fit of various models (linear, quadratic, logistic, etc.) in a phylogenetically controlled framework. Here we present analysis of two key traits expected to constrain diet niches of ruminants in terms of browsing vs. grazing, but for which disparate patterns emerge. Muzzle width (MZW) showed a linear increase with diet: for every 1% increase in grass intake, MZW increases by 0.2037 cm, despite a strong phylogenetic signal. This suggests that larger MZW is an evolutionary response to increased grass intake (satisfying the requirement to feed in bulk or near ground-level). In contrast, the Hypsodonty Index (HI) – height:width ratio of the enamel crown of the posterior (third) molar; functionally a tooth-wear resistance mechanism – increased asymptotically, plateauing at around 90% grass intake. This suggests that only minor shifts towards grazing drove significant HI evolution; beyond this point, diverse dietary options became possible without further HI increases, accounting for the success of many grazer species across diverse environmental conditions. Due to constraints on resource acquisition, species' differences in craniodental traits are key determinants of fitness across environmental conditions. These constraints must be considered in conservation planning; translocation, stocking, and even ex situ feeding regimes of wildlife species need to overcome mismatch between the sometimes subtle variations in morphological adaption and local food resources or conditions. Integrating evolutionary limits into conservation decisions will improve long-term outcomes for biodiversity.

**Keywords**: conservation planning, craniodental traits, dietary niche, ruminant morphology, trait evolution

**Session 5**

---

# THE EFFECT OF RESOURCE LEVEL AND NUMBER OF COMPETITOR INDIVIDUALS ON THE POPULATION CYCLES OF GERMAN COCKROACHES (*BLATTELLA GERMANICA*)

**Jabulile I. Maseko & Aileen van der Mescht**
Department of Zoology and Entomology, University of the Free State, Bloemfontein, South Africa

**ABSTRACT**

Many insect populations go through periodic fluctuations over time leading to cyclic growth. Population cycles are predicted to be caused by extrinsic factors such as weather fluctuations, food availability and predation. However, recent research has shown that intrinsic factors to the population such as delayed density dependent effects and high reproductive rates seem to be more important causes of population cycles. The amplitude, periodicity, and frequency of population cycles differs depending on variation in resource level and interspecific competition. There has been a debate about which factors (intrinsic or extrinsic) cause cycles to take place and from field data, it is difficult to determine which factors are the actual cause of population cycles. To mitigate this, laboratory controlled experimental studies can be done. Using German cockroaches (Blattella germanica) as the study organism, this study aimed to investigate the effects of resource level and number of competitor individuals (American cockroach; *Periplaneta americana*) to study the effects of interspecific competition on population cycles. Changes in total population size, number of adults and nymphs, reproductive, and survival rates of adults of German cockroaches over time were measured and compared across different resource levels and number of competitor individuals. The total population size, number of adults and nymphs, reproductive and survival rate of adults were negatively influenced by an increase in the number of competitor individuals and low resource levels. Furthermore, higher number of competitor individuals led to the dampened population fluctuations for the total population size, number of adults and nymphs. These findings highlighted the importance of interspecific competition and resource availability in shaping population cycles. Understanding the mechanisms of population cycles will advance our ability to control pest populations and to protect species from drifting to extinction.

**Acknowledgements**
Dr Aileen van der Mescht

**Keywords**: birth rate, chaotic growth, demographic parameters, fluctuations

**Session 5** ***(moved from Session 2B)***

---

# ASSESSING DNA INTEGRITY IN WILDLIFE FORENSIC SAMPLES: THE IMPACT OF SAMPLE AGE, PROCESSING TECHNIQUES & ENVIRONMENTAL FACTORS ON SPECIES IDENTIFICATION

**Rivaldo T. Mockson, Gertruida Marx, Karen Ehlers & Paul J. Grobler**
Department of Genetics, University of the Free State, Bloemfontein, South Africa

**ABSTRACT**

Wildlife forensics can play a crucial role in assisting with law enforcement for cases involving both endangered species and their body parts, and illegal hunting of commonly found species. However, the rate of DNA degradation under various conditions and its impact on species identification remains poorly understood. This study aims to determine how sample age and environmental exposure affect species identification, using blood samples from a commonly found species, the blesbok. Blood was collected from a fresh carcass and deposited on materials typically encountered at wildlife crime

scenes; rubberised car mats (typically found in or on the back of vehicles), metal (knife blades), cotton (clothing), and wood. Samples were stored under three conditions: indoors, semi-extreme (outdoor environment but with a tree shade providing partial cover), and extreme (fully exposed to the elements). Sampling occurred daily for the first week, every second day for two weeks, and weekly until day 102. DNA was extracted using the QIAamp DNA Investigator Kit, and the cytochrome c oxidase subunit I (COI) region was targeted for species identification. Initial results revealed that all samples, except cotton, yielded sequences suitable for species identification on days 1 and 7. However, after day 51, only indoor samples produced amplifiable DNA, highlighting the detrimental effect of environmental factors on DNA degradation. Further study will involve sequencing samples intermediate to points in time reported on here, additional substrates (grass and soil), the efficacy of species identification from biltong over time and utilising qPCR to study mixed samples (dry sausage).

**Keywords**: wildlife forensics, DNA degradation, species identification, environmental exposure

**Session 5**

---

# THE REPELLENT ACTIVITY OF POWDERS OF THREE INVASIVE ALIEN PLANTS AGAINST *SPODOPTERA FRUGIPERDA* (LEPIDOPTERA: NOCTUIDAE)

**Ntsoaki W. Sabisa[1], Nontembeko Dube[1] & Osariyekemwen Uyi[2]**

[1]Department of Zoology & Entomology, University of the Free State, Bloemfontein, South Africa

[2]Department of Entomology, University of Georgia, Tifton, USA

## ABSTRACT

Invasive alien plants (IAPs) and insect pests pose considerable risks to crop productivity and ecosystem integrity. In South Africa, the fall armyworm (*Spodoptera frugiperda*) is a highly destructive maize pest, frequently managed using synthetic pesticides with potential risks to human and environmental health. Also, IAPs such as *Chromolaena odorata, Gleditsia triacanthos*, and *Schinus terebinthifolia,* pose a threat to agricultural productivity, biodiversity, and livelihoods. This study showcases a dual approach to addressing insect infestations and overgrowth of invasive alien plants by investigating the repellent potential of these invasive alien species against *S. frugiperda*. The study showed that powders derived from IAPs, specifically the leaf, stem, and root of *C. odorata*, *S. terebinthifolia*, and *G. tria*canthos, exhibited notable repellent effects against S. frugiperda larvae in the laboratory experiments, with overall repellence rates of 83%, 66%, and 50% for each species, respectively. These findings indicate that IAPs can potentially serve as an effective and useful botanical repellent, contrary to the assumption that their ecological harm outweighs any potential benefit. This is an ecologically friendly approach to pest control in line with the objectives of ecological restoration. Biopesticide innovation and IAPs management can provide a cost-effective and ecofriendly alternative to chemical pesticides. These processes increase food security, reduce the usage of chemicals, and increase biodiversity, resulting in a long-term sustainable agriculture.

**Acknowledgements**

Sincere gratitude to the National Research Foundation (NRF) and the Maize Trust for their generous funding and support. Appreciation to the Department of Zoology and Entomology for providing the space and resources necessary for this research. I thank my supervisors for their invaluable guidance and encouragement throughout the project. Lastly, heartfelt thanks to everyone who supported me.

**Keywords**: biopesticides, biological invasion, efficacy, phytochemicals

**Session 5**

---

# EXPLORING DRIVERS OF CLADOGENIC DIVERSIFICATION AND BIOGEOGRAPHIC PATTERNS IN NEAR-SYMPATRIC HERPETOFAUNA ACROSS FOUR GLOBAL BIODIVERSITY HOTSPOTS

**Zhongning Zhao[1], Adriaan Jordaan[2], Chad Keates[3], Neil Heideman[4] & Paul Grobler[1]**

[1]Department of Genetics, University of the Free State, Bloemfontein, South Africa
[2]Natural Science Collections Facility, South African National Biodiversity Institute, Cape Town
[3]Aquatic and Wetland Plant Science Lab, University of Florida, Fort Lauderdale, USA
[4]Department of Zoology and Entomology, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Resolving the processes that generate and maintain biodiversity is essential for informing conservation priorities and understanding Earth's evolving ecosystems. Theory predicts that habitat heterogeneity, climatic oscillations and geological shifts interact to drive lineage diversification and geographic distributions; under this framework, unrelated taxa experiencing the same environmental forces should exhibit congruent evolutionary responses. Here, we test these expectations in two near-sympatric fossorial vertebrate lineages – the skink subfamily Acontinae and the frog genus Breviceps – across four Global Biodiversity Hotspots in southern Africa. We combined a fossil-calibrated molecular phylogeny with diversification-rate modelling, biogeographic reconstruction, state-dependent diversification analysis and environmental niche and correlation assessments to evaluate how paleoclimatic fluctuations, geomorphological events and habitat complexity have shaped speciation and range dynamics. We further explored the association between genetic structure and environmental variables and statistically tested for correlations between diversification rates and paleotemperature. Our analyses reveal a strong negative correlation between diversification rate and background temperature, in line with theory that colder periods promote speciation via refugial isolation. The late Miocene emergence of distinct biomes, rainfall regimes and soil types coincided with pulses of lineage splitting in both groups. Stochastic mapping recovered parallel vicariance and founder-event patterns, indicating shared evolutionary responses to common selective pressures rather than unique, lineage-specific processes. By applying a directly comparative biogeographic framework to two large fossorial clades, this study highlights the combined influence of climatic cooling, geological transformation and habitat heterogeneity in driving diversification. These findings advance our understanding of southern Africa's biodiversity dynamics and underscore the necessity of integrating climatic and geological perspectives in evolutionary and conservation research.

**Acknowledgements**

We gratefully acknowledge the University of the Free State (UFS) for providing research facilities and funding through grant IFR2011041300046, which supported this project. We also extend our thanks to the Northern Cape Department of Environment and Nature Conservation (Permit No. FAUNA 624/2015) and the Department of Economic Development, Environment and Tourism, Limpopo (Permit No. 001-CPM402-00001) for issuing the necessary collecting permits. We appreciate the ethical clearance provided by the UFS Ethical Committee (Animal Experiment No. NR04/2012 and NR07/2015), which was essential for the conduct of this research.

**Keywords**: speciation, habitat heterogeneity, environmental niche analysis, comparative biogeography

**Poster Sessions and Session 5**

# Food Security, Production and Safety

## IDENTIFICATION OF TRAP AND CATCH CROPS TO CONTROL STRIGA GESNERIOIDES IN TOBACCO-BASED CROPPING SYSTEMS

**Francois du Plessis[1,2], Angelinus Franke[1], Elmarie van der Watt[1] & Tesfay Araya[1]**
[1]Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa
[2]Limpopo Tobacco Processors, Rustenburg, South Africa

### ABSTRACT

Cowpea witchweed (Striga gesnerioides) is a root-parasitic plant that causes severe yield losses in crops like cowpea and tobacco by germinating in response to strigolactones and establishing a vascular connection with host roots. This study aims to identify and evaluate the impacts of trap and catch crops on S. gesnerioides infestations. Laboratory, growth chamber, and pot trials have been employed to screen crops based on their ability to stimulate witchweed germination. The laboratory experiment involved placing root segments from potential host crops at the center of Petri dishes surrounded by Striga gesnerioides seeds. Germination rates were assessed with three successive observations every 3 days, using a light microscope to evaluate the stimulatory effects of root exudates on witchweed seed germination. The pot trial evaluates the long-term effects of selected crops, identified in the laboratory study, on Striga gesnerioides seed bank viability by allowing them to grow to full maturity, followed by cultivating tobacco (a known susceptible host) in the same, minimally disturbed soil. The growth chamber trial is designed to assess Striga gesnerioides attachment on selected crops by cultivating them on filter paper substrates pre-inoculated with witchweed seeds, enabling continuous visual monitoring of parasitic interactions. The Petri dish experiment shows that cowpeas and sweet potatoes induce high Striga gesnerioides germination rates (>90% and >50%, respectively) three weeks after planting, while cotton shows moderate induction (10%) at six weeks. In the pot trial at crop maturity of phase one, only tobacco (positive control) and groundnuts exhibited visible signs of witchweed parasitism; the second phase, involving tobacco cultivation, is scheduled for September 2025. Available results indicate that cowpeas, sweet potatoes, and cotton hold potential to induce suicidal germination for S. gesnerioides seed.

**Acknowledgements**
Supervisors: Prof TA Weldeslassie, Prof AC Franke and Dr E van der Watt. Mentors: Mr A Scholtz and Dr D Meyer

**Keywords**: Striga gesnerioides, parasitic weed, trap and catch crops

**Session 8B**

---

## USING KOMAGATAELLA PHAFFI FOR THE PRODUCTION OF LACTONES

**Rosshique Farmer, Laurinda Steyn, Diederik J. Opperman & Martha S. Smit**
Department of Biochemistry and Microbiology, University of the Free State, Bloemfontein, South Afria

### ABSTRACT

Recent advancements in metabolic engineering have enabled the development of highly efficient cell factories capable of producing a diverse array of chemicals, including biofuels, flavours, fragrances, and active pharmaceutical ingredients. Among the leading platform organisms used in this field are Escherichia coli and Saccharomyces cerevisiae. However, when these organisms struggle to express

certain proteins effectively, Komagataella phaffi (also known as Pichia pastoris) presents an alternative yeast host for heterologous protein expression. Previously in our lab, K. phaffi strains were successfully engineered to produce d-dodecalactone, a valuable flavour and fragrance compound, by expressing in-chain hydroxylating cytochrome P450 monooxygenases. This compound is synthesised from dodecanoic acid, but its production is hindered by ß-oxidation of K. phaffi. Unfortunately, both the substrate and product undergo unwanted degradation via ß-oxidation, resulting in lower yields. To address this challenge, we have embarked on a collaborative project with a German research group specialising in CRISPR/Cas technology. The goal of this partnership is to manipulate the ß-oxidation pathway in P. pastoris using CRISPR/Cas techniques to prevent the degradation of d-dodecalactone and its precursor, thereby improving yields. Through this strategic intervention, we plan to explore the enhanced production capabilities of K. phaffi strains with reduced ß-oxidation activity in the context of d-dodecalactone synthesis. Our research will focus on evaluating the effects of limited ß-oxidation on the growth of K. phaffi, the degradation of dodecanoic acid and d-dodecalactone, and the overall production of d-dodecalactone when the P450 gene is introduced.

**Acknowledgements**

Prof MS Smit, Prof DJ Opperman, Ms. Laurinda Steyn, and German collaborators from Heinrich Heine University in Dusseldorf

**Keywords**: Komagataella phaffi, ß-oxidation, d-dodecalactone, Cytochrome, P450 monooxygenases

**Poster Sessions**

---

# INVESTIGATING THE CACTUS PEAR (OPUNTIA FICUS-INDICA) MICROBIOME FOR MICROBES POSSESSING TRAITS RELATED TO THE PROMOTION OF PLANT GROWTH

**Habofanoe Fosa[1], Christopher Rothmann[2], Errol D. Cason[3], Makoena J. Moloi[1], Mpho S. Mafa[1], Norman Muzhinji[1] & Wijnand J. Swart[1]**

[1] Department of Plant Sciences, University of the Free State, Bloemfontein, South Africa
[2] Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
[3] Department of Animal Science, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Plants evolved from living in water to terrestrial environments, co-evolving with microbes to adapt to land life. Beneficial plant associated microbes promote growth and confer protection against biotic and abiotic stressors, positioning them as promising tools in sustainable agriculture. This study aimed to isolate plant growth promoting microbes from the cactus pear microbiome and use them for biofertilisation in wheat. The microbes were isolated and biochemically screened for phosphate solubilisation and the production of plant growth enhancing indole-3-acetic acid, ammonia, catalase, proline and siderophores. For biofertilisation, the microbes were used as seed biopriming agents on wheat. Briefly, 1*10^8 colony forming units of the biopriming agent were inoculated onto the seeds whilst distilled water was used for the control seeds. The seeds were planted in the glass house for 7 days and evaluated for: a) final germination percentage, b) mean daily germination, c) germination energy, d) mean germination time, e) mean germination rate, f) coefficient of geminating velocity, g) coefficient of variation of germination time, h) rate of emergence i) dry mass, j) length of shoots k) length of roots, l) the number of secondary roots, and m) seedling vigour. Bacillus subtilis and B. halotolarens screened positive for plant growth promoting traits. Wheat seeds primed with the Bacillus strains showed a significantly higher ($P < 0.05$) germination percentage than the control seeds with improved rates of seedling emergence; shoot and root length, the number of secondary roots, and seedling vigour. The mean germination time and the coefficient of variation were significantly lower than the control

seeds. There were no significant differences (P > 0.05) in the parameters between the Bacillus strains treated seeds. The Bacillus strains isolated from cactus pear roots show biochemical plant growth promoting capabilities. They can potentially improve and speed up germination and seedling establishment of wheat.

**Acknowledgements**

I would like to acknowledge my supervisors for their support and the University of the Free State for the opportunity to conduct my research

**Keywords**: Biofertiliser, Biopriming, Biostimulant, Plant growth promotion

**Session 8C**

---

# ENHANCING CALF WEANING IN SOUTH AFRICAN BEEF CATTLE PRODUCTION: AN EXPERT VALIDATION OF A DECISION-SUPPORT FRAMEWORK USING THE DELPHI TECHNIQUE

**Brent Jammer, H. Jordaan & W.A. Lombard**

Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Calf weaning plays a fundamental role in the sustainability of cow-calf production systems. In South Africa, conventional weaning at six to nine months is widely practiced, but increasing climatic variability has highlighted early weaning as an adaptive strategy. To support producers in determining the optimal weaning age, we developed a Calf Weaning Decision-Support Framework through an extensive literature review. To ensure its practicality, we validated the framework using the Delphi technique, incorporating real-world insights from livestock experts. A two-round Delphi study was conducted with ten experts in livestock production and research, evaluating key factors influencing weaning age decisions. The study also used the Relative Importance Index (RII) to rank these factors based on expert consensus. The main findings showed strong agreement on productive factors, including weaning weight, conception rate, and dam body condition score alongside financial aspects that influence profitability, such as calf health and feeding expenses, as well as income generated at weaning. Experts identified three new factors-cattle breed, enterprise cash flow needs, and veld type, emphasising the need for flexible weaning strategies tailored to specific conditions. This study concludes that the expert-validated framework is a practical and adaptable tool, empowering South African beef producers to make informed, context-specific weaning decisions.

**Keywords**: cow-calf management, weaning age, decision support, livestock experts

**Poster Sessions**

---

# DEVELOPING A CONSUMER ACCEPTABLE DAIRY FREE, PLANT-BASED MILK USING NIXTAMALIZED MAIZE

**Zenande Langa, Alba du Toit, Faith Matiza Ruzengwe & Taylon Colbert**
Department of Sustainable Food Systems and Development, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Plant-based products have gained popularity over the years due to the growing global health and sustainability trends. Lactose intolerance is a common health problem experienced by people from all income groups. People who suffer from lactose intolerance need to consume dairy-free products. Plant-based milk is expensive on the market; therefore, an affordable alternative is necessary for all people to gain access. Can maize be used as a raw material to develop affordable plant-based milk? White maize was nixtamalized, cleaned and blended with water. The resulting mixture was then strained through a cheesecloth to extract milk. Extracted milk was subsequently flavoured using coffee and chocolate, and the third sample sweetened. A consumer acceptability test was performed on sweetened, chocolate, and coffee flavoured maize milk products using the 9-point hedonic scale and the ranking test. The sensory panel comprised of 40 participants, 85% female and 15% male. The attributes tested were appearance, taste, texture and flavour. The appearance of the chocolate (6.375), coffee (5.675) and sweetened (5.550) maize milk products were similar ($p>0.05$). Chocolate (6.550) and coffee (6.325) flavoured milk had the highest taste rankings ($p>0.05$). Texture ratings for coffee (6.925) and chocolate (6.875) flavoured milk were also similar ($p>0.05$), but both were significantly different from sweetened milk (5.600) ($p<0.05$). The flavour ratings for coffee and chocolate-flavoured milk were higher and similar ($p>0.05$), while the sweetened milk had a significantly lower rating ($p<0.05$). Overall acceptability ratings indicated that the chocolate and coffee-flavoured milk were “liked slightly” ($p>0.05$), whereas the sweetened milk was “disliked slightly” ($p<0.05$). Ranking tests also showed that coffee and chocolate-flavoured milk were the most preferred, whilst sweetened milk was the least preferred. These sensory analysis results suggest that maize milk has the potential for acceptance, particularly when flavoured with chocolate or coffee.

Keywords: Nixtamalization, Maize, Plant-based milk

**Poster Sessions**

---

# THE PERCEPTION OF CONSUMERS ON SUBSTITUTING POULTRY MEAT WITH RABBIT MEAT IN THE EASTERN CAPE: ALFRED NZO DISTRICT

**Lehakoe Letele[1] & Elliot Zwane[2]**
[1]Department of Sustainable Food Systems and Development. University of the Free State. Bloemfontein, South Africa
[2]Department of Agricultural Economics and Animal Production, University of Limpopo. Polokwane, South Africa.

## ABSTRACT

The poultry industry is a significant source of protein for many consumers in South Africa. However, it has faced significant challenges recently, such as population growth, load shedding, avian influenza outbreaks, and rising input costs. These challenges pose a risk to the poultry industry's ability to sustainably meet the needs of consumers who rely heavily on this protein source, as it is the most affordable source of protein for many consumers. This study explores consumer perceptions regarding substituting poultry meat with rabbit meat. There is a need for a more affordable alternative protein source that will reduce the pressure on the poultry industry and meet consumers' meat demands. Consumer awareness of alternative meats for poultry, such as rabbit meat in the Eastern Cape, has not been extensively explored. Thus, the Eastern Cape is the area of interest as it comprises disadvantaged

rural areas. Through the convenience and non-probability sampling techniques in a cross-sectional research design, 100 participants were sampled. The study collected quantitative data using closed-ended questionnaires, which were analysed using descriptive statistics. The findings revealed that 60% of the participants consumed rabbit meat, and approximately 70% perceived it as healthier than poultry due to their organic diet. Participants demonstrated limited awareness of the environmental benefits of rabbit production. Those aware mainly recognise that rabbit production requires less space and fewer resources than poultry. Nonetheless, the majority (62%) of consumers are willing to pay more for sustainably sourced meat. The study concludes by emphasising the need for increased consumer education and effective marketing strategies to promote rabbit meat as a viable alternative to poultry. Rabbit meat production will address protein needs and enhance food security, especially in rural areas where consumers have limited access to affordable and sustainable protein sources.

**Acknowledgements**

I would like to thank the Department of Agriculture in the Alfred Nzo district for providing me with the resources and environment necessary to conduct my research. Special thanks to the staff of the Extension and advisory services, whose support was crucial during the collection of data for my study.

**Keywords**: Rabbit meat, Poultry, Consumer perceptions and Meat consumption

**Session 8A**

---

# AN INTEGRATED DEVELOPMENT PATHWAY FOR DIFFERENT TYPOLOGIES: A SELF-HELP TOOL TO DEVELOP YOUTH IN AGRICULTURE

**Primrose Madende, Henry Jordaan & Johannes I.F. Henning**

Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Supporting youth to actively participate in agriculture is crucial for ensuring food security, promoting economic growth, fostering environmental sustainability, and empowering young people. The article aims to develop an integrated development pathway consisting of a pool of strategies that empowers heterogeneous youth to actively participate in the agricultural activities. Drawing from support strategies that emerged from a literature review of stakeholder-driven and typology-driven development pathways that aim to enhance participation in agricultural activities, an integrated development pathway is pro-posed considering the six livelihood capitals (Natural, Financial, Physical, Human, Social and Psychological) represented within the Modified Sustainable Livelihood Framework. The developed integrated pathway provides a bottom-up approach to development that empowers youth to choose their own specific strategies to enhance access to productive resources to support their active engagement in agriculture. The pathway allows youth to pioneer their own development processes, without being dependent on third-party development agents to initiate the development process. Empowering youth to actively engage in agriculture could effectively contribute to attaining several Sustainable Development Goals (SDGs), such as SDG2, SDG8, SDG12 and SDG13. Policy and other development partners could use the integrated pathway as a roadmap for implementing youth development initiatives, avoiding “double dipping” of support initiatives.

**Acknowledgements**

The Water Research Commission (WRC) of South Africa and the Department of Agriculture, Land reform and Rural Development (DALRRD, the former DAFF) is gratefully acknowledged for initiating, funding and managing the research project.

**Keywords**: youth development in agriculture, self-help development tool, livelihood capitals, development pathway

**Session 8A**

# POTENTIAL OF BIOSTIMULANTS TO ENHANCE ESTABLISHMENT AND GROWTH IN HYBRID POTATO FROM SEED AND TUBER

**F. Madziwanzira, A.C. Franke & E. Van der Watt**
Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa,

## ABSTRACT

Hybrid potato breeding can transform traditional potato production by enabling true potato seeds, which are easier and cheaper to store and transport, have higher multiplication rates, and are free from seed-borne diseases. These advantages are particularly significant for smallholder farmers, who often lack access to clean, high-quality planting material. However, one of the key barriers to fully realising these benefits is the challenge of raising and successfully transplanting seedlings into the field, especially in regions like South Africa, where extreme heat events can disrupt early plant establishment. This study aimed to address that challenge by evaluating whether commercial biostimulants can improve the field establishment of hybrid potato seedlings. It also compared the performance of these hybrids to widely cultivated tetraploid varieties under field conditions. Field trials were conducted over two growing seasons using a randomised complete block design with four replications. The trials tested two hybrid cultivars (SOLHY 012 and SOLHY 007) alongside two commercial varieties (Mondial and Sifra), applying biostimulants (AgraAlgen and Kelpak) as treatments. The second season included hybrid seedling tubers produced from transplanted hybrid seedlings to assess their performance under field conditions. Greenhouse-grown seedlings were transplanted into the field along with commercial tubers and managed under the same conditions. Results showed that biostimulants significantly improved transplant success, particularly under heat stress in the second season, with Kelpak and AgraAlgen increasing establishment rates by 20.1% and 16.7%, respectively, over the control. In the first season, tuber-grown plants yielded more than seed-grown plants; the lowest-yielding commercial cultivar (Sifra) outperformed the top hybrid seed-based cultivar (SOLHY 007) by 52%. However, in the second season, potatoes from seedling tubers produced yields comparable to commercial seed tubers, with no significant differences. The study highlights biostimulants' potential to improve field establishment and support the potential adoption of hybrid cultivars in South African potato production.

Keywords: biostimulants, hybrid potato seedling, tuber, field establishment

Session 8C

# ENHANCING GENETIC EVALUATION IN SA HOLSTEINS: THE ROLE OF GENOMICS AND ADJUSTED SSGBLUP

**Kgaogelo S. Mafolo[1,2], Frederick W.C. Neser[1], Mahlako L. Makgahlela[1,2], Michael D. MacNeil[1,2,3]**

[1]Department of Animal Science, University of the Free State, Bloemfontein, South Africa
[2] ARC Animal Production Institute, Irene, South Africa
[3]Delta G, Miles City, United States of America

## ABSTRACT

The integration of genomics into livestock genetic evaluations gained significant traction globally and the South African Holstein industry is steadily aligning with this progression. Traditional Best Linear Unbiased Prediction (BLUP) evaluations become challenging due to the rising costs of keeping bulls for progeny testing. Therefore, genomic selection offers an efficient alternative, enabling breeders to assess the genetic potential of breeding animals immediately when DNA is available while accelerating selection decisions and genetic progress. The objective of this study was to compare the traditional BLUP, single-step genomic BLUP (ssGBLUP) and adjusted ssGBLUP with an adjusted inverse of the H matrix on the genomic prediction accuracy and bias in South African Holstein cattle. A total of 696 413 milk production records and pedigree data from 541 325 animals were used, along with 1 221 genotypes and 41,407 SNPs from the Holstein cattle after quality control. The prediction accuracy ranged from 0.01-0.03 for ABLUP, 0.23-0.30 for ssGBLUP, and 0.29-0.37 for adjusted ssGBLUP for milk, protein, and fat yields. Similarly, bias ranged from 0.04-0.08 (ABLUP), to 0.30-0.36 (ssGBLUP), and 0.44-0.53 (adjusted ssGBLUP). This study highlights the potential of incorporating genomics and adjusting the inverse of the H matrix, which makes ssGBLUP perform even better when adjusted according to breed-specific settings. The results of this study should encourage the SA Holstein Industry to invest in genotyping more animals and rely on genomic selection to make informed decisions while reducing the costs associated with keeping bulls for progeny testing.

**Acknowledgements**

We would like to thank the National Research Foundation, the Technology Innovation Agency (TIA), and the Dairy Genomics Program (DGP) for funding the genotyping. The SA Holstein Cattle Breed Society is acknowledged for granting permission to use the data. Lastly, we would like to acknowledge the Centre for High-Performance Computing for providing computational resources to perform our analysis.

Keywords: ssGBLUP, Genomic, Prediction, Holstein, Milk

**Session 8A**

# NUTRITIONAL COMPOSITION OF NIXTAMALIZED AND NON-NIXTAMALIZED YELLOW AND WHITE MAIZE AND SENSORY EVALUATION OF THREE PRODUCTS

**Faith Matiza Ruzengwe[1], Alba du Toit[1], Arno Hugo[2], Jan Willem Swanepoel[1] & Onele Suzan Mpemba[1]**

[1]Department of Sustainable Food Systems and Development, University of the Free State, Bloemfontein, South Africa
[2]Department of Animal Science, University of the Free State, Bloemfontein South Africa

## ABSTRACT

Maize, particularly white maize, is a food source throughout South Africa, particularly for economically disadvantaged households. However, relying solely on maize can lead to significant food and nutrition insecurity risks due to nutrient deficiencies and phytic acid, which inhibits the absorption of essential minerals. To address this issue, there is a pressing need for processing methods that enhance the nutritional value of maize. One promising traditional method is nixtamalization, which improves the nutritional value of maize without requiring specialised equipment, making it an accessible solution for many, especially those living in rural areas. Although widely practised in Mexico, nixtamalization remains largely unfamiliar in sub-Saharan Africa. This study investigated the nutritional effects of nixtamalization on white and yellow maize. Yellow maize flour exhibited higher levels of crude protein, neutral detergent fibre, and acid detergent fibre compared to white maize flour. Nixtamalization of both white and yellow maize flour significantly increased the calcium content by approximately fivefold and significantly increased magnesium and potassium levels ($p<0.05$). Sensory evaluation was done with a panel of 100 participants, aged between 18 and 65 years, selected using a non-probability convenience method. Just-About-Right (JAR) was used to assess the attribute intensity using a 5-point scale. Sensory acceptability results of vetkoek, dumpling and steamed bread made from a composite of wheat and nixtamalized yellow/ white maize flour (0%, 15% and 25%) showed that the vetkoek with 25% nixtamalized yellow flour was the most preferred by the consumer panel. The aroma and outside appearance of this vetkoek were rated as Just-About-Right. Only one attribute, taste, was non-JAR, with a mean drop of over 1 on the JAR scale. For taste, this mean drop value indicated that, on average, participants perceived the intensity as less than what they considered "just about right," leading to the perception of it being too little (bland). This vetkoek's overall consumer liking score was 6.86, indicating a slight liking. Consumer sensory evaluations demonstrated acceptance of vetkoek made with the inclusion of 25% nixtamalized yellow maize. These findings suggest that yellow maize has the potential to play a more prominent role in South Africa, beyond its current primary use as livestock feed.

**Keywords**: Nixtamalization, Yellow maize, Just-About-Right, Vetkoek

**Session 8B**

# ASSESSING THE SOCIAL AND ECONOMIC IMPACTS OF CHANGED WATER USE BEHAVIOUR AMONG MAIZE IRRIGATORS IN THE ORANGE-RIET IRRIGATION SCHEME, SOUTH AFRICA

**Markus A. Monteiro, Henry Jordaan & Yonas T. Bahta**
Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa,

## ABSTRACT

Water scarcity is a growing challenge for agriculture in South Africa, particularly in irrigated crop production. Understanding the factors that influence farmers' water use decisions is essential for designing effective policies that promote sustainable and efficient resource use. This study develops an integrated framework that links psychological, biophysical, and socio-economic dimensions, using the Orange Riet Irrigation Scheme in the Free State Province as a case study. The research applies the Theory of Planned Behaviour to identify the psychological factors shaping farmers' willingness to adopt water-saving technologies. These factors, including attitude, perceived behavioural control, and subjective norms, were measured through a structured questionnaire survey and analysed using Structural Equation Modelling to determine their influence on adoption intentions. The results provided insights into the psychological conditions under which different levels of adoption are likely to occur. Based on this, three adoption scenarios were developed: no adoption, partial adoption, and full adoption of water-saving practices. These scenarios were simulated using the AquaCrop model to estimate the effects of water use behaviour on maize yields. The yield outcomes were then fed into a Social Accounting Matrix to evaluate broader economic impacts, including effects on household income, employment, and sectoral activity. This study demonstrates how psychological insights into farmers' decision-making can be combined with crop growth and economic models to assess not only water use behaviour but also the wider implications of changing that behaviour. The results show that adopting water-saving practices can improve crop yields and increase rural incomes, while also influencing the broader economy. This integrated approach provides policymakers with a practical tool to understand and support sustainable water use in agriculture, highlighting the real-world impacts of behaviour change in addressing water scarcity.

**Acknowledgements**

We acknowledge and thank the Water Research Commission (WRC) of South Africa for supporting this research. This study is part of the big project entitled "Assessing the social and economic impact of changed water use behaviour in selected production and irrigation scheme in South Africa", funded by the Water Research Commission (WRC) of South Africa (Project Number: C20222023-00798).

**Keywords**: theory of planned behaviour (TPB), structural equation modelling (SEM), AquaCrop simulation, Social Accounting Matrix (SAM), Integrated framework

**Poster Sessions**

# EXAMINING THE SUSTAINABILITY OF AGROECOLOGICAL PRACTICES IN SMALL-SCALE FARMING SYSTEM: A CASE STUDY OF TSHESENG, QWAQWA.

**Bongiwe Mosikili, Katleho Mashiane, Sanele Mbambo & Solomon Zondo**
Department of Geography, University of the Free State, Phuthaditjhaba, South Africa

## ABSTRACT

Agroecology has emerged as a viable pathway for achieving sustainable agriculture, particularly among small-scale farmers in resource-constrained environments. This study explores the sustainability of agroecological practices among small-scale farmers in Tsheseng village, QwaQwa, with data collected from 24 small-scale farms over a period of 3 months. Using a qualitative case study approach, the research aims to assess how agroecological practices have been sustained and contribute to environmental conservation, social inclusivity, and local livelihoods in Tsheseng community. The study is guided by four key objectives: (1) to identify agroecological and conventional farms; (2) to assess the application of indigenous knowledge in sustaining agroecological practices; (3) to evaluate social inclusivity within agroecological farms, focusing on age, gender, and education level; and (4) to examine sustainable water management practices adopted by small-scale farmers in Tsheseng. Data was collected from twenty (20) owners of home-based gardens through semi-structured interviews, a focus group discussion of four (4) community farm each consisting of 6-10 members and one (1) key informant interview with traditional leader. Qualitative data was analysed using thematic analysis. In addition, GPS coordinates and geospatial data (rainfall, temperature, elevation, and land use land cover) were incorporated to contextualise environmental conditions influencing farming practices using ArcGIS pro. Preliminary findings indicate that the majority of farmers in Tsheseng employ agroecological practices; however, some still rely on non-agroecological methods for pest control and ploughing. The study also reveals that a significant number of 7 farmers integrate indigenous knowledge into their farming systems (35%) and 14 farmers practice community driven water conservation (70%). Nonetheless, social inclusivity remains uneven, particularly regarding youth and gender participation. The study underscores the value of place-based, culturally rooted farming approaches in fostering long-term sustainability and food sovereignty. It contributes to sustainable rural development by showing that agroecological practices enhances both environmental resilience and community systems. The findings have important policy implications, particularly for integrating agroecology into municipal land use plans and climate resilience programs. Additionally, these insights are crucial for practitioners and researchers promoting sustainable agriculture in marginalised, ecologically sensitive regions like Tsheseng.

**Acknowledgements**
Centre for Global Change, UFS Qwaqwa

**Keywords**: Agroecological practices, Conventional practices, Small-scale farmers, Sustainable agriculture

**Session 8A**

# ASSESSING THE SOCIAL PILLAR OF SUSTAINABLE WATER USE IN SOUTH AFRICA THROUGH WATER FOOTPRINT ANALYSIS

**Pascalina Pilane[1], Henry Jordaan[1], Lloyd Baiyegunhi[2] & Yonas T. Bahta[1]**
[1]Department of Agricultural Economics, University of the Free State, Bloemfontein South Africa
[2]School of Agricultural Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa

## ABSTRACT

The social dimension of sustainable water use remains underexplored compared to its economic and environmental counterparts, limiting the available evidence base to inform policy and stakeholder decisions. This study integrates Water Footprint Accounting with a Social Accounting Matrix (SAM)-based input-output model –a partial equilibrium approach – to assess the social impact of water use in the table grape sector of the Western Cape Province, South Africa. By bridging the knowledge gap in understanding the social implications of water use for agricultural production, this study offers an evidence-based approach to assessing water's broader socio-economic impacts. By incorporating blue, green, and grey water footprints into the SAM framework, the analysis provides a comprehensive understanding of water's role in local livelihoods and economic linkages. The results indicate a direct water effect of R 65, 988 (USD 3, 666) and an indirect effect of R 111, 741 (USD 6, 208) in the agricultural sector. An increase of R 1 million (USD 55, 556) in exogenous demand in the agricultural sector generated a value-added/GDP multiplier of blue, green, and grey water footprints of R 2. 4 million (USD 133,333) for water usage and a household income multiplier of R 4. 4 million (USD 244,444). Notably, the fishing and table grape sectors showed the highest value-added multipliers of (R 1. 8 million [USD 100, 000] and R 1. 6 million [USD 88, 889]) and labour multipliers (R 65 million [USD 36, 111] and R 0. 64 million [USD 35, 556]). In alignment with the Sustainable Development Goals (SDGs) 2 and 12 and the African Union's Comprehensive Africa Agriculture Development Programme (CAADP) Strategy 2026–2035, this study provides detailed insights into water usage multipliers, economic impact analysis of water use in agriculture, and a methodological approach to understanding the social dimensions of sustainable water use, which is crucial for water-scarce regions like South Africa.

**Keywords**: community indicators, water footprint assessment, social accounting matrices, evidence-based policy-making decisions

**Session 8B**

---

# SOCIAL SUSTAINABILITY: A SYSTEMATIC REVIEW OF SOCIAL SUSTAINABILITY INDICATORS FOR WATER USE ALONG THE AGRICULTURAL VALUE CHAIN

**Pascalina Pilane, Henry Jordaan & Yonas T. Bahta**
Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Sustainable water use is a crucial indicator of the various environmental, economic, and social pressures on freshwater resources worldwide. Despite its importance, the social dimension of sustainability remains underexplored in the context of studies on water consumption. This paper aims to critically evaluate the existing literature on social sustainability indicators in agricultural water use, clarify the social aspects of sustainability, and examine the intricate connections between water use and various societal factors. By incorporating a range of perspectives, systematic literature reviews can provide insights into research topics that individual studies may overlook or inadequately address. In

total, 314 academic papers published between 2013 and 2023 were assessed, of which 42 met the established eligibility criteria for inclusion in this review. A mixed-methods approach was employed, incorporating a systematic review in line with the rigorous PRISMA framework, scientific mapping conducted with VOSviewer software, thematic analyses, and an exploration of grey literature generated from advancements in artificial intelligence and deep learning technologies. The findings of this review reveal that social sustainability indicators often emerge from existing environmental indicators, highlighting a gap in the understanding of social variables in water resource management. Currently, there are no standardised definitions delineating what constitutes a social indicator of water use, nor are there established methodologies for effectively measuring these indicators. Nevertheless, frameworks such as life cycle assessment and water footprint assessment have made significant strides in identifying indicators that capture the social value of water. These indicators encompass aspects such as the negative externalities associated with productivity loss, issues of equity, and the economic contributions in terms of job creation per cubic metre of water utilised.

**Keywords**: Sustainable freshwater use, mixed-method approach, life cycle assessment, water footprint assessment

**Poster Sessions**

---

# ASSESSING GENETIC VARIABILITY TO ADVANCE GRAIN YIELD, DROUGHT ADAPTION AND BIOMASS ALLOCATION IN WHEAT (TRITICUM AESTIVUM L.) POPULATIONS

**Kwame Shamuyarira[1], Hussein Shimelis[2], Sandiswa Figlan[3] & Vincent Chaplot[4]**

[1]Department of Plant Sciences, University of the Free State, Bloemfontein, South Africa

[2]African Centre for Crop Improvement, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa

[3]Department of Agriculture and Animal Health, University of South Africa, Florida, South Africa

[4]Laboratoire d'Océanographie et du Climat: Expérimentations et Approches Numériques (LOCEAN), Paris, France

## ABSTRACT

Quantifying the magnitude of genetic variance components in new breeding populations guides selection for grain yield (GY), yield components, biomass and root system attributes. The objective of this study was to determine the genetic variability of newly developed wheat populations for grain yield and biomass allocation under different water stress conditions to select the best-performing families for advancement. One hundred bread wheat genotypes comprising of 10 parental lines and 90 F2 families developed using a full diallel mating design were evaluated for plant height (PH), kernels per spike (KPS), shoot biomass (SB), root biomass (RB), total plant biomass (PB) and GY at two sites (Controlled Environment Facility of the University of KwaZulu-Natal and the Ukulinga Research Farm in Pietermaritzburg). Drought was imposed six weeks after planting by withholding water to 50% field capacity (FC). The non-stressed treatment was kept at 80% FC. Higher phenotypic coefficient of variation (PCV) than genotypic coefficient of variation (GCV) was observed for PH, SB, RB, PB and GY. Heritability and genetic advance as a percentage of the mean (GAM) of 41.61% and 3.49%, respectively, were computed for RB under drought-stressed condition. Based on correlation and principal component analyses, geometric mean productivity (GMP) and stress tolerance index (STI) were prioritised for selecting drought-tolerant families with high RB. Direct crosses such as BW162 × LM75, BW152 × LM75, LM70 × LM75, LM71 × LM75 and LM26 × LM75 and reciprocal crosses LM48 × BW140, LM71 × LM26, LM70 × BW152, LM70 × BW141 and LM75 × LMBW152 were identified with better GY under drought conditions and are thus recommended for genetic advancement.

**Acknowledgements**

UFS, UKZN, WRC, ACCI

**Keywords**: Drought tolerance, Heritability, Root biomass, Wheat

**Poster Sessions**

---

# THE SENSORY ACCEPTABILITY OF NIXTAMALIZED SORGHUM THAT HAS BEEN ADDED TO EXISTING RECIPES

**Lwandile Shezi, Alba du Toit, Ayanda Zulu & Faith Matiza Ruzengwe**
Department of Sustainable Food Systems and Development, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Food insecurity is an issue affecting many regions, including Sub-Saharan Africa. One challenge is the need for ample supplies of nutritious and affordable food. Sorghum is a well-known drought-resistant and nutritious crop mainly used for traditional purposes. However, its nutritional potential is often underutilised as a food source. This study aimed to promote the use of sorghum in everyday cooking by substituting it into existing recipes and investigating the consumer acceptability of the products. Sorghum pilaf with lemon pepper chicken and a sorghum base pizza were developed, and sensory analysis was conducted. The sensory panels had 24 UFS staff and students (18 female participants and 6 male participants), constituting 5 age groups: 18-24 (17%), 25-34(58%), 35-44(8%), 45-54(8%), and 55-64(8%). Panelists assessed the appearance, aroma, taste, flavour, mouthfeel, and overall liking of the sorghum pilaf and pizza on a 9-point hedonic scale (ranging between 1-Dislike extremely to 9-Like extremely). The appearance (6.33), taste (6.25), flavour (6.42), and mouthfeel (6.50) were liked slightly, while the aroma (7.83) was liked moderately for the sorghum pizza. Higher ratings were observed for the sorghum pilaf ranging between 7.72-7.95 (like moderately) for appearance, aroma, flavour, and mouthfeel, whilst the taste (8) was liked very much. Overall liking ratings showed that the pilaf was liked moderately (7.92), and the pizza was liked slightly (6.33). These ratings indicate that the overall acceptability of both products met the desired score of greater than 6.0. In conclusion, sorghum can be incorporated into household cooking as a substitute in pizza and pilaf recipes.

**Keywords**: Sorghum, ratings, acceptability, substitute

**Poster Sessions**

---

# ENDOPHYTES IN AFRICAN POTATO AS AN ALTERNATIVE SOURCE OF BIOACTIVE COMPOUNDS

**Aoate Oteng Tsimatsima[1], Andisiwe Matu[1], Angel Valverde[2], Julio Castillo Hernandez[1,3] & Sara Gutiérrez Patricio[4]**
[1]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
[1]Sustainable Development of Livestock and Agroforestry Systems, Instituto de Recursos Naturales y Agrobiología de Sevilla, Seville, Spain
[3]Department of Integrated Science, University of Huelva, Huelva, Spain
[4]Geomicrobiology and Biogeochemistry, Instituto de Recursos Naturales y Agrobiología de Sevilla, Seville, Spain

## ABSTRACT

Medicinal plants have long been used for their therapeutic properties. However, increasing concerns about antimicrobial resistance, overharvesting, and inadequate monitoring necessitate alternative sources of bioactive compounds. Endophytes, microorganisms residing within plant tissues without

causing disease, have been shown to produce antimicrobial metabolites, sometimes identical to those of their host plants. Despite their potential, most studies rely on culture-dependent methods, which exclude ~99% of unculturable candidates. Here, to overcome this limitation and enhance bioprospecting efficiency, metagenomic sequencing and bioinformatics tools were employed to characterise the endophytic community of African potato (*Hypoxis rigidula* var. *rigidula*). The top bacterial endophyte phyla detected were Pseudomonadota (78.66%) and Bacillota (14.31%). While the top detected fungal phyla were Ascomycota (80.19%) and Basidiomycota (16.59%). The two most dominant genera for bacteria were Pseudomonas (74.85%) and Paenibacillus (12.70%), whereas Beauveria (39.74%) and Alternaria (8.79%) showed dominance in the fungal community. All the metagenome-assembled genomes (MAGs) belong to Pseudomonas genus and a total of 75 biosynthetic gene clusters (BGCs) were detected in them. Additionally, twelve (12) putative compounds were linked to the detected BGCs. Thus, this workflow showcases an alternative preliminary route for the bioprospection of novel or special bioactive compounds, which provides a broader scope to give a voice to the hidden potential of the invisible majority.

**Acknowledgements**

This research was funded by National Research Foundation (NRF) and the German Academic Exchange Service (DAAD), grant number MND210617612491 and the Technology Innovation Agency (TIA).

**Keywords**: Endophytes, metagenomics, genome mining, African potato, biosynthetic gene clusters (BGC)

**Session 8C**

## CHOLERA INVASION SPEED AND THE INTERVENTION STRENGTH

**Komi Afassinou[1], Narcisse R. Loufouma Makala[1] & Ousmane Koutou[2]**
[1]Department of Mathematics and Applied Mathematics, University of the Free State, Phuthaditjhaba, South Africa
[2]Université de Joseph-KI-ZERBO, Burkina Faso

### ABSTRACT

We formulate a mathematical model which captures the essential dynamics of cholera infection transmission. Control interventions such as vaccination program and environmental sanitation service are incorporated to analyse the impact of both interventions on the infection dynamics. The qualitative and numerical analyses of the model are carried out. Through these analyses, a great attention is brought to certain uncommonly used infection features such as invasion speed of an infection which historically has been ignored by infectious disease modellers. The analyses of these key model parameters not only reveal the required intervention strength needed to curb the infection spread but also indicate which either control intervention should be prioritised. The numerical results approve the qualitative findings and promise an infection free population, should the control intervention speed be greater than the invasion speed of the infection.

**Keywords:** vaccination rate, sanitation rate, invasion speed, intervention strength

**Session 2A**

---

## PRODUCTION OF LEISHMANIA AND CANDIDA SPECIES C24-STEROL METHYLTRANSFERASES FOR THE DEVELOPMENT OF DUAL ANTIFUNGAL AND ANTIPARASITIC THERAPIES

**Bernadette Belter, Carmien Tolmie & Dirk Opperman**
Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein Campus

### ABSTRACT

Opportunistic fungal infections and parasitic diseases are a growing global health threat, particularly in immune-compromised populations and regions with high HIV/AIDS prevalence, such as Sub-Saharan Africa. The limited arsenal of antifungal agents and the rise of resistance demand new therapeutic targets. One promising target is $\Delta^{24}$-sterol methyltransferase (SMT), a key enzyme in ergosterol biosynthesis, which is absent in mammals, making it ideal for selective drug development. This study focuses on the heterologous expression of homologous SMT enzymes from Candida albicans, Leishmania donovani and Leishmania major in Escherichia coli using pNIC-NHSTIIT-GG and pET-based expression vectors. Proteins were purified using Ni-NTA-affinity chromatography, followed by protease cleavage to remove the Nterminal His-tag and size-exclusion chromatography. An N-terminally truncated form of C. albicans SMT was successfully expressed and purified, and initial crystallisation trials using commercial screens have yielded promising crystals in the presence of S-adenosyl-L-homocysteine or S-adenosyl-L-methionine. These conditions are currently being optimised for reproducibility, which ensures consistent and highquality crystal formation before X-ray diffraction experiments. SMTs from Leishmania spp. have been successfully expressed, and ongoing work focuses on enhancing solubility through construct engineering, including truncations, the addition of fusion tags

and buffer optimisation for purification. Future steps include X-ray crystallographic fragment screening to identify small-molecule fragments capable of binding to the SMT active site. By structurally characterising SMTs and identifying fragment hits, this project aims to, in future, identify lead compounds for the development of novel dual antifungal and antiparasitic therapies against protein homologs that minimise off-target effects in humans.

**Acknowledgements**

Funding: National Research Foundation (NRF). Special thanks to the Structure Based Drug Discovery (SBDD) and Biocatalysis laboratories

**Keywords**: antiparasitic, antifungal, sterol-methyltransferase, x-ray, crystallography

**Poster Sessions**

---

# MAGIC MUSHROOMS: WHERE CHEMISTRY, MYCOLOGY AND THE LAW COINCIDE

**Juan-Claude C. Botha[1], Anwar E.M. Noreljaleel[2], J. Augustinus Viljoen[1] & Marieka Gryzenhout[1]**

[1]Department of Genetics, University of the Free State, Bloemfontein, South Africa

[2] Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Psychedelic mushrooms, commonly referred to as magic mushrooms, contain the hallucination-causing alkaloids, Psilocybin and Psilocin. These mushrooms are of forensic interest due to their legal status. In South Africa, both Psilocybin and Psilocin are classified as Schedule 7 drugs under the Medicines and Related Substances Act. In addition, the Drugs and Drug Trafficking Act prohibits the possession, use, and manufacture of these compounds. Breaching these laws is a criminal offense, thus necessitating reliable and accurate analysis of magic mushrooms in investigations. This study explores both taxonomic and chemical approaches to identify psychedelic mushrooms. Four species commonly seized by the SAPS were taxonomically classified based on micro- and macromorphological characteristics. The species, African Transkei (AT), Trinity, Golden Teacher (GT), and Natal Superstrength (NSS), had spore sizes ranging between 52.64 - 83.65 µm2, with GT having the biggest spores. However, since taxonomy is only limited to species identification, chemical analysis was conducted to detect and quantify Psilocybin and Psilocin. Various extraction solvents were evaluated via HPLC-MS/MS for optimal alkaloid isolation. Methanol and acidified ethanol were relatively the best solvents to extract Psilocybin and Psilocin, respectively. Furthermore, Psilocin concentrations range between 0.110 – 0.594 m/m% while those of Psilocybin range between 0.330 – 4.059 m/m% across species. Trinity contained the highest concentrations of Psilocin, while NSS contained the highest concentrations of Psilocybin. Lastly, a five-step chemical synthesis of Psilocin and Psilocybin was undertaken. Three steps of the synthesis have been successfully completed till date, with the third intermediate product, 3–dimethylaminooxalyl–4–acetylindole, being confirmed by NMR. This product is yet to be reduced to form Psilocin, and this will be followed by phosphorylation to produce Psilocybin. The findings of this research will contribute to forensics, as it will aid the police by refining psychedelic mushroom identification techniques.

**Keywords**: magic mushrooms, Psilocybin, Psilocin forensics

**Session 2C**

---

# HERD SEROPREVALENCE OF MYCOBACTERIUM AVIUM SUBSPECIES PARATUBERCULOSIS IN FREE-RANGING CATTLE FROM RURAL AREAS OF SOUTH AFRICA

**Kara Bruwer[1], Deborah Cooke[2], Giovanni Ghielmetti[3], Lisa Lackey[1], Michele Miller[4], Tanya J. Kerr[4], Tristen Lourens[1] & Wynand J. Goosen[1,4]**

[1]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
[2]Department of Agriculture and Rural Development, Pietermaritzburg, South Africa
[3]Vetsuisse Faculty, University of Zurich, Zurich, Switzerland
[4] SAMRC Centre for Tuberculosis Research, Stellenbosch University, Stellenbosch, South Africa

**ABSTRACT**

Mycobacterium avium subspecies paratuberculosis (MAP) is an opportunistic pathogen and the causative agent for Johne's disease in domestic and free-ranging ruminants. Johne's disease, a chronic enteric infection, causes decreased milk production, and lethargy, but ultimately leads to premature death. As such, it has a significant impact on human welfare and contributes to economic instability worldwide. Moreover, MAP is zoonotic and has been detected in humans routinely; it is strongly associated with Crohn's disease, inflammatory bowel disease, sarcoidosis and others. Considering the impact that MAP has, there is a crucial need for surveillance, reporting, prevention and control programs. Despite groundbreaking advances in vaccines and serological assays, these measures are not in place. It is especially dire for rural communities, particularly in South Africa (SA), since the highest prevalence of HIV/AIDS is reported from these areas, and the people are at high risk for opportunistic pathogens such as MAP. This study focuses on using an inhouse comparative pure protein derivative (PPD) ELISA and the Cattletype® MAP Ab Kit (ELISA) for the detection of MAP in rural cattle herds, in comparison to a historically potentially unexposed cohort, and statistical analysis to estimate the seroprevalence of MAP in cattle from the rural communities of KwaZulu-Natal, South Africa, for the first time. The Comparative PPD ELISA revealed that the screened herds have an apparent seroprevalence of 66.89% (2023 cohort) and 12% (2024 cohort) to avian PPD; while the Cattletype® MAP ELISA estimated 37.16% and 12%, respectively. This study would create awareness to the threat MAP poses to these rural communities and pave the way for better prevention and control programs that would not only protect the rural cattle, but also the people and their welfare.

**Keywords**: Mycobacterium avium subspecies paratuberculosis, serology, Cattletype MAB Ab Kit, Comparative PPD ELISA

**Poster Sessions**

---

# PHYTOCHEMICAL INVESTIGATION OF THE ETHYL ACETATE EXTRACT OF ADENIUM MULTIFLORUM (APOCYNACEAE): BIOASSAY GUIDED FRACTIONATION, TOXICITY, AND IN-SILICO EVALUATION AGAINST CANCER

**Maria S. Chukwuma, Abdul R. Issahaku, Anke Wilhem, Anwar E.M. Noreljaleel & Susanna L. Bonnet**

Department of Chemistry, University of the Free State, Bloemfontein, South Africa

**ABSTRACT**

Medicinal plants have been used traditionally for many years and continue to be a vital source of innovative and effective pharmaceutical products. Adenium multiflorum Klotzsch, commonly known as impala lily, belongs to the genus Adenium in the family Apocynaceae. The plant is traditionally used for wound healing and has been reported to contain antibacterial, antifungal, and anti-tyrosinase

properties. However, the few studies that have been done on this plant showed that not many compounds have been isolated; therefore, bio-assay-guided fractionation and toxicity screening of the ethyl acetate crude extract of A. multiflorum were performed, as well as the isolation of chemical compounds. This study was augmented by an in-silico study to determine the potential binding proteins of the compounds. The toxicity results of the ethyl acetate extract showed non-toxicity of the plant. 3,5,7-trihydroxy-2-(4-methoxyphenyl)-4H-chromen-4-one (kaempferide) and 2-(3,4-dimethoxyphenyl)-3,5,7-trihydroxy-4H-chromen-4-one (dillenetin) were isolated and elucidated in this study. It is the first time that these compounds have been isolated from the stem of A. multiflorum. The computational study determined the potential binding proteins of kaempferide and dillenetin through molecular docking. The computational results of the compounds were compared to the cocrystalised compounds and betulinic acid. The general performance of kaempferide and dillenetin relative to betulinic acid and the ligands suggests they have the potential to bind to multiple oncogenic proteins. Data obtained from this study showed that A. multiflorum has potential anti-cancer properties.

**Acknowledgements**

I sincerely thank my supervisors, Dr. Susanna L. Bonnet and Prof. Anke Wilhem, for their immense support and guidance in ensuring that this project was a success. My huge appreciation also goes to the National Research Foundation of South Africa for the financial support. Also, I thank my colleagues Dr Abdul Issahaku and Dr Anwar Noreljaleel for their good effort and assistance; they are appreciated.

**Keywords**: phytochemistry, toxicity, Adenium, anti-cancer, In-silico

**Poster Sessions and Session 2A**

---

# IDENTIFICATION OF NAD-INDEPENDENT AVIBACTERIUM PARAGALLINARUM ISOLATES FOR PLASMID EXTRACTION AND THE TRANSFORMATION OF REFERENCE SEROVARS

**Azil Coertzen, Mariana Erasmus & Robert R. Bragg**

[1]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Infectious coryza (IC) remains a serious problem in many parts of the world despite the widespread use of various vaccines. Avibacterium paragallinarum, which is responsible for IC infections in poultry, is categorised into different serovars and was first identified in the 1930s. Early signs of infection in chickens can be seen in facial swelling, nasal discharge, and sneezing. Untreated infection can lead to retardation in the growth experienced by broilers and a decrease in egg production. This can affect the food security of many countries that rely on poultry production as a main protein source. In this study, a strain of A. paragallinarum that does not require nicotinamide adenine dinucleotide (NAD+) for growth was isolated from infected chickens. This indicates that these field isolates can thrive without the presence of NAD+. Past studies have shown that the NAD+-independence was caused by a transmissible plasmid. Therefore, this study aims to introduce the plasmid into the reference serovars of A. paragallinarum. The results indicated that this was the first successful transformation of four out of nine reference serovars of A. paragallinarum by creating competent cells and applying heat shock. The reference serovars of A. paragallinarum are known for their dependence on a colony feeder that consistently supplies the bacteria with NAD+. This requirement limits the number of bacteria that can be cultured and increases the chances of contamination. Therefore, successfully transforming these reference serovars with the plasmid extracted from NAD+-independent field isolates can help vaccine companies overcome these limitations. This advancement could enhance vaccine development and lead to the use of these modified reference serovars as live vaccines. In conclusion, the impact of these

transformed reference serovars could significantly improve the prevention of infectious coryza in poultry, thereby contributing to food security.

**Keywords**: Avibacterium paragallinarum, nicotinamide adenine dinucleotide (NAD), references serovars, transformation

**Poster Sessions**

---

# NANOPORE SEQUENCED TARGETED METAGENOMIC ANALYSIS OF INANIMATE SURFACES WITHIN A CLINICAL SETTING

**Xandi Gouws[1,2], Julio Castillo Hernandez[1], Marianna Erasmus[2], Samantha McCarlie[1] & Robert R. Bragg[1,2]**

[1]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
[2]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Increasing disinfectant-resistance has caused multidrug-resistant microorganisms to persist in the environment, leaving hospital inanimate surfaces visibly clean but microbially contaminated. Advanced sequencing technology reveals a far greater microbial diversity, especially detecting unculturable bacteria. This raises concerns about the microbial diversity in clinical settings and possible role unculturables could play in infectious diseases. This study compared traditional culturing techniques to metagenomic analysis within an academic hospital with the necessary approvals and ethics, over a six-month period. High-touch surfaces in a neonatal intensive care unit (NICU) were sampled using surface testing agar plates and swabs, before and after disinfection. A protocol was designed to extract DNA directly from the swabs followed by nanopore sequencing analysis to identify culturable and unculturable bacteria, before and after disinfection. Minimum inhibitory concentration (MIC) tests were performed on disinfectants routinely used in the NICU to determine efficacy of hospital cleaning protocols. Metagenomic analysis revealed greater bacterial diversity than traditional culturing and similar diversity profiles pre- and post-disinfection, indicating the presence of unculturable bacteria and residual DNA, respectively. Serratia marcescens, known to cause outbreaks in NICUs, was a notable possible pathogen that was detected only via sequencing despite being culturable. MIC levels were determined to be below the concentration of the disinfectants used in the NICU, indicating that the disinfectants should be effective against the detected bacteria. The results have important implications for the healthcare industry, especially in high-risk environments like NICUs. It provides compelling evidence for modernising microbial surveillance using sequencing technologies. Metagenomics analysis is crucial for routine surveillance and infection control for the detection of possible pathogenic and resistant unculturable bacteria. Residual DNA poses a risk for emergence of new pathogens through horizontal gene transfer and false-positive results of viable cells. Thus, re-evaluation of disinfection protocols is important for elimination of viable bacteria but also residual DNA.

**Keywords**: metagenomics, nanopore, disinfectant resistance, hospital-acquired infections

**Session 2B**

---

# MINING NATURE'S PHARMACY FOR GABA MIMETICS: A COMPUTATIONAL DRUG DISCOVERY STUDY

**Abdul R. Issahaku, Anke Wilhelm, Elizabeth Erasmus, Hendrik Visser & Marietjie Schutte-Smith**
Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Gamma-aminobutyric acid (GABA) signalling is the principal inhibitory pathway in the central nervous system. It is critical in neuronal cell proliferation and fate determination. Any aberration in GABA inhibition results in psychiatric and neurological diseases. Thus, modulating GABAergic neurotransmission has become the basis of drug therapy for psychiatric and several neurological diseases. Though GABA and muscimol are classical activators of GABA receptors, the search for novel activators continues unabated. In this study, the binding mechanism of GABA and muscimol was elucidated and applied in the search for small molecule GABAergic activators from natural compound libraries using comprehensive computational techniques. It was revealed that the high-affinity binding of GABA and muscimol was mediated by a water molecule involving a1Thr129 and then stabilised by strong interactions including salt bridges with ß2Glu155 and a1Arg66 amidst hydrogen bonds, p-p stacking, and p -cation interactions with other residues. The binding of GABA and muscimol was also characterised by stability and deeper penetration into the protein's hydrophobic core, which resulted in conformational changes of the binding pocket and domain, by inducing correlated motions of the residues. Thermodynamics analysis showed GABA and muscimol exhibited total binding free energies of -19.85±8.83 Kcal/mol and -26.55±3.42 Kcal/mol respectively. A pharmacophore model search, based on the energy contributions of implicating binding residues, resulted in the identification of ZINC68604167, ZINC19735138, ZINC04202466, ZINC00901626, and ZINC01532854 as potential GABA-mimetic compounds from metabolites and natural products libraries. This study has elucidated the binding mechanisms of GABA and muscimol and successfully applied them to identify GABA-mimetic compounds.

**Keywords**: GABA, Muscimol, GABAA-R, molecular dynamics, simulation, pharmacophore modelling

**Session 2C**

---

# ISOLATION OF PRENYLATED FLAVONOIDS FROM *ORMOCARPUM TRICHOCARPUM* SEEDS AS POTENTIAL CENTRAL NERVOUS SYSTEM TREATMENTS

**Tsebo S. Jim[1], Anke Wilhelm[1], Sophia Khom[2] & Susan L. Bonnet[1]**
[1]Department of Chemistry, University of the Free State, Bloemfontein, South Africa
[2] Department of Pharmaceutical Sciences, University of Vienna, Austria

## ABSTRACT

In Africa, with its enormous diversity of plants, only a small percentage of traditional medicinal plants have been investigated as a treatment for mental illness. Mental illness is an under-recognised socio-economic burden and is becoming one of the most demoralising illnesses worldwide. In an earlier study, we evaluated the seed extracts and fractions of *Ormocarpum trichocarpum* for antipsychotic, antioxidant and anti-inflammatory potential. This study aims to isolate and characterise compounds from the previously isolated seed fractions of *O. trichocarpum* to identify the compounds that affect the antipsychotic, GABAA receptor modulation. The DCM crude extract and its active fraction with the highest GABAergic effect were further purified and afforded five prenylated flavonoids: 6,8-

diprenylaromadendrin (1), lonchocarpol A (2), 6,8diprenylgenistein (3) and two isomers of isoerysenegalensein E (4 and 5). 6,8-Diprenylaromadendrin (1) and the two isoerysenegalensein E isomers (4 & 5) displayed positive GABAA receptor modulation. 6,8-Diprenylaromadendrin (1), lonchocarpol A (2) and 6,8-diprenylgenistein (3) displayed antioxidant and anti-inflammatory properties. Diprenylaromadendrin (1) exhibited the best GABAergic effect, whereas 6,8diprenylgenistein (3) showed the most potent antioxidant and anti-inflammatory effect. This is the first report of the isolation of prenylated flavonoids from *O. trichocarpum*. These results suggest that the isolated compounds may be developed into promising herbal treatment alternatives for mental illnesses and neurological disorders.

**Acknowledgements**

The Department of Chemistry, Faculty of Natural and Agricultural Sciences, and Department of Pharmacology, IKS Unit, Faculty of Health Sciences, University of the Free State, and the Department of Pharmaceutical Sciences, Faculty of Life Sciences at the University of Vienna for providing research and laboratory facilities.

**Keywords**: prenylated flavonoids, GABAA receptor modulation, antioxidant, anti-inflammatory

**Session 2D**

---

# INVESTIGATING THE IN-VITRO ANTI-INFLAMMATORY AND ANTI-CANCER ACTIVITY OF DIOSCOREA SYLVATICA

**Selloane Lehasa, Anofi.O.T. Ashafa & Pheello.J. Mojau**

Department of Plant Sciences, University of the Free State, Phuthaditjhaba, South Africa

## ABSTRACT

Medicinal plants play an important role in the global healthcare system by providing alternative and affordable therapeutic remedies. Dioscorea sylvatica is one of the wild yams species under family *Dioscoreaceae,* and it is widely distributed in South Africa with suggestive medicinal potential such as anti-inflammatory, anti-tumour and anti-cancer properties. However, its status on the Red List of South African species brings concerns and urgent need to conserve and sustain these plant species for scientific utilisation in future. The aim was to document and investigate *D. sylvatica* anti-inflammatory and anti-cancer medicinal properties. The 5-lipoxygenage (5-LOX) model assay and MTT assay were used to evaluate the anti-inflammatory and anti-cancer properties of D. sylvatica crude extracts. The results from the 5-LOX model, showed that ethanol extract exhibited the best inhibitory activity with an IC50 value of 3.063±0.040 µg/µL, followed by hydro-ethanol extract with 4.042±6.993 µg/µL. Anti-cancer studies showed that acetone extract depicted low cytotoxicity level at its highest concentration of 17.9 mg/mL with cell viability above 80%, and weak cytotoxicity level at 8.9 mg/ML with cell vitality of 69% was also recorded, suggesting potential for a good anti-cancer agent against HuTu-80. All extracts seemed to be highly cytotoxic at all concentrations against H4IIE-luc cancer cell line. Furthermore, this study will provide a very useful benchmark for the use of D. sylvatica in healthcare as an alternative to synthetic drugs in treatment of inflammation and cancer; the study will also promote the importance of following correct harvesting methods and seasons as a remedy to threatened species.

**Keywords**: medicinal plants, Dioscorea sylvatica, anti-inflammatory, anti-cancer

**Session 2C**

---

# RURAL CATTLE AS RESERVOIRS OF ZOONOTIC MYCOBACTERIA: GENOMIC INSIGHTS FROM KWAZULU-NATAL, SOUTH AFRICA

**Tristen Lourens[1], Deborah M. Cooke[2], Giovanni Ghielmetti[3], Michele A. Miller[4], Rachiel Gumbo[4], Tanya J. Kerr[4] & Wynand J. Goosen[1]**

[1]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
[2]Department of Agriculture and Rural Development: Veterinary Epidemiology, Pietermaritzburg, South Africa
[3]Section of Veterinary Bacteriology, Institute for Food Safety and Hygiene, University of Zurich, Zürich, Switzerland
[4]South African Medical Research Council Centre for Tuberculosis Research, Division of Molecular Biology and Human Genetics, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa

## ABSTRACT

Cattle from KwaZulu-Natal (KZN), South Africa, an endemic *Mycobacterium bovis* area, serve as a unique reservoir for zoonotic mycobacteria due to their extensive grazing patterns and shared environments with other livestock and wildlife. Consequently, rural cattle differ considerably from commercial cattle with regards to microbial exposure and infection dynamics. This study addresses the gap in understanding the genomic composition and zoonotic potential of secreted mycobacteria from rural cattle in KZN, revealing how culturing biases and microbial competition can obscure *M. bovis* detection and distort microbial community profiles. This study aimed to analyse secreted mycobacterial communities from KZN rural cattle positive on the GeneXpert MTB/RIF Ultra assay (Ultra), using next-generational sequencing (NGS). Oronasal swabs (n = 12) and faeces (n = 93) were opportunistically collected in 2023 from rural KZN cattle (n = 93). The Ultra was performed on all samples, of which 3/12 and 9/93 had Mycobacterium tuberculosis complex (MTBC) DNA present, respectively. Samples were further subjected to the Mycobacteria growth indicator tube (MGIT) system. Subsequently, 77/105 and 5/105 were positive for solid media growth. DNA was extracted from raw specimens, primary MGITs, and solid-media colonies containing MTBC DNA (n = 12). Region-of-difference PCR (RD-PCR) was performed on extracted DNA from all Ultra-positive primary MGITs and solid-media colonies for speciation. Extracted DNA from raw faeces and MGITs was further subjected to mycobacterial-specific PCRs targeting the following genes: 16s, hsp65, rpoB, MAC hsp65, gyrA, gyrB1, and gyrB2. Targeted amplicon NGS was conducted using the Oxford Nanopore Technologies (ONT) PromethION 2 solo. Finally, whole-genome sequencing (WGS) was performed on DNA from all solid-media-cultured isolates. RD-PCR identified seven culture samples as *M. bovis* (n = 3 MGITs and n = 4 solid-media isolates). Finally, *M. komossense* (n = 1), M. avium (n = 1), *M. bovis* (n = 2), and M. litorale (n = 1) were confirmed using WGS on solid-media-cultured isolates. This is the first study to report *M. bovis* isolation from free-ranging rural cattle secretions, providing genomic insights into mycobacterial communities, each with their own zoonotic potential. Furthermore, the findings highlight how *M. bovis* is masked by other Mycobacteria present in raw specimens, likely because of competition during downstream culturing. Finally, targeted NGS showed the considerable diversity loss from raw material to primary MGITs and subsequent solid media, likely due to harsh decontamination and culture pre-processing requirements. Ultimately, this research supports informed public health and veterinary interventions by providing a foundational understanding of microbial dynamics in cattle across varied environments, advancing our knowledge regarding disease transmission at the livestock–wildlife–human interface.

**Acknowledgements**

The National Research Foundation (NRF) (Grant # PMDS240624231695), Wellcome Foundation (Grant # 222941/Z/21/Z), University of the Free State Green Futures Hub, National Geographic, and the European Union Global Health EDCTP3 Joint undertaking and its members (project 101103171).

Keywords: mammalian tuberculosis, *Mycobacterium bovis*, rural cattle, disease transmission

**Session 2A**

# THE REPURPOSING OF ARTEMISININ AS AN ANTI-CRYPTOCOCCUS AGENT

**Maphori Maliehe, Jacobus Albertyn, Nozethu Mjikane & Olihile Sebolai**
Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

*Cryptococcus (C.) neoformans* has emerged as a pathogen of global importance due to treatment issues, drug resistance, and ill-tolerance. It is therefore prudent to consider repurposing an already FDA-approved drug as an anti-Cryptococcus agent to circumvent these challenges. The study sought to evaluate the impact of the anti-mitochondrial artemisinin, on the growth, mitochondrial function and virulence of cryptococcal cells. An in vitro susceptibility assay was performed to assess the growth inhibitory properties of artemisinin on *C. neoformans*. The ultrastructural changes induced by treatment were examined using electron microscopy. Mitochondrial function was evaluated by monitoring the overproduction of ROS as well as cytochrome c release from mitochondria and its activation of caspase 3. A systemic cryptococcal infection was then established in *Galleria mellonella*, and the infected larvae were monitored to determine cocoon formation. The larvae were also assessed for the expression of IMPI gene, an inhibitor deployed to prevent the dissemination of pathogens. It was shown that a 10-fold increase in artemisinin concentration led to growth inhibition of cryptococcal cells in a dose-dependent manner. Treated cells were characterised by elevated ROS levels ($p < 0.05$) and cytochrome c ($p < 0.05$) in the cytoplasm – all hallmarks of a dysfunctional mitochondrial. Moreover, the activation of caspase 3 was notably higher ($p < 0.05$) in treated cells than in non-treated cells. Concerning the larvae, the larvae with treated cells could form cocoons, while those infected with non-treated cells could not. Moreover, the levels of IMPI were significantly higher ($p < 0.05$) in treated cells than in non-treated cells, suggesting enhanced clearance of artemisinin-treated cells. The preliminary data presented in this study present empirical evidence of artemisinin serving as a repurposed control agent that could inhibit cryptococcal growth and assist an infected animal in clearing infection.

**Keywords**: Cryptococcus neoformans, artemisinin, mitochondria, repurposing

**Session 2D**

---

# INVESTIGATION OF THE POTENTIAL OF BIOCL COMPOSITE AS A CATALYST FOR THE BIGINELLI REACTION

**Oladiran T. Ajiboye & Meloddy H. Manyeruke**
Department of Chemistry, University of the Free State, Bloemfontein 9300, South Africa

## ABSTRACT

Biginelli reaction is a three-component one-pot cyclocondensation between urea, diketone/ke-toester and substituted aryl aldehydes that is used to synthesise DHPMs. The presence of bioactive chiral centres in 3,4-dihydropyrimidin-2(1H)-ones (DHPMs) has made them to be sought-after compounds for pharmacological applications. In the industry, they are used as raw material for fabric dyes, adhesives and polymers. Without catalyst, the rate of this reaction is slow. In this work, $BiOCl/NiS_2/Bi_2S_3$ composite was made through a solvothermal process from bismuth nitrate, nickel chloride, EDTA, thiourea, thioacetamide and ethylene glycol. The obtained product was characterised by using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDX), transmittance electron microscopy (TEM), and UV-vis spectrophotometry. The material was then used as a catalyst for the Biginelli reaction, and the material was found to show potential as a catalyst for this reaction. The relative intensity of a $CH_3$ signal ($\delta$ =1.72 ppm) of the product was monitored over 2 h in

the NMR spectra. The relative peak intensities were found to be 0, 104.6, 165.1 and 447.7 at 0.5, 1.0, 1.5 and 2.0 h respectively for the investigated catalyst. The increase in the relative peak intensity over time shows that the composite is a potential catalyst for the Biginelli reaction.

**Acknowledgements**

Hendrik Visser, Marietjie Schutte-Smith, Sussana Bonnet and Anke Wilhem are acknowledged for their support

**Keywords:** nanoparticles, catalysis, 3,4-dihydropyrimidin-2(1H)-ones

**Session 2C**

---

# ANTI-CANDIDA ACTIVITY OF SAPIENIC ACID RICH LIPIDS FROM *THUNBERGIA ALATA*

**Tinotenda S. Matumbura, C.H. Pohl-Albertyn & O.M. Sebolai**

Department of Microbiology and Biochemistry University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Invasive fungal infections represent a significant global health threat largely due to their increasing resistant to conventional antifungal therapies. In the light of this challenge researchers have been investigating the antifungal properties of fatty acids as potential alternatives that may mitigate resistance and reduce environmental impact. This study focuses on *Thunbergia alata* seed oil (a source of sapienic acid, a monounsaturated fatty acid found in the human sebum). Lipids were extracted from commercially sourced Thunbergia alata seeds and analysis of the lipid profile confirmed that sapienic acid constitutes more than 80% of the total seed lipid content. The extracted lipid was evaluated for their ability to inhibits biofilm formation of *C. albicans* and *C. auris* and compared to crude high-oleic sunflower oil. Sunflower oil, known for its antifungal activity, served as a control to provide a baseline for assessing the unique antifungal potential of *T. alata* oil. Remarkably, *T. alata* lipids demonstrated ~60% inhibition of biofilm growth in both species at a concentration of 10% whereas the sunflower oil demonstrated ~40% inhibition. Significant morphological alterations in the yeast cells including shrinkage and structural irregularities were revealed by scanning electron microscopy. Moreover, when tested on macrophages, the lipid exhibited no toxicity and appeared to enhance macrophage activity. This study demonstrated *T. alata* oil can effectively inhibit biofilm formation without exhibiting toxic effects on macrophages, highlighting its potential as a novel, cost effective and environmentally sustainable antifungal agent.

**Acknowledgements**

Study Leader: Prof C H Pohl-Albertyn; Co-Study Leader: Prof O M Sebolai

**Keywords**: Antifungal fatty acids, Antifungal resistance, *Thunbergia alata*, Candida

**Session 2E**

---

# ASSESSING THE IMPACT OF DECANOYL-RVKR-CHLOROMETHYL KETONE ON *CRYPTOCOCCUS NEOFORMANS* CELLS

**Colleen Mc Quire, Maphori Maliehe, Nozethu Mjokane & Olihile Sebolai**
Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South

## ABSTRACT

*Cryptococcus (C.) neoformans* is a basidiomycetous yeast that rose from being an obscure fungus to an important fungal pathogen. Part of its success is attributed to its arsenal of virulence factors that allow it to subvert the immunological response in a susceptible host. This includes the production of proteases that could permeabilise the phagosomal membrane, leading to internalised cells escaping. This project sought to assess if a protease inhibitor, decanoyl-RVKR-chloromethyl ketone (DEC-RVKR-CMK), could decrease cryptococcal growth and increase their susceptibility towards macrophage phagocytosis. The in vitro susceptibility of cryptococcal cells was assessed by measuring the optical density of the cells following exposure to different DEC-RVKR-CMK concentrations. Additionally, the DEC-RVKR-CMK-treated cells and non-treated cells were co-cultured with macrophages to assess their susceptibility to macrophage phagocytosis by using the pHrodo stain to assess the internalisation of cryptococcal cells by macrophages and a spread plate method to enumerate cells that survived internalisation. It was shown that a 10-fold increase in DEC-RVKR-CMK concentration led to the growth of cryptococcal cells being inhibited in a dose-dependent manner. In the study, 0.1 mM was defined as the minimum inhibition concentration, and it led to over 75% growth inhibition. There was no difference ($p > 0.05$) in the efficiency of macrophages to internalise DEC-RVKR-CMK-treated cells and non-treated cells. However, no colonies of DEC-RVKRCMK-treated cells could be recovered on mycological agar, while non-treated cells yielded colonies on the agar. The in vitro preliminary data obtained in this study suggest DEC-RVKR-CMK may be ideal for controlling cryptococcal growth. The clinical relevance of the study may lie in impairing the ability of cryptococcal cells to escape from macrophages, thus avoiding immunoprocessing. It is thus prudent to show if this quality can be observed in other *C. neoformans* strains and elucidate the molecular mechanism underpinning the reported observations.

**Acknowledgements**
My family, Prof Sebolai, Cryptococcus Lab, Pathogenic Yeast Group, NRF

**Keywords**: *Cryptococcus neoformans*, Decanoyl-RVKR-chloromethyl ketone (DEC-RVKR-CMK), Macrophage, Proteases

**Poster Sessions**

---

# THE ROLE YEAST KEXIN PROTEASES PLAY IN CRYPTOCOCCUS NEOFORMANS BRAIN INVASION

**Khwezi Mdana, Jacobus Albertyn, Maphori Maliehe, Nozethu Mjokane & Olihile M. Sebolai**
Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

*Cryptococcus (C.) neoformans* is among a handful of pathogens that disseminate haematogenously and can breach the highly selective barrier that sits between the brain and blood, namely the blood-brain barrier (BBB). The BBB is primarily composed of tightly joined endothelial cells whose integrity is maintained by proteins called the tight junction proteins, such as occludin. These proteins are essential for regulating movement in the interstitial space, thus keeping the neural environment free of toxins, including microbes. Therefore, their breakdown compromises the integrity of the BBB, leading to increased permeability. With this poster contribution, it was sought to explore the role of cryptococcal

hydrolytic enzymes like the yeast kexin proteases, Kex2p, in the brain invasion strategy of cryptococcal cells by providing in silico and biochemical evidence of cryptococcal Kex2p proteolytically cleaving occludin. For referencing, furin was included as a reference protease, as it hydrolyses occludin in human cells. It was determined that Kex2p was a suitable ligand that could interact with occludin based on the calculated Kex2p-occludin complex's HADDOCK score of -92.3 +/- 1.1 and RMSD of 7.3 Å +/- 0.3. These scores were comparable to those of the furin-occludin complex, i.e., HADDOCK score of -103.4 +/- 10.9 and RMSD of 1.1 Å +/- 0.7. Successful heterologous expression of the cryptococcal Kex2p was validated using SDS-PAGE. To confirm biochemical cleavage, a peptide cleavage assay was performed using a fluorogenic mimetic occludin 20-mer peptide as the substrate. Here, it was established that the recombinant Kex2p could cleave the occludin mimetic peptide, and its enzymatic efficiency was statistically comparable to that of furin ($p > 0.05$). These preliminary findings suggest that Kex2p may cleave occludin, contributing to increased BBB permeability, which in turn could promote dissemination of cryptococcal cells to the brain.

**Acknowledgements**

Prof O.M. Sebolai Prof J. Albertyn Miss M. Maliehle, Dr N. Mjokane, members of the Cryptococcus laboratory, and members of the Pathogenic Yeast Research Group

**Keywords**: *Cryptococcus (C.) neoformans,* Heterologous expression, Protein-protein DOCKing (HADDOCK), Yeast kexin protease (Kex2p)

**Poster Sessions**

---

# RECOMBINANT PRODUCTION OF PORCINE FOLLICLE STIMULATING HORMONE

**Banele R. Mhlanga, Carmien Tolmie, Frans H. O'Neill, Hester G. O'Neill & Nkhasi Lekena**

Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Follicle stimulating hormone (FSH) is a glycoprotein hormone involved in mammalian reproductive processes, including gametogenesis and endocrine regulation. Purified FSH extracts are used in animal breeding to improve reproductive outcomes, thereby contributing towards food security. The FSH extracts are sourced from porcine pituitaries, but animal-derived FSH have significant drawbacks such as sanitary risks, inter-batch variability, and potential interspecies immunogenicity. To mitigate these drawbacks, we aim to produce recombinant porcine FSH (pFSH) in Chinese hamster ovary (CHO-K1) cells using various promoter systems to identify optimal regulatory elements for stable and high-yield expression. Three constructs were engineered, each incorporating one of the following promoters: the immediate-early promoter from cytomegalovirus (CMV), the promoter for elongation factor-1 alpha (EF-1a), and CMV with CpG island elements (CMV-IE). The latter is included an attempt to circumvent possible promoter silencing. These constructs were generated using NEBuilder HiFi DNA assembly (New England Biolabs) and confirmed with Sanger- or Oxford Nanopore sequencing. Transient expression was assessed through immunofluorescence assays (IFA) using an anti-His antibody, revealing the CMV promoter to be more effective than EF-1a under short-term expression conditions. Stable CHO-K1 cell lines are being generated using geneticin selection pressure. Once generated, the stable cells will be used to produce pFSH which will be purified via immobilised metal affinity chromatography (IMAC). Functional verification will be done using a luminescence-based FSH receptor assay in CHO-K1 cells. This research contributes toward developing a recombinant alternative to traditional animal-derived pFSH with an improved safety profile. Since such a recombinant hormone peptide can be produced in a controlled environment, batch-to-batch variability can be mitigated. Recombinant pFSH can subsequently be used in reproductive biotechnology applications, particularly

within animal husbandry and agricultural bioproduction systems and will contribute to alleviating global supply limitations of the hormone.

**Acknowledgements**
AniPharm Pty Ltd, Prof WJ Goosen.

Keywords: recombinant protein production, FSH, CHO-K1, promoter systems

**Poster Sessions and Session 2A**

---

# THE ACTIVATION OF HIV-1 GP160 GLYCOPROTEIN BY CRYPTOCOCCAL KEXIN PROTEASES

**Nozethu Mjokane & Olihile M. Sebolai**
[1]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

*Cryptococcus (C.) neoformans* is an important fungal pathogen that is often at the centre of advanced HIV disease, causing significant mycosis-related deaths. While we know much about the pathobiology of this organism, it is unclear it could also potentiate HIV invasion in a susceptible host. It is uncertain if cryptococcal proteases could contribute to the priming of the latent fusogenic glycoprotein 160 (gp160). The current study aimed to determine if *C. neoformans* yeast kexin protease (Kex2p) could cleave the HIV-1 gp160, leading to potential host invasion. In humans, cleavage of this glycoprotein is performed by furin. The study was initiated by predicting the possible protein-protein interactions between HIV-1 gp160-furin and HIV-1 gp160-Kex2p using the using the High Ambiguity Driven protein-protein DOCKing (HADDOCK). In anticipation of obtaining enzymatic evidence of hydrolysis, the cryptococcal Kex2p was first isolated from the supernatant of lysed *E. coli* BL 21 (DE3) cells, which were transformed with an expression vector containing the gene encoding for this protein. The resultant recombinant protein was then used in a biochemical peptide cleavage assay containing a fluorescent 20-mer peptide mimicking the HIV-1 gp160. In a separate experiment, a recombinant furin was used. The in silico comparative analysis revealed that the *C. neoformans* Kex2p was a suitable ligand to activate the latent HIV-1 gp160. To confirm the veracity of this finding, it was crucial also to obtain experimental evidence. The Kex2p could cleave the mimetic HIV-1gp160 peptide. Importantly, the biochemical efficiency of Kex2p to hydrolyse the mimetic HIV-1 gp160 peptide was comparable to that of the recombinant furin. These preliminary in vitro data suggest that it is foreseeable that Kex2p could potentially cleave latent HIV-1 gp160. This highlights the importance of resolving cryptococcal cells colonising patients infected with HIV to regulate the unwanted proteolysis of the fusogenic HIV-1 gp160.

**Keywords**: *Cryptococcus neoformans*, HIV-1 gp160, furin, Kex2p

**Session 2A**

---

# CRYSTALLOGRAPHIC AND MECHANISTIC INVESTIGATION OF RHODIUM TROPOLONE COMPLEXES FOR CATALYTIC MODEL REACTIONS

**Setjhaba Mosese, Alice Brink & Johan Andries Venter**
Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Homogeneous catalysis involves a catalyst that is in the same phase as the reactants, allowing for highly selective and efficient reactions at lower temperatures and pressures. The catalytic activity can be carefully controlled by adjusting the coordinated ligands and the metal centre of the catalyst, aiding the synthesis of complex molecules with great precision. With methanol carbonylation being one of a primary homogeneously catalysed processes involved in acetic acid production, the selectivity is approximately 99%, and numerous structures have been reported. Despite progress, creating highly selective catalysts still remains a significant challenge in many of these mechanisms. In this perspective, we have utilised tropolone (Trop) as a bidentate ligand to synthesise six rhodium(I) tropolonato complexes, [Rh(O,O-bid)(CO)($PR_3$)] (where O,O-bid=Tropolonato and R = Ph, Cy, p-Tol and combinations thereof), by systematically varying the tertiary phosphine ligands in the order of increasing electron density. The rhodium tropolone complexes proved to be highly selective and their characterisation using infrared spectroscopy (IR), NMR spectroscopy (1H, 13C, and 31P), and X-Ray crystallography is reported. The kinetic study of the rhodium(I) tropolone complexes using IR, NMR and UV/Vis spectroscopy is under investigation. The potential of said complexes for anti-cancer drug development is marked and therefore are considered herein. The variative influence of tropolone bidentate ligand and phosphine ligand systems will be described to increase the current understanding of catalytic activity and complex activity, which may have diverse applications.

**Acknowledgements**
Financial support from the University of the Free State, the Department of Higher Education and Training, and the AvaCare Group is gratefully acknowledged. We also thank SASOL, the University of the Free State, and the Central University of Technology Joint Research Program for the financial assistance with this project.

**Keywords**: Catalysis, rhodium, tropolone, phosphines, anti-cancer activity

**Poster Sessions**

---

# ACTIVATION OF THE SARS-COV-2 LATENT SPIKE GLYCOPROTEIN PROTEIN BY *CANDIDA ALBICANS* PROTEASES

**Lebogang Moukangwe, Carlien H. Pohl-Albertyn, Nozethu Mjokane & Olihile M. Sebolai**
Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

The manifestation of fungal co-infection in patients with COVID-19 has been a matter of concern due to the potential for increased disease severity. While immune dysregulation following SARS-CoV-2 infection creates conditions that facilitate fungal infections, the possibility of fungal infections contributing to viral invasion remains unclear. This study investigated the role of fungal proteases, specifically yeast kexin protease (Kex2p) from *Candida albicans*, in activating the latent SARS-CoV-2 spike glycoprotein. The recombinant *C. albicans* Kex2p was isolated and purified from the supernatant of *E. coli* BL21 (DE3) lysate. To confirm the successful heterologous production, an SDS-PAGE gel was prepared, and the protein was immunodetected using an anti-His-tag antibody. The recombinant Kex2[

was then assessed for its ability to (1) cleave a prepared fluorogenic 20-mer peptide mimicking the spike glycoprotein, (2) mediate macrophage transduction with SARS-CoV-2 pseudovirions, and (3) characterise the immunological response associated with Kex2p-mediated pseudovirion entry. Since activation of the SARS-CoV-2 spike glycoprotein in humans typically involves furin, furin was used as a reference protease for comparison. Recombinant Kex2p was successfully isolated, as indicated by an 85 kDa band on the SDS-PAGE gel and blotted membrane. It cleaved the mimetic spike glycoprotein, transduced macrophages with SARS-CoV-2 pseudovirion, and elicited IL-6 and IFN-y production in in transduced cells. The biochemical efficiency of this protein to cleave the mimetic peptide and transduce macrophages was comparable ($p > 0.05$) to recombinant furin. Furthermore, IL-6 and IFN-y levels elicited by Kex2p-mediated pseudovirion entry were also comparable ($p > 0.05$) to those elicited by furin. These findings provide enzymatic evidence for the possible interaction between *C. albicans* Kex2p and the SARS-CoV-2 spike glycoprotein, potentially leading to the priming of fusogenic spike glycoprotein. It is foreseeable that in co-infection scenarios, C. albicans Kex2p could contribute to SARS-CoV-2 invasion.

**Acknowledgements**

Cryptococcus lab, Pathogenic yeasts, Avacare health, Department of Microbiology and Biochemistry

**Keywords**: COVID-19, Mimetic peptide, Pro-inflammatory cytokines, Protein-protein DOCKing (HADDOCK)

**Poster Sessions**

---

# ISOLATION, CHARACTERISATION AND EVALUATION OF CYTOTOXICITY COMPOUNDS FROM THE STEM BARK OF *ELAEODENDRON BUCHANANII*: IN VITRO AND SILICO STUDIES

**Jennifer Nambooze[1], Abdul Rashid Issahaku[1], Adolifinah Mmapula Raseasala[2], Anke Wilhelm1, Lucie Rárová[3], Marie Kvasnicová[4,5], Motlalepula Gilbert Matsabisa[2], Recardia Laken Simoney Schoeman[2] & Susan Bonnet[1]**

[1]Department of Chemistry, University of the Free State, 9300, Bloemfontein, South Africa
[2]Department of Pharmacology & Physiology, Faculty of Health Science, University of Free State, Bloemfontein, South Africa
3Department of Experimental Biology, Faculty of Science, Palacký University, Olomouc, Czech Republic
4Laboratory of Growth Regulators, Faculty of Science, Palacký University, Olomouc, Czech Republic
5 Institute of Experimental Botany of the Czech Academy of Sciences, Lysolaje, Czech Republic

## ABSTRACT

*Elaeodendron buchananii* is a tropical forest plant member of the Celastraceae family, and its medicinal uses have been documented. Nonetheless, little is known about the specific bioactive compounds with a specific medicinal effect. Thus, the bioassay isolation technique has been used to identify five cytotoxic compounds from the ethyl acetate and methanol extracts of *Elaeodendron buchananii* stem bark. With $IC_{50}$ values of 25.5 ± 6.0 µg/mL, 8.8 ± 0.8 µg/mL, 13.5 ± 0.2 µg/mL, 2.34 ± 0.4 µg/mL and 11.9 ± 3.0 µg/mL, respectively, for the ethyl acetate extract and >50 µg/mL, 11.9 ± 1.3 µg/mL, >50 µg/mL, 13.56 ± 1.2 µg/mL and >50 µg/mL for the methanol extract, respectively, against the MCF7, HeLa, RPE-1, DU145 and BJ cell lines, both extracts showed interesting cytotoxic activity compared to other extracts. Compounds 1 and 2 were isolated from the ethyl acetate extract, 3 and 4 were isolated from the methanol extract, and compounds 2, 3 and 4 are novel. Compounds 1 – 4 have been isolated from this plant for the first time. All four compounds showed moderate cytotoxicity at the maximal dose of 125 µg/mL when compared to the untreated, negative control and positive control with mean cell viable of 50.2 ± 6.6, 56.2 ± 20.5, 60.2 ± 21.1 and 56.0 ± 6.2 for compounds 1, 2, 3 and 4,

respectively against DU145 cell line. Computational analysis further revealed that the compounds may bind to key proteins in the DU145 cell line, particularly EGFR. While they exhibited strong docking scores and induced conformational changes in the protein, their poor membrane permeability could account for their moderate bioactivity in the cells. These findings suggested developing anti-cancer medications or therapies employing extracts from *Elaeodendron buchananii* and a few other identified chemical compounds.

**Acknowledgements**

Jennifer Nambooze is very thankful to the Organization for Women in Science for the Developing World (OWSD) and the Swedish International Development Cooperation Agency (SIDA) for the PhD fellowship and the University of the Free State, Bloemfontein, South Africa for the necessary tools and equipment to carry out this research

Keywords: *Elaeodendron buchananii*, cytotoxic activity, bioactive compounds

**Poster Sessions**

---

## SPATIAL ANALYSIS OF ACCESS TO HEALTHCARE IN BLOEMFONTEIN: LINKING DISTANCE, SOCIOECONOMIC AND PUBLIC ACCESS PERCEPTIONS

**Nandipha P. Nophale & Sandile C. Shongwe**

Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

Spatial statistics plays a crucial role in analysing location-specific data, facilitating the identification of patterns and relationships that impact various observations. This research paper investigates healthcare access in Bloemfontein, South Africa, focusing on five critical dimensions: accessibility, affordability, availability, accommodation, and acceptability. The research aimed to uncover spatial variations in access and identify barriers related to distance, socioeconomic status and perceptions of care. Employing a self-administered, structured questionnaire, the study targets both permanent and non-permanent residents through a non-probability purposive sampling method. A survey research design, complemented by ArcGIS, enabled the exploration of the spatial characteristics of healthcare access in Bloemfontein. Statistical analyses, including logistic regression and other supervised learning algorithms was used to assess the relationship between the dimensions of access and healthcare accessibility. Public facilities do not follow a random distribution and had spatial autocorrelation. However, private facilities showed a random distribution and had no spatial autocorrelation. Moreover, the ethnic groups, payments of services and opinions on availability, accessibility and accommodation were found to be significant in the respondent's experience of access to healthcare. From the respondent's opinions about National Health Insurance (NHI), three themes were identified as economic, quality care and politics. Furthermore, this study highlights the need for more facilities to be built or expanded to accommodate the growing population. The respondent's opinions on the NHI indicate a need for a more comprehensive dialogue among all stakeholders to ensure that the needs of the Bloemfontein community are effectively addressed in the planning and implementation of the NHI.

**Keywords**: Spatial Statistics, Bloemfontein, Geographic Information System, National Health Insurance

**Session 2B**

---

# SYNTHESIS AND GABAERGIC ACTIVITY OF LARGE SUBSTITUENTS OF 1,5-BENZODIAZEPINE

**Anwar E.M. Noreljaleel, Abdul R. Issahaku, Anke Wilhelm, Karel G. von Eschwege & Susan L. Bonnet**

Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Benzodiazepines are one of the primary groups of psychoactive drugs that influence the central nervous system by targeting the benzodiazepine site of GABAA receptors. They positively modulate these receptors to enhance the effects of GABA, producing anxiolytic, anticonvulsant, myorelaxant, and hypnotic effects utilised for therapeutic purposes. Although several benzodiazepines have been approved for use, they are associated with cognitive impairment and other undesirable side effects. This study aims to explore novel benzodiazepines derived from 1,5-benzodiazepine that have minimal side effects. Large substituents of 1,5benzodiazepine were synthesised by reacting o-phenyldiamine, p-toluene sulphonic acid and suitable acetophenone derivatives. All the synthesised compounds were tested for GABAergic activity, but all showed no significant IGABA potentiation after testing the compounds at 10, 100, and 300 µM. However, further assessment of the compounds' binding affinity to GABAA receptors revealed relatively good scores. Compounds A, IA, PD, and CHA exhibited docking scores of -8.78 kcal/mol, -6.37 kcal/mol, -5.38 kcal/mol, and -5.20 kcal/mol respectively, while SM and PDP were identified as non-binders compared to diazepam, which showed a score of -7.75 kcal/mol. Additionally, pharmacokinetic assessments of the compounds indicated that they are P-glycoprotein substrates. This protein is responsible for the efflux of drugs from cells, which may partially explain why the compounds showed low GABAergic activity, as their concentration in cells could be limited by this protein. The insights from this study highlight the shortcomings of the synthesised compounds as GABAA receptor modulators and emphasise the need for further modification and optimisation to enhance their effectiveness.

**Acknowledgements**

Directorate Research Development (DRD) at the University of the Free State. The University of Vienna, Austria, for assisting with the GABA screenings.

**Keywords**: GABAA receptors, benzodiazepines, Molecular docking, P-glycoprotein substrates

**Poster Sessions**

---

# ASSESSING THE ANTI-CRYPTOCOCCUS QUALITY OF REFORMULATED ASPIRIN

**M.P. Rapeso, C.H. Pohl, N. Mjokane & O.M Sebolai**

Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

*Cryptococcus (C.) neoformans* is a fungal pathogen that can breach the blood-brain barrier (BBB) to localise in the brain. This is compounded by treatment challenges associated with controlling cryptococcal growth in the brain. Current therapies face limitations: amphotericin B cannot cross the BBB, and fluconazole, while able to cross, is often ineffective due to resistance. This study aimed to reformulate aspirin by encapsulating it in D-a-tocopheryl polyethylene glycol succinate (TPGS), characterise the formulation, and evaluate its in vitro and in vivo efficacy against *C. neoformans*. Aspirin

was encapsulated in TPGS using a colloidal dispersion method. The resulting aspirin-TPGS micelles were characterised using Fourier transform infrared spectroscopy (FTIR) and Zeta particle analyser. The EUCAST protocol was used to assess the in vitro growth susceptibility of cryptococcal cells towards aspirin-TPGS formulation at concentrations of 1, 2, and 4 mM. For comparative analysis, cells were also treated with standard aspirin, fluconazole, and amphotericin B at the same concentrations. FTIR analysis confirmed successful encapsulation of aspirin in TPGS. The aspirin-TPGS micelles had a particle size of 10.97 nm, a polydispersity index of 0.175, and a zeta potential of 3.668. It was determined that aspirin when dispersed in TPGS, it was more potent than standard powder of aspirin at 1, 2 and 4 mM. This may be due to enhanced lipophilicity enhancing membrane penetration. Importantly, the aspirin-TPGS was more effective than fluconazole across all concentrations and showed comparable efficacy to amphotericin B at the same concentrations. The findings indicate that aspirin-TPGS micelles exhibit significant in vitro antifungal activity against *C. neoformans* and may offer an effective alternative to current treatments. Further studies will investigate the ability of aspirin-TPGS to cross the BBB using an in vitro hCMEC/D3 cell model to enhance our understanding of its therapeutic efficacy in complex biological systems.

Keywords: Aspirin, *Cryptococcus (C.) neoformans*, Drug reformulation, D-a-tocopheryl polyethylene glycol succinate (TPGS)

**Poster Sessions**

---

# DETAILED KINETIC-MECHANISTIC STUDIES FOR UNDERSTANDING SOLUTION BEHAVIOUR IN APPLIED CHEMICAL PROCESS MODELS IN NUCLEAR MEDICINE AND CHEMOTHERAPY

**Andreas Roodt**
Department of Chemistry, University of the Free State, Bloemfontein

## ABSTRACT

The delicate interplay between structure and (re)activity [reaction rates] of model radiopharmaceutical and chemotherapeutic agents studied at UFS Chemistry is presented, focusing on Tc (diagnosis), Re (radiotherapy) and Pt (chemotherapy). The intimate mechanism of the simple water (aqua) substitution reaction using the model radiopharmaceutical synthon, fac-$[M(CO)_3(aqua)_3]$+ is highlighted {Metal M=Tc(I), Re(I)]}. The coordinated water is easily replaced by appropriate bio-active bidentate nucleophiles to form *fac*-$[M(LLBid)(CO)_3(aqua)]$n-, exhibiting different biologically utilisable properties. Depending on the bidentate ligand used to block two coordination sites, a Dissociative, or at least an Interchange Dissociative mechanism, is induced, displaying rapid kinetics as studied by high pressure stopped flow spectroscopy. Next, using kinetic principles, and carefully manipulating conditions, dinuclear and tetranuclear mixed nuclide Tc-99m, Tc-99, and Re complexes are generated via self-assembly, yielding frameworks containing simple single donor atom bridges. The model potential theranostic complexes are confirmed by HPLC. Additionally, a proof-of-concept to modify the water solubility/potential biological effects of a bis(diphenyl-phosphino) alkylamine (PNP) bidentate ligand for Re-186, Re-188 and Tc-99m, to potentially study the radiotoxicity of PNP complexes, is presented. Finally, a 'simple' platinum complex, cis-$[Pt(Carvone)Cl_2]$ is discussed. Carvone is a naturally occurring diolefinic terpene exhibiting multiple pharmacological properties such as antibacterial, antifungal, antiparasitic, antineuraminidase, antioxidant, anti-inflammatory and anticancer activities. The cis-platin analogous complex has a square–planar geometry with carvone coordinated as a 2x neta-2 bidentate ligand and two chlorido ligands in the remaining cis positions. A detailed kinetic study analysed the mechanistic behaviour of the Pt(II) complex with strong pyridine–like nucleophiles such as DMAP. Five reactions observed illustrate the complexity of the 'simple complex', and the advanced

concepts required to study the process properly. Some implications of the detailed kinetics studied, the rate law derived, and the mechanism, relating to (the often complex) in vivo behaviour will be presented.

**Acknowledgements**

Funding: UFS, SA NRF, Swiss NSF. Collaborators: Swiss: R. Alberto and co-workers; UFS co-workers: H.G. Visser, M. Schutte-Smith, A. Brink, D.V. Kama, P.P. Mokolokolo, Z. Bezuidenhout.

**Keywords**: Kinetics, Mechanism, Radio-pharmacy, Chemotherapy

**Session 2D**

---

# ANTIFUNGAL ACTIVITY AND MECHANISM OF ACTION OF PHENOTHIAZINES: INHIBITION OF CANDIDA BIOFILMS, MORPHOGENESIS, AND LIPID METABOLISM

**L.K. Setsiba, C.H. Pohl-Albertyn & J. Albertyn**

Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Fungal infections pose a significant global health threat, particularly in immunocompromised individuals such as those living with HIV/AIDS, cancer, or organ transplants. These infections affect over 300 million people annually, causing more than 1.5 million deaths. In South Africa, the burden is amplified by the overlapping epidemics of HIV, tuberculosis, and poverty, yet fungal diseases remain under-prioritised in national health policies. *Candida albicans* remains the most common cause of invasive candidiasis, owing to its ability to undergo morphological changes and form drug-resistant biofilms. In parallel, *Candida auris*, a recently emerged multidrug-resistant species, has become a major global concern due to its persistence in healthcare settings and high levels of antifungal resistance. Conventional antifungal treatments are often ineffective against biofilms, necessitating the search for novel agents. Phenothiazines (PTZs), originally developed as antipsychotic drugs, have shown potential antifungal activity, including disruption of biofilms and synergy with standard antifungals. This study aimed to assess the antifungal activity and potential mechanisms of action of five commercial PTZs against Candida biofilms. Minimum inhibitory concentrations (MICs) were determined for biofilms of *C. albicans* and *C. auris*. Biofilm biomass and metabolic activity were quantified using crystal violet and XTT assays. Sub-MIC concentrations were then used to examine changes in biofilm morphology (via scanning electron microscopy), synergy with fluconazole, lipid content, germ tube formation, hyphal elongation, mitochondrial membrane potential, and reactive oxygen species (ROS) levels. CPZ and PMZ significantly reduced metabolic activity and disrupted biofilm structure. Both compounds exhibited synergistic effects with fluconazole. Treatment also led to a decrease in total lipid content, suggesting membrane disruption or interference with lipid biosynthesis. All PTZs reduced mitochondrial membrane potential and ROS production, with the most pronounced effect observed in FPZ-treated cells. These findings highlight the potential of PTZs as adjunctive antifungal agents targeting biofilm-associated resistance mechanisms in Candida.

**Acknowledgements**

National Research Foundation (NRF)

**Keywords**: Candida, phenothiazine, antifungal biofilm

**Session 2E**

# SELF-STARTING CONTROL CHART WITH SUPPORT VECTOR REGRESSION: A CASE STUDY ON INTERVENTIONAL X-RAY MACHINE OF PHILIPS HEALTHCARE COMPANY

**Sandile Shongwe[1], Ali Yeganeh[1], Fatemeh Sogandi[2] & Jun Li[3]**

[1]Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa
[2]Department of Industrial Engineering, University of Torbat Heydarieh, Torbat-e Heydariyeh, Iran
[3]Department of Statistics, University of California – Riverside, Riverside, USA

## ABSTRACT

The challenge of efficiently collecting baseline data, particularly in applications with short production runs, has led to the development of self-starting CUSUM charts that enhance the monitoring capabilities. Additionally, in many applications, both the location and scale parameters can shift simultaneously during the monitoring period. On the other hand, the use of Machine Learning (ML) techniques has gained a strong reputation for effectively monitoring various process situations. As a novel approach, this study proposes a new self-starting monitoring scheme based on a CUSUM statistics and a support vector regression to enhance the out-of-control detection performance based on average run length criteria. This innovative method is quicker in detecting out-of-control signals as compared to conventional statistical methods. Our method fills a research gap by incorporating some novel input features and evolutionary training algorithm to overcome the challenge of limited historical data in Phase I analysis. Comprehensive simulation results show that the proposed method outperforms the competitor for monitoring location and scale parameters under different known and unknown shift patterns. Additionally, a practical case study on the interventional X-ray machine of Philips healthcare company is used to illustrate the application and benefits of this novel method.

**Acknowledgements**
UFS Postdoctoral Funding

**Keywords**: Control chart, Machine learning, Support vector regression (SVR), X-ray machine.

**Poster Sessions and Session 2B**

# IMPLEMENTING OF FAMILIAL SEARCHING TO ASSIST WITH THE IDENTIFICATION OF UNIDENTIFIED HUMAN REMAINS IN THE SOUTH AFRICAN POLICE SERVICE

**M. Singh[1], J.H. Smith[2] & K. Ehlers[1]**

[1]Department of Genetics, University of the Free State, Bloemfontein, South Africa
[2]SAPS:DFS:OM Section Head, Forensic Database Management, SAPS, Pretoria, South Africa

## ABSTRACT

Familial searching in a forensic DNA database of law enforcement involves conducting a medium stringency searching process using a known relative's DNA profile to identify a partial match, as close relatives share genetic material. In South Africa the identification of missing persons and unidentified human remains (MPUHR) is a significant challenge, with approximately 10 000 decedents remaining unidentified and receiving pauper burials. Currently, identification methods are predominantly limited to fingerprints and visual identification, which often prove ineffective due to the decomposition of the

body. An alternative method that is available is the use of DNA, specifically through familial searching. The aim of the study was to develop and implement a familial searching protocol utilising National Forensic DNA Database of South Africa (CODIS Module). Familial searching case studies were successfully configured and analysed in National Forensic DNA Database of South Africa (CODIS Module). The results indicated that a minimum number of 21 autosomal Short tandem repeat (STR) loci is required for reliable identification. Additionally, statistical evaluation of familial candidate matches using likelihood ratio provided both kinship identification and a measure of evidential strength. However, homozygote genotypes, mutations and the presence of tri-alleles negatively impacted familial searching outcomes. Known biological relatives are essential in performing familial searching. Results have shown that having DNA profiles from both biological parents is critical. However, in the South African context, this is not always feasible. Therefore, stringent familial searching protocols and policies must be established to ensure the successful implementation of familial searching within the National Forensic DNA Database of South Africa (CODIS Module).

**Acknowledgements**

Supervisor, Dr K Ehlers and Co-Supervisor, Brig (Dr) JH Smith

**Keywords**: Familial Searching Unidentified human remains (UHR) National Forensic DNA Database (NFDD) CODIS

**Session 2B**

---

# HETEROLOGOUS EXPRESSION OF STAPHYLOCOCCAL AND CLOSTRIDIAL LANTIBIOTICS IN *ESCHERICHIA COLI*

**Sihle N. Skosana & Winschau F. van Zyl**

Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Amid the urgent need for new antibiotics, lantibiotics demonstrate promising therapeutic potential. Lantibiotics are peptides that, after ribosomal synthesis, undergo diverse post-translational modifications (PTM), leading to dehydrated Ser and Thr residues and subsequent lanthionine/methyl-lanthionine formation. Lantibiotics provide an innovative alternative for cell growth inhibition of multidrug-resistant pathogens due to their dual mechanism of action (pore formation and inhibition of cell wall biosynthesis) with low resistance development. Since lantibiotics are mainly produced by Gram-positive organisms and are very effective against closely related Gram-positive bacteria, this study aimed to use genome mining and synthetic biology as a tool to design novel lantibiotics with high activity and specificity towards pathogenic Clostridium and Staphylococcus. Five lantibiotics from the genomes of clostridial species and *Staphylococcus capitis* (nisinJ) were identified using sequences of known peptides and bioinformatic tools, including NCBI-BLASTp and RiPPMiner. The well-studied lactococcal nisinA lantibiotic biosynthetic pathway was used to heterologously express the identified peptides using Escherichia coli BL21 (DE3). The signal peptide of nisinA was fused to all core peptide sequences to allow modification using the NisC cyclase and NisB dehydratase PTM enzymes, followed by production using an mCherry-fusion expression system. Five expression plasmids were constructed successfully, and transformed into *E. coli* cells, then tested for protein expression. Following purification using affinity chromatography and cleavage optimisation for removal of the mCherry protein and the nisinA leader peptide, the lantibiotics were tested for antimicrobial activity using an agar overlay assay against various bacterial target species. Two out of the five putative clostridial peptides and nisinJ demonstrated antimicrobial activity. This study demonstrated the use of the *E. coli* mCherry-fusion system and the modification machinery of nisinA to produce novel and functional lantibiotic derivatives. The produced peptides will be used in future studies to analyse the extent of PTM's and

further screening for bioactivity against clinically relevant clostridial and staphylococcus antibiotic resistant species.

**Acknowledgements**

Dr W.F. van Zyl, Antimicrobial Peptides and Probiotic bacteria laboratory (UFS), National Research Foundation (NRF), Council for Scientific and Industrial Research (CSIR)

Keywords: antimicrobial drug resistance, antimicrobial peptides, heterologous expression systems, synthetic biology

**Poster Sessions**

---

# BIOCATALYTIC PRODUCTION OF CHIRAL SULFOXIDES USING UNSPECIFIC PEROXYGENASES

**Sinèad Suter, Ana Ebrecht, Diederik J. Opperman, Marta S. Smit**

Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Sulfoxides are an important class of organo-sulfur compounds in pharmaceuticals and have found widespread applications in, amongst others, anti-microbial medication, proton pump inhibitors, blood pressure and narcolepsy medication. Sulfoxides with the sulfur linked to two different substituents are stereogenic. These enantiomers show differences in their pharmokinetics, duration of action, side effects and potency. Traditional chemical oxidative synthesis often yields racemic mixtures, or overoxidation to the sulfone, necessitating downstream purification of the active enantiomer which is difficult and expensive. Biocatalysis has emerged as a promising alternative for the synthesis of chiral sulfoxides from their corresponding prochiral sulfides. Baeyer-Villiger monooxygenases and cytochrome P450 monooxygenases both use molecular oxygen and expensive nicotinamide cofactors for sulfoxidation reactions, whereas unspecific peroxygenases (UPOs) only require hydrogen peroxide. To date, the majority of these biocatalysts, however, have yielded the R-sulfoxide enantiomers. The aim of this research is to produce a UPO-driven biocatalytic system to produce chiral sulfoxides as active pharmaceutical ingredients or their precursors. This aim is investigated through the screening of novel short UPOs for their activity against sulfur-containing compounds and investigating their enantiospecificity toward these compounds. Here, we have screened a small library of UPOs from various fungi for chiral sulfoxidation reactions. The UPOs were heterologously produced in Escherichia coli, purified and their activity evaluated using thioanisole as the model sulfide. Although all the UPOs showed activity towards thioanisole, only three produced the Senantiomer. Of these, the UPO from Helicocarpus griseus (HgrUPO) showed high conversion (97% of 10 mM) of thioanisole, with the highest enantiomer excess (92%). Unfortunately, the reaction also yielded the overoxidised sulfone. HgrUPO was subsequently screened against a panel of diverse sulfides. Sulfoxidation was observed with all the substrates tested, however, reduced activity was observed with substitutions on the aromatic ring. To determine the molecular determinations of enantioselectivity, HgrUPO was crystallised, and the structure was solved using X-ray crystallography. The 1.5 Å structure revealed an overall fold similar to other short UPOs, with a phenylalanine sidechain positioned in the active site that potentially directs the binding of thioanisole and controls enantioselectivity. The high conversion rates and enantiospecificity of this UPO underscore the potential of biocatalysts for large-scale production, offering safer, more environmentally friendly and cost-effective alternatives to traditional chemical methods.

**Acknowledgements**

Prof DJ Opperman, Prof MS Smit, Ana Ebrecht, CSIR-IBS funding

**Keywords**: Unspecific peroxygenases, biocatalysis, chiral sulfoxides, green chemistry.

**Poster Sessions and Session 2E**

---

# MISUSE OF DISINFECTANTS CAUSE ANTIBIOTIC RESISTANCE IN CLINICALLY SIGNIFICANT SPECIES OF *SERRATIA*

**Wanja Swart, Robert R. Bragg & Samantha J. McCarlie**
Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Until as recently as 2018, antibiotic and disinfectant resistance development were viewed as separate occurrences. However, rising deaths due to antimicrobial resistance and the growing threat of hospital-acquired infections (HAIs) since the SARS-CoV-2 pandemic, begs the question of potential links between the two. This study (2022–2023) examined whether exposure to disinfectants, particularly since the recent pandemic, contributes to co-resistance development in nosocomial pathogens. Minimum Inhibitory Concentration (MIC) tests were performed in triplicate on clinical multidrug-resistant (MDR) Serratia strains and *Serratia marcescens* ATCC 13880 wild type, assessing susceptibility to Ampicillin and Quaternary Ammonium Compound (QAC)-based disinfectants. Resistance to QACs was then experimentally induced in both strains in triplicate, through 10 days of sub-lethal exposure to QAC. This was done to determine QAC resistance development rate in sub-MIC environments. Post-induction Ampicillin MICs were determined to extrapolate if QAC resistance induction had effects on Ampicillin susceptibility. Clinical strains already showed reduced QAC susceptibility compared to wild type, suggesting in-hospital resistance acquisition due to prior sub-MIC exposure. After induction, the wild type and clinical strains exhibited 31.5-fold and 12.2-fold reductions in QAC susceptibility, respectively. Notably, without any antibiotic exposure, both strains showed increased resistance to Ampicillin – 1.6-fold in wild type and 2.7-fold in the clinical isolates. These results confirm that even brief exposure to sub-lethal QAC levels can drive significant disinfectant resistance and simultaneously reduce antibiotic susceptibility. This demonstrates co-resistance development between disinfectants and antibiotics, emphasising the risk that patients may acquire MDR nosocomial infections from environmental bacteria that developed resistance following exposure to sub-MIC levels of disinfectants within hospital settings.

**Keywords**: disinfectant resistance, antibiotic resistance, co-resistance, nosocomial infection

**Session 2B**

---

# ZOONOTIC PATHOGENS OF ONE HEALTH CONCERN IN SMALL AFRICAN CARNIVORES: A SYSTEMATIC REVIEW

**Mpho Tawana[1], Aliza le Roux[1] & Martin M. Nyanga[2]**
[1]Department of Zoology and Entomology, University of the Free State, Phuthaditjhaba, South Africa
[2]Next Generation Sequencing Unit, Division of Virology, Faculty of Heath Sciences, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Earlier work has indicated that Carnivora often host zoonotic pathogens, but the potential risk posed by smaller species, in particular, has not been quantified. With human health inextricably linked to animal

and environmental health – the One Health triangle – this is a risk that needs to be understood on a continent where biodiversity conservation remains as much a priority as sustainable human development. We therefore sought to investigate the current state of knowledge regarding zoonoses in small carnivores in Africa. We conducted a systematic review of articles published on zoonotic pathogens of small carnivores in African countries following PRISMA 2020 guidelines, searching five databases (AJOL, EBSCO, Google Scholar, PubMed and Scopus) for specific search terms: "zoono*", the names of known small carnivores, and all African countries. A total of 113 articles met inclusion criteria for this systematic review. Of 19678 sampled small carnivores only 10239 reported positive for zoonotic pathogens, including 5 viruses (6534 small carnivores), 19 bacteria (1634 small carnivores), 41 helminths (797 small carnivores) and 22 protozoans (1042 small carnivores) from 22 African countries more. Out of the 54 African countries, publications stemmed from only 22 countries, predominantly in Sub-Saharan Africa. The majority of studies were conducted in South Africa (n = 46), followed by Namibia (n = 13) and Zimbabwe (n = 12), with only one study reported in Libya, Malawi, Mauritania, Morocco, Mozambique, Niger, Senegal, and Uganda. We found that publication output increased steadily over time, with the highest output between 2010 and 2020. Zoonotic pathogen research appears to be is concentrated in South Africa, with more than half of the African continent never surveyed. Systematic surveillance for zoonotic pathogens clearly remains inadequate, constraining our ability to predict and prevent future spillover events and outbreaks in the human population.

Keywords: Zoonotic, pathogens, carnivores, Africa

**Session 2A**

---

# SEEDING STRUCTURE-BASED DRUG DISCOVERY FOR 24C-STEROL METHYLTRANSFERASE FROM *CANDIDA ALBICANS*

**Carmien Tolmie[1], Bernadette Belter[1], Dirk Opperman[1], Frank von Delft[2,3,4], Lizbe Koekemoer[2], Matjepe Ngoasheng[1], Michael Fairhead[2], Nokwanda Mpontshane[1], Rodney Hart[5] & Valmary van Breda[5]**

[1]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
[2]Centre of Medicines Discovery, University of Oxford, Oxford, UK
[3]Diamond Light Source, Harwell Science and Innovation Campus, Oxford, UK
[4]Department of Biochemistry University of Johannesburg, Auckland Park, South Africa
[5]Institute for Deciduous Fruit, Vines and Wine, Agricultural Research Council, Stellenbosch, South Africa

## ABSTRACT

Opportunistic pathogenic fungi cause invasive fungal disease, including candidaemia, cryptococcal meningitis, and invasive aspergillosis, with extremely high mortality rates (20-100%). Antifungal drug resistance and multi-drug resistance have emerged against the four clinically used antifungal classes and pose a global threat to human health and well-being. The rate of mortality is especially concerning in immune-compromised patients, of which a large population resides in Sub-Saharan Africa due to the high HIV/AIDS incidence. There is thus an urgent need to develop new resistant-robust therapies, preferably with a novel mode of action. Here we put forward 24C-sterol methyltransferase (SMT), a critical enzyme in the ergosterol biosynthesis pathway in fungi, as a viable target for the development of such novel antifungals. We have recently established protocols to heterologously produce SMT from *Candida albicans*, *Candida auris*, *Cryptococcus neoformans* and *Aspergillus fumigatus* in *Escherichia coli*. This required construct engineering to generate a library of expression vectors. Furthermore, we have successfully purified and crystallised SMT from Candida albicans. Next, our aim is to identify novel small fragment binders that can be progressed into hit series using the structure-based drug discovery

technique of X-ray crystallographic fragment screening. Furthermore, we are developing a high-throughput assay for SMT to evaluate and triage the designed compounds. The overarching ambition is to, in future, produce a direct-acting antifungal treatment with low toxicity, with the goal of global, equitable, and affordable access.

**Acknowledgements**

National Research Foundation of South Africa Agricultural Research Council, Africa-Oxford Initiative (AfOx), Protein crystallography small research facility (PX-SRF), Centre for Medicines Discovery, University of Oxford, Diamond Light Source synchrotron

**Keywords**: C24-sterol methyltransferase. *Candida albicans*. Antifungal drug development. Fragment screening

**Session 2E**

---

# HETEROLOGOUS EXPRESSION OF EPIDERMIN-LIKE LANTIBIOTICS IN *LACTOCOCCUS LACTIS*

**Gabrielle van den Heever & Winschau F. van Zyl**

Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

The critical need for the discovery of new and more effective antimicrobial agents against antibiotic resistant pathogenic microbes is highlighted by the global increase in microbial antibiotic resistance. Epidermin is a potent lantibiotic peptide naturally produced by *Staphylococcus epidermidis* Tü329, with demonstrated antimicrobial activity against pathogens such as Propionibacterium acnes and *Staphylococcus aureus*. Its targeted efficacy highlights its therapeutic potential for the topical treatment of acne and other skin infections. Lantibiotics are ribosomal peptides that undergo extensive post-translational modifications catalysed by specific enzymes, yielding compounds with unique modes of action. However, natural producers often yield low quantities, hindering their application on a large scale. This study aimed to construct a heterologous bacterial expression system to produce epidermin and two genome mined epidermin-like derivatives using the biosynthetic pathway of the prototypical nisinA lantibiotic and the Nisin-Inducible Expression System. This system makes use of a plasmid-free Lactococcus lactis derivative and the nisin-inducible promoter in a two-plasmid system. The pNZ8048 expression plasmid carries a chloramphenicol resistance marker and a 6x histidine tag while the pMSP plasmid carries an erythromycin resistance marker for selection of recombinant cells. The nisinA PTM genes were PCR amplified using genomic DNA isolated from the L. lactis F10 nisinA producer and cloned into the pMSP plasmid. Precursor peptide genes were synthesised by Twist Bioscience followed by insertion into the pNZ plasmid. Each recombinant pNZ and the pMSP plasmid were successfully co-transformed into electrocompetent L. lactis cells. Recombinant single colonies were selected on M17 media containing both antibiotic markers. This was followed by protein expression trials, IMAC purification of the cell-free culture supernatants and SDSPage gel electrophoresis. Only one of the lantibiotics demonstrated antimicrobial activity against as determined using agar spot plate assays. Future experiments will use LC-MS to confirm molecular weights and predicted PTMs, followed by bioactivity screening against clinically relevant acne-associated bacteria.

**Acknowledgements**

National Research Fund (NRF), Dr WF van Zyl, Antimicrobial peptides and probiotic bacteria laboratory

**Keywords**: lanthipeptides, antimicrobial peptides, novel antimicrobials, heterologous expression

**Poster Sessions**

# LANDSCAPE TRANSFORMATION IN THE ABAYA-CHAMO SUB-BASIN, ETHIOPIA: SPATIO-TEMPORAL LULC CHANGES AND SUSTAINABILITY CONCERNS

**Melku D. Alemu, Achamyeleh G. Mengistu & Johan van Tol**
Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa

This study examines the spatio-temporal dynamics of Land Use and Land Cover (LULC) in Ethiopia's Abaya Chamo Sub-Basin from 2016 to 2021, focusing on six landscapes. Sentinel-2A satellite imagery was analysed using a Supervised Classification Approach (Maximum Likelihood Algorithm). LULC accuracy improved over time, with overall accuracies rising from 86% in 2016 to 89.9% in 2021, and Kappa values increasing from 0.8119 to 0.8644. Significant transformations were observed due to agricultural expansion, urbanisation, and vegetation degradation. Forest cover in Abaya Guangua grew from 42.24% to 45.52%, while agricultural land declined by 49.24%. Arba Minch saw a 23.26% rise in agricultural land, with grassland decreasing by 73.45%. Chencha's agricultural land expanded by 20.02%, while forest and grassland decreased by 4.89% and 17.93%, respectively. Hobicha recorded a 2.79% agricultural increase and a 45.86% rise in bare land. Loka Abaya's agricultural land increased by 20.79%, with a 29.43% grassland decline. Mierab Abaya's agricultural land expanded by 7.24%, while forest cover declined by 7%. Over 50% of some landscapes remained unchanged, yet significant shifts were evident. Mierab Abaya had the highest LULC changes (56.44%), followed by Arba Minch (52.82%), Abaya Guangua (47.37%), Chencha (48.31%), Hobicha (49.11%), and Loka Abaya (48.30%). Agricultural expansion, poverty, rapid urbanisation, fuelwood demand, illegal settlements, and deforestation are the major drivers of LULC changes. These pressures shape the sub-basin's socio-economic and environmental landscape, highlighting the urgent need for sustainable landscape restoration to mitigate land degradation.

**Acknowledgements**

We extend our sincere gratitude to the staff of the Rift Valley Lakes Basin Office and the Ministry of Water and Energy technical staff, as well as the communities in the Abaya-Chamo Sub-Basin and the enumerators who contributed significantly to this research project. We would also like to express our sincere gratitude to Mr Niguse Geresu for his technical assistance in satellite image acquisition and analysis. Your invaluable support and participation were crucial to the successful completion of this research.

**Keywords:** Agroecological zones, Landscape Restoration, Sentinel 2A, Geographical Information System, Remote Sensing

**Session 1**

# IMPACTS OF TRADITIONAL GOLD MINING PRACTICES ON ORGANIC CARBON ACROSS LAND USES IN TIGRAY, ETHIOPIA

**Meaza Zenebe Gebrehans[1,2,3], Emiru Birhane[3,4,5], Kassa Teka[3], Mitiku Haile[3], Tesfay Araya[1] & Tewodros Tadesse[6,7]**

[1]Department of Soil, Crop, and Climate Sciences, University of the Free State, Bloemfontein, South Africa
[2]Department of Plant Science, Raya University, Maichew, Ethiopia
[3]Department of Land Resources Management and Environmental Protection, Mekelle University, Mekelle, Ethiopia
[4]Institute of Climate and Society, Mekelle University, Mekelle, Ethiopia
[5]Faculty of Bioscience and Aquaculture, Nord University, Steinkjer, Norway
[6]Department of Agricultural and Resource Economics, Mekelle University, Mekelle, Ethiopia
[7]Research Center in Agri-food Economics and Development (CREDA), Castelldefels, Barcelona, Spain

## ABSTRACT

Traditional gold mining (TGM) is rapidly expanding across Africa, including conflict-affected regions such as Tigray, Ethiopia, without environmental safeguards and restoration plans. It causes severe ecosystem degradation, although studies are scarce regarding the impacts of TGM practice on carbon stock depletions. This study assessed the impact of TGM on soil organic carbon (SOC) stock, total organic carbon (TOC), bulk density (BD), and soil coarse fragment (CF) content across different land uses (farmland and woodland), slope positions, and soil depths. A total of 192 composite and 192 undisturbed soil samples were collected from mined and unmined sites at two soil depths (0–30 cm and 30–60 cm), along with 48 nested plots for estimating plant carbon stocks using allometric equations. Data were analysed using Generalized Linear Mixed Models (GLMMs), Spearman correlation, and mediation analysis. TGM significantly reduced SOC and TOC while increasing CF and BD. Significantly highest SOC (53.22 t ha-1) was observed in unmined woodland foot slopes, while the lowest (3.48 t ha-1) was recorded in mined farmland on upper slopes. SOC losses due to TGM exceeded 70% in upper-slope woodlands, and TOC declined by over 50% in mined upper slopes. Spearman correlation analyses indicated strong negative relationships between SOC and CF (-0.81, p<00.1), and strong positive correlation between total BD and CF (0.71, P<0.001). Mediation analysis revealed that over 54% of SOC loss was indirectly attributed to TGM-induced increases in CF, driven by the destructive nature of TGM, including arbitrary excavation of soil layers, and enhanced erosion of fine soil particles collectively resulting accumulation of CF. These findings demonstrate that TGM depletes soil and plant carbon stocks, contributing to carbon emissions. This research supports the Green Futures hub by uncovering the adverse impacts of TGM on organic carbon stocks, highlighting the need for restoration of post-mined landscapes.

**Acknowledgements**

We acknowledge the financial support for field and soil laboratory analysis from Climate Research and Education to Advancing Green Development in Africa (CREATE-GreenAfrica) Co-funded by the European Union and NORAD-ICP-V-Project funded by the Norwegian University of Life Sciences with RADO/EXTERNAL/PD0055//2024 project registration number. We also appreciate Mekelle University, Ethiopia, for allowing the laboratory facilities for this research and University of Free State, South Africa, for hosting Meaza Zenebe and enabled her to access resources of the University.

**Keywords**: Bulk density, Carbon stock, Mediation analysis, Slope position

**Session 1**

# ASSESSMENT OF THE UPPER ORANGE-SENQU RIVER MORPHOLOGICAL EVOLUTION USING REMOTE SENSING

**Lehlohonolo Mofokeng[1], Pululu S Mahasa[1] & Solomon Tesfahichael[2]**
[1]Department of Geography, University of the Free State, Phuthaditjhaba, South Africa
[2]University of Johannesburg, Auckland Park, South Africa

## ABSTRACT

The study investigates the morphological evolution as part of assessing the degradation of the upper Orange-Senqu River through river channel reconstruction by analysing the variations in channel width, water classification, lateral migration rates and meander dynamics. The study area extends from the origin of the river in the Mokhotlong district of Lesotho to the town of Douglas in South Africa. The study used the Google Earth Engine (GEE) remote sensing approach, which integrates multi-temporal Landsat imagery (MSS, TM and ETM+ sensors) and Sentinel-1 Synthetic Aperture Radar (SAR) data to monitor surface water and river morphological changes over a 40-year period (1983–2023). The study follows a 5-year interval, divided into summer (December-February) and Winter (June-August). High-resolution images enabled the precise identification of water bodies and the calculation of the water surface, the extent of erosion and channel enlargement as well as land use and land cover. Morphological changes were assessed by analysing planform changes using Geographic Information Systems (GIS) and remote sensing techniques. By combining the Landsat and SAR datasets, monitoring of the channels was improved through cloud-free observations and higher temporal resolution. Sentinel-1, part of the Copernicus programme, consists of two radar satellites (S1A and S1B) operating in the C-band at 5.405 GHz with dual polarisation (VV and VH), providing a spatial resolution of 10 metres and repetition cycles of 12 days, which are reduced to 6 days when both satellites are active

**Keywords**: River Assessment, River evolution, Remote sensing, GIS

**Session 1**

---

# TOWARDS A LANDSLIDE EARLY WARNING SYSTEM FOR SOUTH AFRICA: MODEL DEVELOPMENT AND EVALUATION

**Johan van Tol & Jaco Kotze**
Department Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

In April 2022, extreme rainfall in KwaZulu-Natal, South Africa, triggered deadly floods and over 300 landslides, resulting in more than 440 deaths and displacing over 40,000 people. Landslides, caused by the downslope movement of soil and rock, are projected to increase due to more frequent intense rainfall linked to climate change. South Africa lacks a dedicated landslide early warning system (LEWS), relying instead on general flood warnings that do not incorporate slope-specific conditions. Since pre-storm soil moisture is a critical landslide trigger, this study explored the use of hydrological modelling to estimate soil moisture and integrate it with slope stability modelling to assess landslide risk. The SWAT+ model was applied in the U60F catchment, where significant landslides were observed in April 2022. The model simulated soil moisture across 10 layers (each 100 mm thick) in more than 2,000 Hydrological Response Units (HRUs) over 23 years. Outputs from SWAT+ were coupled with an infinite slope stability model using the MohrCoulomb failure law to calculate the Factor of Safety (Fs) daily for each HRU. During the April 2022 storm (>300 mm in 2 days), the model successfully identified high-risk

zones where all observed landslides occurred. Around 65% of the catchment showed no simulated slope failure and no landslides were reported in those areas. This coupled modelling approach effectively predicts landslide-prone areas and demonstrates strong potential for informing the development of South Africa's first LEWS, especially in high-risk, data scarce regions.

**Keywords**: Hydrological Modelling, SWAT+, Slope Stability, KwaZulu-Natal

**Session 1**

# Pollution, Waste Management and Waste Minimisation

## PHARMACEUTICAL RESIDUES IN SURFACE WATER BODIES FROM UPPER ORANGE- SENQU RIVER BASIN: OCCURRENCE WITHIN TWO SEASONS USING LIQUID CHROMATOGRAPHY COUPLED WITH MASS SPECTROMETRIC TECHNIQUE

**Gladys Belle,[1], Brenda B. Moodley[2], Christoff J. Truter[3], Elizabeth O. Omotola[4], Olatunde S. Olatunji[2], Paul J. Oberholster[1] & Roshila Moodley[5]**

1Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa,
2 School of Chemistry and Physics, University of KwaZulu-Natal, Durban, South Africa,
3 Water Institute, Stellenbosch University, Stellenbosch, South Africa,
4 Department of Chemical Sciences, Tai Solarin University of Education, Ijebu Ode, Nigeria
5Department of Chemistry, University of Manchester, England, United Kingdom

### ABSTRACT

Residues of pharmaceutical compounds (PCs) are among the contaminants of emerging concern in the environment. These PCs have garnered the attention of researchers, primarily due to the detrimental impact they cause on living organisms. PCs are inherently bioactive and may pose specific toxic or carcinogenic effects when present in living organisms. Endocrine- disrupting pharmaceuticals may cause reproductive toxicity in fish and increase the risk of breast or prostate cancer in humans. The present study investigated the occurrence of four PCs residues: prednisone (PRD), metabolite-prednisolone (m- PRD), dexamethasone (DEX), and azithromycin (AZI), in selected surface water sampling sites within the Upper Orange- Senqu River Basin in the Free State Province, South Africa, during the summer and winter of 2024. Water samples were collected at the discharge point of a wastewater treatment plant (WWTP) effluent as well as from each site's upstream and downstream sections. The analytes were isolated using solid-phase extraction for optimal recoveries from the aqueous matrix, which exceeded 80% in all cases. The limits of detection (LoDs) (µg/l) for AZI, m- PRD, PRD, and DEX were 0. 0209, 0. 0079, 0. 0053, and 0. 0094, respectively, while the limits for quantification (LoQs) (µg/l) were 0. 0696, 0. 0262, 0. 0176, and 0.0312. 0312. Among the monitored PC residues, DEX (41. 79 µg/l) and AZI (19. 32 µg/l) recorded the highest mean concentrations in the water samples during summer and winter, respectively. AZI residues exhibited the highest detection frequency across all sampling sites. Disparities were observable in the concentrations of analytes among the three different sections of each sampling site. The results indicated that the South African environment is polluted with the pharmaceuticals investigated. Continuous research should be conducted to ascertain the occurrence of pharmaceuticals in surface water sources. This study will raise awareness that encourages communities to adopt specific safe disposal methods, assisting in the reduction of the impact of pharmaceuticals on our water resources.

**Acknowledgements**

This research was supported by the Water Research Commission (WRC) Research, Development, and Innovation grant (Grant Number: 2023/2024-01308), Project Title, Aquatic Ecosystem and Human Health Risk Assessment of COVID-19 Drugs within a Transboundary Water Basin

**Keywords**: pharmaceutical residues, detection frequency, Liquid Chromatographic-Mass Spectrometric, surface water

**Poster Sessions and Session 9B**

# INFLUENCE OF METHANESULFONIC ACID (MSA) AND ORGANIC SUBSTRATES ON RARE-EARTH ELEMENTS (BIO)LEACHING

**Sanele Cebekhulu[1], Alba Gomez-Arias[2], Julio Castillo[3], Maleke Maleke[4], Manuel Caraballo[5], Olusola Ololade[1], Sanelisiwe Mathangana[6] & Zovuyo Yekane[1]**

[1]Centre for Environmental Management, University of the Free State, Bloemfontein, South Africa
[2]Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Seville, Spain
[3]Facultad de Ciencias Experimentales, Universidad de Huelva, Huelva, Spain
[4]Department of Life Sciences, Central University of Technology, Bloemfontein, South Africa
[5]Department of Mining, Mechanic, Energetic and Construction Engineering, Higher Technical School of Engineering, University of Huelva, Huelva, Spain
[6]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Rare earth elements (REEs) are essential for modern day technological advances, yet their extraction remains a major challenge. Alkaline tailings represent an underutilised secondary resource for REEs recovery. These tailings host microbial communities capable of enhancing mineral dissolution through biogeochemical processes integrated with low-impact chemical treatments. Therefore, exploiting this method of extraction can offer a promising alternative towards sustainable and circular mining practices. This study explores the role of methanesulfonic acid (MSA), a greener lixiviant compared to strong acids such as hydrochloric and sulphuric acids, and supplementary carbon sources in promoting REEs mobilisation from alkaline tailings under controlled batch conditions. We investigated different MSA concentrations (0, 25, 50, 75, and 100 mM) and the effect of carbon sources such as glucose and methanol on REEs mobilisation from the tailings. Increasing MSA concentrations led to a progressive decrease in pH and a corresponding increase in electrical conductivity (EC), indicating mineral dissolution. For example, the average REE concentration released at 25 mM were Gd (0.20 µg/L) > Eu (0.18 µg/L) > Sc (0.15 µg/L) > Dy (0.10 µg/L) > Er (0.03 µg/L) and at 100 mM were Pr (0.43 µg/L) > Sm (0.40 µg/L) > Gd (0.34 µg/L) > Dy (0.15 µg/L) > Er (0.04 µg/L). The use of MSA as a lixiviant demonstrated high leaching efficacy compared to the two carbon sources. Although significantly lower, the use of glucose enhanced the release of REEs such as Eu (0.03 µg/L) > Sc (0.02 µg/L) = Gd (0.02 µg/L) > Er (0.00 µg/L) = Dy (0.00 µg/L), probably due to stimulated microbial activity. On the other hand, methanol treatments showed minimal leaching up to 0.47µg/L total REEs released, implying limited microbial utilisation. Overall, these findings introduce MSA as a novel and effective lixiviant for REEs from alkaline tailings, supporting the development of biogeochemically informed strategies to extract REEs and support the potential use of indigenous microbial communities in carbon-supplemented environments for enhanced bioleaching.

**Keywords**: Rare-earth elements, MSA, alkaline tailings valorisation, resource recovery

**Poster Sessions**

# VALORISING RECYCLED CEMENT FOR SUSTAINABLE FLY ASH-BASED GEOPOLYMER BINDERS: ENHANCING AMBIENT CURING AND REDUCING RELIANCE ON SLAG

**Damund de Klerk[1,2], Abdolhossein Naghizadeh[1], Megan Welman-Purchase[3] & Stephen Ekolu[2]**

[1]Department of Engineering Sciences, University of the Free State, Bloemfontein, South Africa

[2]Department of Civil Engineering, Nelson Mandela University, Gqeberha, South Africa

[3]Department of Geology, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

This study investigates the potential of recycled ordinary Portland cement (OPC) waste powder as a supplementary binder to enhance the performance of fly ash – based geopolymer systems under ambient curing conditions. Fly ash – based geopolymers typically exhibit extended setting times and require elevated temperature curing to attain early – age strength, posing sustainability challenges. In this research, recycled cement material – obtained by crushing and milling hardened OPC concrete – was incorporated into geopolymer mortars at dosages of 0% – 20% by weight. The mixtures were activated using a binary alkali solution of sodium silicate and sodium hydroxide and compared against systems containing ground granulated blast – furnace slag (GGBFS). Evaluations included flowability, setting time at ambient temperature, compressive strength, drying shrinkage, and pore – related physical characteristics, supported by X – ray diffraction and scanning electron microscopy analyses. The incorporation of 7.5% – 10% recycled OPC was found optimal, achieving initial setting times between 100 – 165 minutes, limiting drying shrinkage to below 0.50%, and producing 28 – day compressive strengths around 60 MPa, outperforming both the control and GGBFS – modified mixes. This work demonstrates a pathway for valorising cementitious waste materials, thereby advancing sustainable construction practices. By integrating waste utilisation with material innovation, the study supports the broader agenda of achieving societal resilience and environmental sustainability through scientific advancement.

Keywords: ambient curing, recycled Portland cement, compressive strength, setting time, drying shrinkage

**Session 9A**

---

# SUSTAINABLE PHOSPHATE REMOVAL WITH CAO-BIOCHARS

**Elham Jalali, Elizabeth Erasmus, Hendrik G. Visser & Marietjie Schutte-Smith**

Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Ecological balance depends on phosphate stripping because, although phosphorus is an essential nutrient, excessive phosphorus in water leads to problems such as eutrophication. Bark pyrolysis and modification for improving phosphate adsorption towards the recovery of phosphorus for a long duration are discussed here. Biochar is a porous, carbon-rich solid material produced by the thermal decomposition of biomass in an environment with limited or no oxygen. Because of their porous nature, biochars derived from bark and waste eggshells with a mass ratio of 1:1 (bark: eggshells 1:1) pyrolysed at 800°C have been investigated as adsorbents. Their activity has been promoted using CaO. Calcium (Ca) is not harmful to the ecological environment, and it is abundant in nature and inexpensive, making it an appropriate metal element for modifying the adsorbent. The efficiency of CaO-modified biochars in phosphate adsorption from aqueous solutions is under investigation here. In this paper, we demonstrate that CaO-biochars have vastly superior adsorption capacities to unmodified biochars;

CaO-biochar at 800°C achieved a removal of 90%. These results are of specific interest to the treatment of fertiliser production wastewater, for the recovery of phosphate from aqueous solution or phosphate-enriched farm runoff. CaO-biochars solve nutrient pollution and water quality issues through a highly effective and low-cost process of phosphate removal. This technological advancement in adsorbents can help industrial and scientific communities adopt environmentally friendly water treatment methods.

**Keywords**: phosphate removal, biochar, CaO modification, wastewater treatment

**Poster Sessions**

---

# ADVANCEMENTS IN REMOTE SENSING TECHNOLOGIES FOR ENHANCED DETECTION AND MONITORING OF OFFSHORE OIL SPILLS: AN INTEGRATION WITH DISASTER PREPAREDNESS AND RESPONSE STRATEGIES

**Thobelani Jiyane[1], Motebang D.V. Nakin[2], Patricks Voua Otomo[3] & Z. Mncube[1]**

[1]Department of Geography, University of the Free State Phuthaditjhaba, South Africa
[2]Risk and Vulnerability Science Centre, Walter Sisulu University, Mthatha, South Africa
[3]Department of Zoology and Entomology, University of the Free State, Phuthaditjhaba, South Africa

## ABSTRACT

This study explores the application of remote sensing technologies specifically synthetic aperture radar (SAR) and unmanned aerial vehicles (UAVs) for detecting and monitoring offshore oil spills in Algoa Bay and Strandfontein, South Africa. Marine oil spills threaten environmental health, biodiversity, and coastal livelihoods, necessitating rapid and accurate detection methods. Recent incidents, such as the September 2024 Algoa Bay spill and the grounding of vessels MVP and Ultra Galaxy near Strandfontein, reveal gaps in existing response strategies. Employing a mixed-methods approach, the research integrates quantitative data from satellite-based SAR (Sentinel-1) and UAV aerial surveys with qualitative insights from stakeholder interviews and environmental surveys. A key aspect of the methodology involves pixel fusion and temporal validation of SAR and UAV data, which enhances detection accuracy, reduces detection time, and improves spatial coverage of spill extents. Spatial analysis using GIS-based mapping, along with statistical correlation of spill areas with environmental impacts such as habitat health and biodiversity providing a comprehensive assessment of spill effects. Thematic coding of stakeholder interviews offers insights into response challenges and policy gaps. Preliminary findings indicate that combining SAR and UAV data through pixel fusion and temporal validation significantly improves real-time spill detection, enabling faster and more precise response efforts. Additionally, the study identifies critical gaps in current policies and disaster preparedness plans, emphasising the need for policy reform and better stakeholder coordination. Ultimately, this research aims to inform policymakers, conservationists, and maritime authorities to develop more robust, technologically advanced spill management strategies. Integrating SAR and UAV technologies within disaster response frameworks has the potential to enhance early detection, protect marine ecosystems, and mitigate the environmental and economic impacts of future oil spills in South Africa.

**Acknowledgements**

I would like to express my sincere gratitude to the National Research Foundation (NRF) and the German Academic Exchange Service (DAAD) for their generous funding and support of this research. Their financial assistance has been instrumental in enabling me to conduct this study and pursue my academic and professional goals. I am also grateful for the guidance and encouragement from my supervisors, colleagues, and all those who contributed their time and expertise throughout this project.

**Keywords**: SAR, UAV, Marine Oil Spills, Preparedness

**Session 9A**

---

## UPCYCLING OF KERATIN-LADEN BIOMASS WASTE

**M.W. Krüger[1], D.J. Opperman[1] & N.K. Birkeland[2]**
[1]Department of Microbiology and Biochemistry, University of the Free State, Bloemfontein, South Africa
[2]Department of Biological Sciences, University of Bergen, Bergen, Norway

### ABSTRACT

Keratin is an abundant recalcitrant fibrous protein found in all vertebrates. ß-Keratin is the major component of feathers, which due to the wide-spread poultry industry, has become a major waste product. Current methods of disposal and upcycling of keratin waste are thermal degradation and chemical degradation. Both these methods, however, have drawbacks such as negative environmental impacts and destroying nutrient rich products. Biotechnological upcycling of feather waste has gained interest as various microorganisms capable of degrading keratin have been isolated. These microorganisms produce keratinases, enzymes responsible for the hydrolysis of keratin. The structural properties that confer keratinolytic activity to protease are, however, not well understood. *Fervidobacterium pennivorans* strain T demonstrates high keratinolytic activity and optimal growth at 70°C. Several potential keratinases have been identified through multi-omics approaches from *F. pennivorans*. These keratinases are from diverse metallo-protease families (M3, M32, M42, M55) as well as a S8 serine protease. The potential keratinases were recombinantly expressed in Escherichia coli, purified and their keratinolytic activity determined on whole – as well as milled-feathers. Additionally, their X-ray crystal structures were solved for structural comparisons and key regions that play a role in their keratinolytic activity were identified and confirmed through mutagenesis. We also demonstrate the capability of multiple thermostable keratinases to degrade feathers, either as purified enzyme or as enzyme cocktails, to hydrolysates that can potentially be used in the agricultural industry for fertilizer or animal feed to create a circular bio-economy.

**Keywords**: Keratinase, protease, upcycling, X-ray Crystallography

**Session 9A**

---

## CAN THE GEOTAXIS BEHAVIOUR OF MOSQUITO LARVAE (CULICIDAE) BE A RELIABLE PREDICTOR OF WATER QUALITY? AUTHORS

**Nkabeleng Constance Lechesa & Patricks Voua Otomo**
Centre for Global Change, University of the Free State, Phuthaditjhaba, South Africa

### ABSTRACT

Geotaxis is the behavioural response of an organism under the influence of gravitational forces. Geotaxis can either be negative or positive. A negative geotaxis refers to when an organism moves away from the centre of the earth and a positive geotaxis refers to when an organism moves towards the centre of the earth. Mosquito larvae display negative geotaxis behaviour in aquatic environments as this is their survival mechanism. In this study we used manganese metal, pymetrozine insecticide and distilled water (control) to assess the mortality and geotaxis of the mosquito larvae after exposure to these chemicals. Cohorts of ten Culex.sp second instar larvae were exposed to varying concentrations

of the solutions. Mortality assays were conducted in 100 ml glass beakers filled to capacity. Exposures were carried out in 4 replicates and incubated for 24 hours at 20 ± 2 °C in a Kelvinator incubator (K385 FF). After the exposure duration, the dead larvae (fully immobile or unresponsive to tactile stimuli) were counted. Geotaxis behaviour assays were carried out at a room temperature between (18-20$^{o}$C) and 15 individual Culex.sp second instar larvae were exposed and recorded for all treatments of pymetrozine, manganese and distilled water (control). During the exposure time of 10 minutes, the cumulative time the mosquito larvae spent breathing at the water surface, moving upward within the water column and downward below the water surface or resting at the bottom of the water column was evaluated. The results indicated that larval mortality increased with increasing concentrations of both manganese (LC50 =572.074 mg/L) and pymetrozine (LC50 =20.259 mg/L). At 20 mg/L pymetrozine concentration, negative geotaxis behaviour decreased thus indicating a possible link between geotaxis behaviour and mortality. Further research is needed to enhance these approaches and evaluate their applicability across different species and environmental backgrounds.

**Acknowledgements**

Supervisor: Patricks Voua Otomo, Director for NRF Centre for Global Change

**Keywords**: geotaxis, manganese, mortality, pymetrozine, water quality

**Poster Sessions and Session 9B**

---

# ASSESSING THE IMPACT OF CLEANER PRODUCTION STRATEGIES ON WASTEWATER MANAGEMENT IN TSHIAME INDUSTRIAL DEVELOPMENT ZONE (TIDZ), SOUTH AFRICA

**Buyani Mosiea[1], P.P. Mokolokolo[2] & T. Okello[1]**

[1]Department of Geography, University of the Free State, Phuthaditjhaba, South Africa

[2]Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Water scarcity and pollution are among the most pressing environmental challenges of the 21st century, especially in the rapidly industrialising regions of the global South. In South Africa, the expansion of industrial parks is fuelling economic growth but exacerbating environmental impacts through high resource consumption and the discharge of pollutants. This study evaluates the effectiveness of Resource Efficiency and Cleaner Production (RECP) in wastewater management at the Industrial Development Zone in the Free State Province. RECP is a global strategy that aims to optimise resource use and prevent pollution through sustainable production methods. The study uses a mixed-methods approach that combines quantitative laboratory analyses of wastewater samples from various sites within the park and from nearby rivers with qualitative findings from stakeholder interviews, field observations, and literature reviews. The analysis focuses on pollutants such as heavy metals and nutrients, the degree of RECP integration, and opportunities to implement circular economy principles. Preliminary results show gaps in RECP uptake, varying pollutant levels, and limited reuse strategies. These results highlight both the potential and limitations of RECP in South African industrial parks and provide information for the development of cost-effective, environmentally friendly wastewater management systems.

**Keywords:** wastewater management, cleaner production, resource efficiency, circular economy, RECP, industrial parks,

**Session 9C**

---

# COATED MAGNETITE NANOPARTICLES FOR EXTRACTION OF TRACE ORGANIC CONTAMINANTS FROM WASTEWATER

**Viwe Mzinjani[1], Philiswa N. Nomngongo[2] & Vladimir Azov[1]**

[1]Department of Chemistry, University of the Free State, Bloemfontein, South Africa

[2]Department of Chemical Sciences and DSI-NRF SARChI Chair in Nanotechnology for Water, University of Johannesburg, Doornfontein, South Africa

## ABSTRACT

The deposition of waste substances into subsurface groundwater, rivers, dams, oceans, etc., leads to worldwide water pollution and puts aquatic life, humans, and the environment at tremendous risk. These pollutants come from different industrial activities, with various new contaminants emerging over time. The conventional treatment techniques often fail to remove emerging contaminants like dyes, pharmaceuticals, and endocrine disruptors to acceptable levels. Advanced adsorption techniques show promising removal capabilities for both organic and inorganic contaminants. However, an adsorbent with a high sorption surface area, low preparation cost, easy preparation procedures, and a high reusability factor that can allow their efficient collection, for example, using a magnetic field, is needed. Here, we show that magnetite nanoparticles (NPs) coated with amphiphile shells and cyclodextrin molecular hosts can remove organic dyes with high adsorption capabilities. The magnetite NPs were synthesised via co-precipitation of $Fe^{2+}$ and $Fe^{3+}$ ions using ammonium hydroxide under inert conditions. The amphiphilic shells and modified cyclodextrins were attached through phosphate groups. Characterisation methods such as TEM, SEM, FTIR, EDS, PXRD, UV-Vis, MS, and NMR confirmed successful synthesis of organic amphiphiles and functionalisation of the magnetite NPs. The coated magnetite NPs were tested as dye removal agents in dye-spiked water samples, the efficiency of absorption was measured using UV-Vis spectroscopy. Longer alkyl chains on the coating molecules enhanced adsorption due to dispersion interactions., Cyclodextrin-modified NPs are still to be tested. The magnetic susceptibility of the nanoparticles allows for their easy separation using an external magnet. Our results suggest that amphiphile-coated magnetite NPs can be used to extract organic contaminants from water. Their easy separation, non-toxicity, stability over a wide pH range, and high reusability factor make them an ideal material that can be used in wastewater treatment plants.

**Acknowledgements**

I would like to thank the NRF for the PhD bursary.

**Keywords**: Nanoparticles, Adsorption, Wastewater, Pollutants

**Poster Sessions**

# ENHANCED PHOTOCATALYTIC REMOVAL OF AMMONIA NITROGEN VIA $ZnFe_2O_4/TiO_2$ HETEROJUNCTION

**Matin Naghizadeh & Karel von Eschwege**
Department of Chemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Photocatalysis offers a promising approach for environmental remediation, leveraging light-driven chemical reactions to degrade pollutants. Ammonia nitrogen ($NH_{4+}$-N) in wastewater poses significant ecological and health risks, necessitating efficient removal strategies. Traditional photocatalysts, such as titanium dioxide ($TiO_2$), suffer from limited visible light utilisation and rapid charge carrier recombination, hindering its practical application. Recent research has explored spinel ferrites such as zinc ferrite (ZnFe2O4) for its narrow bandgap and visible light response; however, its standalone performance remains suboptimal due to inefficient charge separation. ZnFe2O4/TiO2 p-n heterojunctions (ZT-5, ZT-10, ZT-15) were synthesised via a solvothermal and sol-gel method, combining $ZnFe_2O_4$ with tetrabutyl titanate, followed by hydrothermal treatment at 200°C and calcination at 400°C and characterised by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscope and energy-dispersive Xray spectroscopy (SEM-EDS). This study addresses the challenge of enhancing photocatalytic efficiency for $NH_{4+}$-N degradation by developing a novel p-n heterojunction photocatalyst. Here we show that the $ZnFe_2O_4/TiO_2$ heterojunction, particularly the ZT-10 composition (1:10 molar ratio), achieves a remarkable 98.52% removal of $NH_{4+}$-N (50 mg/L) under visible light. This performance surpasses that of standalone $TiO_2$ or $ZnFe_2O_4$, which typically exhibit lower degradation efficiencies due to recombination losses. XRD verified the spinel-anatase structure, with FT-IR and SEM-EDS planned to analyse morphology and elemental composition. The enhanced activity stems from the formation of an internal electric field (IEF) at the p-n heterojunction, which accelerates charge carrier separation and boosts the production of reactive oxygen species, such as superoxide (•O2?) and hydroxyl (•OH) radicals. These findings advance the understanding of heterojunction-driven photocatalysis, offering a pathway to overcome limitations of conventional materials. In a broader context, this work contributes to sustainable wastewater treatment by enabling efficient pollutant degradation under visible light, reducing energy costs. The development of such photocatalysts aligns with global efforts to address water pollution, providing a scalable solution for mitigating the environmental impact of industrial and agricultural effluents. This approach exemplifies how material engineering can enhance green technologies, fostering cleaner ecosystems accessible to interdisciplinary scientific exploration.

**Acknowledgements**
We acknowledge the support of Professor Sheying Dong's research group at the School of Chemistry and Chemical Engineering, Xi'an University of Architecture and Technology, Xi'an 710055, China.

**Keywords**: Photocatalyst, Ammonia Nitrogen, $ZnFe_2O_4/TiO_2$, p-n Heterojunction

**Poster Sessions**

# THE USE OF YEAST BIOASSAYS TO DETERMINE THE POTENTIAL RISK OF AZITHROMYCIN, A COVID-19 DRUG, ON THE AQUATIC ECOSYSTEM AND HUMAN HEALTH IN THE ORANGE-SENQU RIVER BASIN

**Thuto A. Ramosoeu[1], Elizabeth O. Omotola[2], Gladys N. Belle[3], Marinda Avenant[1], Paul J. Oberholster[3]**

[1]Centre for Environmental Management, University of the Free State, Bloemfontein, South Africa
[2]Department of Chemical Sciences, Tai Solarin University of Education, Ijebu Ode, Nigeria
[3]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Azithromycin is a widely used macrolide that is frequently detected in aquatic ecosystems. The presence thereof in surface waters raises concerns about its potential risk to aquatic organisms and human health. This study investigated endocrine-disrupting and dioxin-like activities of environmental water samples from a transboundary river basin using in vitro bioassays. The protocols applied were the Yeast Estrogen Screen (YES) and Yeast Anti-Androgen Screen (YAAS), which were used to assess estrogenic and anti-androgenic activities, respectively, while the Aryl Hydrocarbon Assay evaluated dioxin-like activities. Sampling was conducted during summer and winter to reflect seasonal variation. The results revealed detectable estrogenic and anti-androgenic activity at several sites, with Estradiol Equivalent (EEQ) concentrations ranging from less than the limit of detection (LOD) to 35 ng/L during the summer season and less than the LOD to 58 ng/L during winter. Flutamide equivalent (FEQ) concentrations, expressing anti-androgenic activity, ranged between less than the LOD and 40 µg/L in summer and less than the detection limit to 47 µg/L in winter. Dioxin-like activity, measured in ß-Naphthoflavone Equivalent, ranged below the detection limit to 1050 ng/L in summer and below the LOD to 1130 ng/L in winter. These concentrations exceeded values that were reported in the literature, suggesting a potential risk of endocrine disruption in aquatic organisms and a possible health concern for humans through exposure. The findings highlight the importance of better pharmaceutical management and the need for further research on the long-term effects of azithromycin and similar compounds in aquatic environments.

**Keywords**: azithromycin, yeast bioassays, endocrine disruption, aquatic ecotoxicology

**Session 9B**

---

# INVESTIGATING THE GEOCHEMISTRY OF ARSENIC AND URANIUM IN WETLAND SEDIMENTS NEAR MINING SITES IN WELKOM, SOUTH AFRICA

**Bokang Tsiane[1,2], Mariana Erasmus[2], Megan Welman-Purchase[3], Robert Hansen[3] & Yolandi Schoeman[2]**

[1]Centre for Environmental Management, University of the Free State, Bloemfontein, South Africa
[2]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa
[3]Department of Geology, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Wetlands situated near mining operations often serve as sinks for toxic trace elements such as arsenic (As) and uranium (U). However, under certain environmental conditions, these elements can become remobilised, posing risks to aquatic ecosystems and human health. This study investigates the geochemical behaviour of As and U in wetland sediments near mining sites in Welkom, South Africa, an area historically impacted by extensive gold mining. The research aims to understand how spatial variation, seasonal dynamics, and sediment properties influence the mobility and retention of these

contaminants. Fieldwork involved the seasonal collection of water and sediment samples from selected wetland sites. In-field measurements included pH, oxidation-reduction potential (ORP), temperature, and electrical conductivity. Laboratory analyses encompassed water chemistry, bacteriological assessments, X-Ray Fluorescence (XRF), X-Ray Diffraction (XRD), and evaluations of organic matter content, porosity, and bulk density. Results show that water samples at site WW01 contained 0.037 mg/L As and 0.042 mg/L U, exceeding South African (SANS 241:2015) and WHO drinking water limits (0.01 mg/L for As; 0.03 mg/L for U). Sediment analyses revealed that site WS02, with minimal reactive iron phases, contained elevated concentrations of 14 $mg/kg^{-1}$ As and 12 $mg/kg^{-1}$ U, compared to 9 $mg/kg^{-1}$ and 6 $mg/kg^{-1}$ at WS01, where Fe-rich minerals like jarosite and pyrite were present. The findings highlight the critical influence of redox conditions, mineralogical composition, and sediment characteristics in regulating contaminant dynamics in wetland environments. This research provides essential insights into the biogeochemistry of As and U in mining-impacted wetlands and informs the development of targeted remediation and management strategies to protect downstream ecosystems and human populations dependent on these water resources.

**Keywords**: Geochemistry, Arsenic, Uranium, Heavy, metal contamination

**Poster Sessions**

---

# ASSESSING THE OCCURRENCE AND THE ENVIRONMENTAL RISK OF A COVID-19 DRUG, DEXAMETHASONE, IN THE ORANGE-SENQU RIVER BASIN

**Lerato J. Tsilo[1], Gladys B. Belle[1], Elizabeth O. Omotola[2], Marinda Avenant[3] & Paul J. Oberholster[1]**

[1]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa

[2]Tai Solarin University of Education, Ijebu Ode, Nigeria

[3]Centre for Environmental Management, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Pharmaceuticals as contaminants of emerging concern have recently been receiving a great deal of attention because they have been depicted to pose immense threats to aquatic ecosystems at the trace concentrations which they are detected. The outbreak of Covid-19 has led to their aggravated prevalence in aquatic environments because some drugs were repurposed to alleviate its symptoms. Despite concerns associated with them, South Africa and Lesotho amongst other African countries, still lack regulatory frameworks and monitoring programs. In this regard, this study investigates the presence and aquatic risk of dexamethasone, a repurposed Covid-19 drug, in the Orange-Senqu River basin to enhance its limited occurrence data and understanding of the environmental risk it imposes. It also applies chemometric parameters to infer the vulnerability of sites to pollution and establish river health using time series analysis. The occurrence of dexamethasone in the 8 selected sites has shown variability. The incorporation of land use/land cover and human geographical concepts are recommended to be parallel with similar studies. In water samples, from sites 4, 5 and 8 the detected concentrations are 15.43µg/ml, 39.42µg/ml, and 12.28µg/ml, respectively. In sediments from sites 1, 5, 7 and 8, the detected concentrations are 1.59µg/g, 18.21 µg/g, 8.10 µg/g and 18.44 µg/g, respectively. The sample stations show relative stability with outliers stretching across the corrosivity level of Larson-Index ranging between 0.8 to 1.2. The water quality index showed that all the sites are positioned considerably within excellent water quality classes with exceptions of sites 3, 4, 6, and 8 which are associated with poor water quality to an insignificant extent. The risk quotient applied for computing the environmental risk demonstrated that risk levels are higher for fish in both water and sediment samples at maximum values of 39.42 and 18.44, respectively.

**Acknowledgements**
Water Research Commission

**Keywords**: dexamethasone, environmental risk, Covid-19, wastewater treatment plant

**Session 9B**

---

# ARSENIC BEHAVIOUR IN GOLD MINE TAILINGS: INTEGRATING GEOCHEMISTRY FOR SUSTAINABLE REMEDIATION

**Megan D. Welman-Purchase[1,2] & Wayne J. Nel[1]**
[1] Department of Geology, University of the Free State, Bloemfontein, South Africa
[2]Centre for Mineral Biogeochemistry, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Arsenic contamination in legacy gold mine tailings represents a critical environmental challenge, particularly in regions with a long history of mining activities and limited post-mining rehabilitation. This study explores how integrated geochemical and environmental science can support sustainable remediation strategies that protect ecosystems and communities. We investigate arsenic speciation and mobility in gold mine tailings using a suite of complementary analytical techniques, including X-ray diffraction (XRD) and X-ray fluorescence (XRF) for mineralogical and chemical characterisation, and field probes for pH and oxidation-reduction potential (ORP) to assess in situ environmental conditions. Together, these analyses help identify the geochemical pathways that control arsenic mobility and its potential for environmental release. Building on these insights, the study evaluates the potential of passive and low-intervention remediation strategies. Natural attenuation processes include the formation of stable mineral phases that immobilise arsenic. The presence of microbial mechanisms is explored, including Dissimilatory Arsenic Reduction (DAR), which reduces arsenic, possibly increasing the mobility under specific environmental conditions. These natural and bio-based processes offer promising long-term solutions that align with principles of sustainability, reducing the need for costly and energy-intensive remediation interventions. This case study demonstrates how science can be integrated across disciplines to address environmental legacies in a way that supports both environmental resilience and human health. The methodologies applied here are transferable and can be adapted to assess other metalloids in different contaminated environments. By emphasising an evidence-based, systems-thinking approach, this research contributes to the development of remediation practices that are not only technically sound but also socially and environmentally responsible.

**Keywords**: gold mine tailings, arsenic, geochemical behaviour, passive remediation

**Session 9A**

---

# BASOTHO RURAL DOMESTIC HERITAGE FOR ARCHITECTURE TEACHING AND LEARNING

**Gerhard Bosman**
Department of Architecture, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Rural domestic dwellings can be used to teach architecture students the purpose of space organisation at environmental levels from public to private domains while actively illustrating the relationship between art, architecture and placemaking. Rural space-making is an efficient starting point to explain this relationship to architecture students in central parts of South Africa that surround Lesotho. The main question is: How can traditional Basotho approaches to space and place-making in central South Africa enhance spatial organisation skills among undergraduate architecture students through participatory rural *litema* wall workshops? By engaging in hands-on, real-world experiences, students are introduced to a unique dwelling typology, seeing art and architecture crafted from traditional materials that offer comparative insights into their urban lived experience. This immersive learning environment provides a decolonised foundation for innovative teaching and learning, where instructors use the contrast between rural and urban domestic architecture to illustrate spatial distinctions and parallels. From a constructivist perspective, the study employs Symbolic Interaction Theory (SIT) and a Participatory Action Research (PAR) approach, incorporating experimental workshops and student surveys to gather qualitative data on students' perceptions of thresholds and environmental levels during service learning. The research also examines the perspectives of *litema* artists and participating students within a shared social and rural context, fostering a cultural-historical appreciation. This experimental approach can be optimised in other contextual rural historical environments to support teaching with service learning, an effective tool to help architectural students tap into their own lived worlds to better understand space and place organisation while designing for others.

**Keywords**: Service-learning, architecture, Basotho litema wall-art, space and place-making

**Session 4**

---

# FROM FOUNDATIONS TO FUTURES: CONSTRUCTIVIST PEDAGOGY FOR SUSTAINABILITY IN QUANTITY SURVEYING EDUCATION

**Mart-Mari Els**
Department Quantity Surveying and Construction Management, University of the Free State, South Africa

## ABSTRACT

Advancing science for societal impact and a sustainable future necessitates the active engagement of diverse professional sectors, notably the built environment. As a foundational element of this sector, the built environment possesses substantial potential to contribute meaningfully to sustainable development goals (SDG). Within this context, quantity surveyors serve as key agents in promoting sustainability through informed decision-making and effective resource management. However, the persistent shortage of qualified quantity surveyors underscores the urgent need to strengthen their educational and professional development pathways. Foundational education, particularly for

underprepared first-year students, is crucial in establishing the competencies required for advanced learning and future professional success. This paper advocates for a constructivist pedagogical approach, grounded in Vygotsky's sociocultural theory, as a means to enhance student engagement and knowledge acquisition. Emphasising social interaction and contextual learning, this approach fosters both individual academic achievement and the broader objective of cultivating a sustainability-conscious workforce in the built environment sector. Utilising a qualitative case study design, this study employed classroom observations, reflective journals, and pre- and post-tests to examine the effectiveness of constructivist strategies within the building measurement module—a core component of the first-year quantity surveying curriculum. The findings indicate that Vygotsky's principles, particularly instructional scaffolding and the support of a more knowledgeable other, significantly benefited underprepared students. These results highlight the transformative potential of constructivist pedagogy in addressing educational gaps and equipping future quantity surveyors to contribute to a more sustainable built environment.

**Keywords:** Built Environment, Quantity Surveying Education, Sustainability, Vygotsky's Sociocultural Theory

**Session 4**

---

# PEDAGOGY FOR A PLANET IN CRISIS

**Lindi Heyns[1] & Annalene Nell[2]**

[1]Department of Zoology and Entomology, University of the Free State, Bloemfontein, South Africa
[2]Centre for Teaching and Learning, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Biodiversity loss and sustainability challenges are among society's most pressing issues, requiring scientists who can think creatively, communicate clearly, and lead transformative action. However, traditional science pedagogy often emphasises content mastery and technical skills over broader competencies such as communication, leadership, and creativity. This narrow focus can limit students' readiness to engage with complex socio-ecological problems that demand collaborative solutions and meaningful public engagement. Pedagogical approaches that incorporate authentic assessments explicitly aim to broaden what is valued in student learning. These approaches encourage students to apply their knowledge in authentic contexts, supporting the broader goal of preparing them for real-world challenges. This project explores how an authentic, assessment-based approach can equip undergraduate Zoology students with the competencies needed for environmental and societal problem-solving. A novel two-part assessment, comprising a popular science article and a TED-style talk, was implemented over two academic years within a second-year Zoology module. This assessment design advanced science communication proficiency, increased student confidence, and consistently improved overall academic performance. These outcomes demonstrate that communication skills and confidence are important complementary dimensions of student success, particularly within authentic assessment contexts. The preliminary findings highlight the value of integrating authentic, creative assessments into science curricula. Unlike traditional reliance on standardised tests and technical reports, this approach develops conceptual understanding and a broader range of scientific competencies. Embedding such pedagogical innovations in undergraduate programmes is essential for preparing future scientists to respond effectively to global environmental challenges. This assessment design offers a promising example of how science education can evolve to meet the urgent demands of a planet in crisis.

**Keywords**: authentic assessment, science communication, creative competencies, undergraduate education

**Session 4**

# PORTFOLIOS OF LEARNING EVIDENCE AND INTERVIEW ASSESSMENTS IN A MATHEMATICAL STATISTICS COURSE

**Michael Johan von Maltitz**
Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Considerable research suggests that traditional assessments in higher education are outdated, and newer, more authentic assessment strategies should be pursued. One such form of authentic assessment is a portfolio of learning evidence, and another is the oral interview or oral assessment. However, the portfolio and interview are not only methods of assessment, but also primary drivers of learning and creative thinking. In statistics and data science education, the portfolio of learning evidence and interview assessment have not been implemented widely, although some authors have explored the implications of assessments. This mixed-methods study examines the interplay between the use of portfolios and interview assessments in a mathematical statistics course and Fink's framework for significant learning. The study finds that there are indeed numerous advantages that can be gained from using these novel methods instead of traditional learning and teaching methods.

Keywords: Authentic Assessment, Fink's Taxonomy, Significant Learning

**Session 4**

# Simulations, Modelling and Data Science

## FINE-TUNING CODELLAMA WITH LORA FOR CLASSIFYING HUMAN VS AI-GENERATED C# CODE

**Adewuyi A. Adegbite & Eduan Kotze**
Department of Computer Science and Informatics, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

Text mining has become a critical tool in analysing textual and structural patterns in Natural Language Processing. Existing studies often rely on traditional machine learning for code classification, but advanced transformer-based large language models (LLMs) and explainability tools remain underexplored. Challenges remain in adapting LLMs efficiently for specific classification tasks while maintaining computational efficiency. This study addresses the task of accurately classifying human written versus AI-generated C# code by leveraging supervised fine-tuning and Low-Rank Adaptation (LoRA) applied to CodeLlama, a state-of-the-art LLM for code understanding. As a baseline model, we use Term Frequency - Inverse Document Frequency (TF-IDF) lexical features coupled with a Support Vector Machine (SVM) to establish reference classification performance. We then fine-tune CodeLlama on a curated dataset of human written and AI-generated C# code, employing LoRA to efficient adaptation and reduced computational load. To interpret model predictions, we apply Local Interpretable Model-agnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP), identifying key syntactic and structural features for classification. Our findings compare character-based and word-based n-gram models in the SVM baseline and evaluate CodeLlama through fine-tuning. This research highlights the potential of fine-tuned LLMs for GenAI detection in code, contributing to an interpretable approach to code authenticity verification and automated review.

**Keywords:** Large Language Models, C# Code, GenAI Detection, LoRA, CodeLlama

**Session 7C**

---

## UAV AERIAL IMAGERY SEGMENTATION AND CROWN PROJECTION AREA ADJUSTMENT FOR MODELLING DBH IN A COMPLEX CANOPY STRUCTURE OF THE TROPICAL RAINFOREST

**Tiegsti Hadush Berhe[1,2], E.H. Kloosterman[3], Tesfay Araya[1] & Y.A. Hussin[3]**
[1] Department of Soil, Crop and Climate Sciences, University of the Free State, Bloemfontein, South Africa
[2] Mekelle University College of Dryland Agriculture and Natural Resources Mekelle, Tigray, Ethiopia
[3] Faculty of Geo-Information Sciences and Earth Observation, University of Twente, Enschede, Overijssel, Netherlands

### ABSTRACT

Accurate measurement of Diameter at Breast Height (DBH) is significant for accurate tree carbon stock calculation. The measurement of the DBH in a complex forest canopy structure is labour-intensive and time-consuming. Unmanned Aerial Vehicle (UAV) aerial imagery is applicable for tree height and Crown Projection Area (CPA) measurement. To apply CPA as a proxy to DBH for aboveground carbon stock estimation, evaluating the relationship between DBH and CPA is vital. The aim of this study is to

estimate the DBH of a single tree inside a forest that has a complex vertical (stratum) structure. For accurate DBH estimation, occluded tree crown measurement is crucial. This study was conducted in a vertical canopy structured Berkelah tropical rainforest in Malaysia. An aerial image of part of the large forest was acquired using a DJI Phantom 4 Advanced UAV with a colour camera. The Pix4D capture app was used for flight mission preparation with moderate speed, a 90° angle, and 90% forward overlap. The flight height was prepared to be 120 metres. Using photogrammetry with AGISOFT Photo Scan Professional, an orthophoto was produced. Orthophoto segmentation was performed in e-Cognition, and segmented CPA was produced. CPA adjustment following automatic image segmentation was conducted using the tree canopy circularity measure in ArcMap, as tree crown intermingle influences the segmentation accuracy. The relationship between DBH measured in the field and CPA extracted from orthophoto segmentation was tested using DBH as dependent and CPA as an independent variable. The relationship between CPA and DBH revealed a non-linear (power model) with an $R^2$ value of 0.76. The automatically segmented CPA after occluded crown adjustment explained DBH measured at the field with an $R^2$ value of 0.8. The relationship was validated, and an $R^2$ value of 0.62.

**Keywords**: CPA adjustment, DBH Modelling, Tropical rainforest, UAV aerial imagery

**Poster Sessions and Session 7C**

---

## DETERMINING THE MOST SUITABLE DISTRIBUTION AND ESTIMATION METHOD FOR EXTREMES IN FINANCIAL DATA WITH DIFFERENT VOLATILITY LEVELS

**Thusang J. Buthelezi & Sandile C. Shongwe**
Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

Extreme events in financial markets can lead to significant losses, highlighting the importance of modelling extreme returns for effective risk management. In finance, accurately modelling the tail behaviour of extreme log returns is critical for understanding and mitigating risks across diverse asset classes. This research employs extreme value theorem (EVT) to identify the most suitable probability distributions and estimation methods for modelling the tail behaviour of log returns from three financial datasets, each representing a distinct asset class with distinct volatility levels. These datasets include: (i) South African government bonds, a fixed-income asset class with low volatility, (ii) Amalgamated Banks of South Africa (ABSA), an equity (stock) asset class with moderate volatility, and (iii) Ethereum, a digital (cryptocurrency) asset class with high volatility. The study analyses daily log returns over the period from 1st January 2020 to 31st December 2024, to fit five EVT models: generalised extreme value, generalised logistic, Gumbel, generalised Pareto and reverse Gumbel. For each dataset, the parameters of these distributions are estimated using the following methods: least squares, weighted least squares, maximum likelihood, L-moments and relative least squares. The performance of each model and estimation method is evaluated through goodness-of-fit tests and accuracy measures across the three volatility levels. The study aims to determine the optimal approach for each dataset, understand how volatility influences model accuracy and explore the role of EVT in enhancing portfolio diversification for risk mitigation. By addressing these objectives, the research seeks to advance risk modelling practices and provide actionable insights for portfolio management across diverse asset classes in volatile financial markets.

**Keywords**: Extreme value theorem, generalised extreme value, generalised logistic generalised Pareto, maximum likelihood

**Session 7B**

---

# RELATING THE SPAIN 2025 BLACKOUT TO OPTIMISED INDUSTRIAL BIOMASS YIELD

**Muhammad S. Cassim[1], Ethan Codron[1], Jacques Maritz[1] & Leonardo Rydin-Gorjão[2]**
[1]Unit of Engineering Sciences, University of the Free State, Bloemfontein, South Africa
[2]Faculty of Science and Technology, Nordic University of Life Sciences

## ABSTRACT

Understanding the role of effective communication of microbial consortia within engineered bioreactors is crucial for optimising biofuel production in an increasingly resource-conscious world. This study investigates how collective behaviour in microbial networks can be modelled and optimised to enhance biomass yield. We aim to test the hypothesis that increased synchronisation among oscillatory cellular processes (e.g., nutrient uptake cycles, circadian rhythms) directly improves system robustness and biofuel output under varying environmental conditions. In microbial or cellular consortia, the ability of components to synchronise and respond collectively to environmental cues often determines overall system efficiency and yield. By analysing the synchronisation of network components, we can observe how community-level interactions influence system dynamics, enabling more precise control over biomass production as synchronisation is modulated. To explore this, we implemented a modified Kuramoto model to simulate phase-coupled oscillators representing microbial metabolic processes within a bioreactor environment. Simulations varied in parameters such as coupling strength, nutrient distribution uniformity, and light availability. Synchronisation was quantified using the global order parameter (r). The model captures how oscillatory components, such as cellular processes or nutrient cycles, achieve synchrony and how this synchrony affects the system's output. Our findings suggest that systematic changes within these networks, such as nutrient distribution or light availability, can be used to demonstrate, using the same order-parameter framework, that temperature fluctuations during the Spanish Blackout of 2025 led to a drop in synchrony, comparable to nutrient-heterogeneity-induced desynchronisation in our model. Specifically, both exhibit cascade-like failures under desynchronisation, reinforcing the need for redundancy and adaptable coupling in system design. This study offers a novel perspective on system robustness and optimisation by drawing parallels between inter-cellular communication and complex infrastructural dynamics. Ultimately, our results contribute to a deeper understanding of biosystem synchronisation and present a framework for improving biofuel yields through strategic network design and control.

**Keywords**: Kuramoto Model Stochastic Simulations Non-linear Dynamics Biosystems

**Poster Sessions**

# COOLING INDUCED FRACTURING IN IMPACT MELT DIKES DERIVED FROM DRONE PHOTOGRAMMETRY AND PYTHON SIMULATION: EXAMPLE FROM THE LESUTOSKRAAL GRANOPHYRE DIKE IN SOUTH AFRICA

**Martin D. Clark[1], Elizaveta Kovaleva[2], Francois D. Fourie[3], Matthew S. Huber[4] & Stephanus Riekert[5]**

[1]Department of Geology University of the Free State, Bloemfontein, South Africa
[2]School of Agricultural, Earth and Environmental Science University of KwaZulu-Natal, Durban, South Africa
[3]Institute for Groundwater Studies, University of the Free State, Bloemfontein, South Africa
[4]Planetary Science Institute, Tucson, USA
[5]High Performance Computing Cluster, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Large meteorite impact events produce significant amounts of crustal melt, which can be emplaced as dikes below the crater floor over protracted time periods following the cratering process. Their emplacement is theorised to be controlled by stresses associated with the presence and opening of crustal-scale fractures, hydrostatic pressures associated with the overlying melt sheet, and lithostatic stresses of the impacted crust. At least two compositionally distinct phases of impact melt are present within the impact melt dikes at the Sudbury and Vredefort Impact Structures, underpinning the debated concept of a prolonged and multi-phase emplacement process. In this study, cooling fractures within the Lesutoskraal impact melt dike at Vredefort are investigated as a possible pathway to facilitate multi-phase emplacement. Through a combination of high-resolution (0.612 mm/pixel) drone orthophotography and numerical simulation of stress induced during cooling of impact melt shows that (1) the dominant fracture orientation within the impact melt dike is parallel to dike margins, related to a perpendicular and tensional cooling stress, and (2) the magnitude of the tensional cooling stress could reach up to -75 MPa, sufficient to overcome the lithostatic stresses at the observed depth of dike emplacement. Depending on simulation parameters such as the initial temperature of the impact melt, cooling fractures in the impact melt are shown to form within 150 days after their emplacement representing a possible mechanism for emplacement of later phases of impact melt into the centre of earlier impact melt phase.

**Acknowledgements**

This work is produced within the framework of interdisciplinary project GRAVITAS ("Geological Research and Analysis of Vredefort Impact with Timely Anthropological Studies"), funded by the Directorate for Research Development, University of the Free State, 2019–2020, as well as funding provided by the Hans Merensky Foundation to the MAGIC (“Merensky Airborne Geological Image Classification”) research group. We thank the University of the Free State High Performance Computing Cluster (HPC) for computational support.

**Keywords**: Cooling Fractures Drone Python Thermal Stress

**Session 7A**

# ON THE CONSTRUCTION OF A GENERIC KURAMOTO MODEL SOLVER

**Ethan Codron[1], Jacques Maritz[1], Leonardo Rydin Gorjão[2], Muhammad Cassim[1] & Nelme Opperman[1]**

[1]Department of Engineering Sciences, University of the Free State, Bloemfontein, South Africa
[2]Faculty of Science and Technology, Norwegian University of Life Sciences, As, Norway

## ABSTRACT

Studies on synchronous behaviour of complex networks of coupled oscillators often employ the Kuramoto model as a tool to simulate oscillator dynamics. This approach enables the investigation of system parameters pertaining to synchronicity, such as the order parameter r, and the D-parameter. Despite several numerical simulators being publicly available, they are often limited in functionality and parameter customisation, e.g., only solving the first order Kuramoto model, failing to account for stochasticity, having fixed values for certain parameters such as inertia, or enforcing an all-to-all topology with uniform coupling strength. One of the most notable simulation packages is NetworkDynamics.jl, a Julia package for simulating networks defined by any evolution functions, though it is still limited in only being usable in Julia. In-house simulators are often built and tailored to the study in question, whether using packages like NetworkDynamics.jl, Python's own NetworkX, or completely from scratch. We therefore realise that synchronicity studies would ultimately benefit from a generic Kuramoto model simulator i.e., one that can simulate any complex network of coupled oscillators, regardless of application, order, and programming language. In this paper, we present our solver that fits the aforementioned criteria and show that it is on-par in terms of speed and accuracy with existing simulation packages.

**Keywords**: Kuramoto model synchronicity simulation network dynamics

**Poster Sessions and Session 7C**

---

# COPULA-BASED ESTIMATION OF SYNTHETIC FLOOD DESIGN HYDROGRAPHS FOR REGIONAL APPLICATIONS IN SOUTH AFRICA

**Sandile S. Dladla[1], J.C. Smithers[2], O.J. Gericke[3], T.R. Kjeldsen[4] & U. Maharaj[2]**

[1]Hydroscience Group, University of Free State, Bloemfontein, South Africa
[2]Centre for Water Resources Research, School of Engineering, University of KwaZulu-Natal, Durban, South Africa
[3]Department of Civil Engineering, Central University of Technology, Bloemfontein, South Africa
[4]Department of Architecture and Civil Engineering, University of Bath, Bath, United Kingdom
[6.]GroundTruth, South Africa

## ABSTRACT

Reliable flood estimation is essential for sustainable water resource planning and the protection of infrastructure under increasing hydrological variability. This study presents a statistically rigorous and regionally adaptable framework for estimating Synthetic Flood Design Hydrographs (SFDHs) based on copula-based joint probability models of peak discharge and flood volume. The approach integrates multivariate distribution fitting, copula theory, Monte Carlo simulation, and clustering of non-dimensional hydrograph shapes to generate design hydrographs corresponding to specified return periods (e.g. 2, 5, 10, 20, 50, and 100 years). Initial results from selected South African catchments show that the majority of gauging stations exhibit dependence structures best captured by Gumbel and Frank copulas. By identifying design pairs on return-period-specific isolines and applying inverse marginal transformations, physically and statistically consistent design events are obtained. These are merged with the most probable hydrograph shapes, derived through k-means clustering, to reconstruct realistic

synthetic hydrographs. The method enables the derivation of flood hydrographs at both gauged and ungauged sites by linking flood characteristics with regional catchment descriptors. This enhances the transferability of the approach and supports broader applications such as dam safety assessments, hydraulic modelling, and climate-resilient infrastructure design. The ongoing work contributes towards integrating advanced hydrological science into practical tools for flood risk management, with strong potential for supporting long-term sustainability goals across southern Africa.

**Acknowledgements**

Engineering Sciences, University of the Free State; Centre for Water Resources Research, School of Engineering, University of KwaZulu-Natal; Umgeni Water-Amanzi; and Water Research Commission

**Keywords**: copula modelling, design flood hydrograph, regionalisation, flood risk

**Session 7A**

---

# COMPARATIVE ANALYSIS OF TAIL RISK IN EMERGING AND DEVELOPED MARKETS: AN EXTREME VALUE THEORY PERSPECTIVE

**Sthembiso Dlamini & Sandile C. Shongwe**

Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

This research explores the application of extreme value theory in modelling and quantifying tail risks across different equity markets, with a specific focus on the Nairobi Securities Exchange (NSE20), the South African Equity Market (FTSE/JSE Top40), and the US Equity Index (S&P500). The study aims to recommend the most suitable probability distribution between the Generalized Extreme Value Distribution (GEVD) and the Generalized Pareto Distribution (GPD), and to assess the associated tail risk using the risk measures Value at Risk (VaR) and Expected Shortfall (ES). GEVD is fitted to samples of maxima/minima extracted from the returns of all three indices using three different block sizes. For the GPD, the peak-overthreshold approach is implemented using the Hill's plot and the mean residual life plot to select appropriate thresholds. For each equity index, the probability models were ranked based on goodness-of-fit and accuracy using a combination of graphical and numerical methods. Events such as the 2008 Global Financial Crisis and the COVID-19 pandemic have shown the devastating impact of extreme market movements on societies and economies. Beyond its technical contributions, this study has broader implications for building sustainable and resilient financial systems. By improving the modelling of extreme market risks in both emerging and developed economies, the research supports better-informed decision-making for policymakers, financial institutions, and investors. Accurate tail risk estimation can improve financial resilience, guide regulatory frameworks, and contribute to economic sustainability by mitigating the effects of rare but severe financial shocks—especially in regions vulnerable to global volatility. The results indicate that the maxima and minima returns of block size 21 yield the best fit for all indices (except S&P500 minima), with most cases following a Fréchet distribution. For GPD, the Hill's plot performs best across all indices.

**Keywords**: extreme value theory, generalized extreme value distribution, generalized Pareto distribution, Nairobi securities exchange

**Poster Sessions and Session 7C**

---

# RISK ESTIMATION USING COMPOSITE MODELS FITTED TO THE J520 INDUSTRIAL INDEX

**Zander Greyling & Sandile C. Shongwe**
Department of Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Accurate risk estimation in financial markets relies heavily on the ability of statistical models to capture the underlying distribution of returns. Model fitting, a core aspect of this process, works by minimising the difference between observed and predicted values to uncover meaningful structure in the data. In financial contexts, especially those involving extreme gains or losses, standard models often fall short due to the presence of heavy-tailed behaviour. This study extends previous research on single-distribution fitting to explore whether composite models can more effectively model the J520 Industrial Index listed on the Johannesburg Stock Exchange. Composite modelling allows for the distinct treatment of the head and tail components of the data – capturing both frequent small fluctuations and rare but extreme movements – thereby addressing shortcomings of single-distribution approaches. Here we show that, across 256 composite models constructed from 16 base distributions, several combinations (e.g., Inverse Burr–Gamma, Loglogistic–Inverse Paralogistic) outperform all single models in terms of goodness-of-fit, as measured by Akaike-, Bayesian Information Criterions, and negative log-likelihood. These composite models also yield more robust and conservative estimates for key financial risk metrics—Value-at-Risk (VaR) and Tail Value-at-Risk (TVaR) – at 95%, 99%, and 99.5% confidence levels. Risk metrics are particularly important for investors to forecast expected risk and absolute losses. The results confirm that the complex, heavy-tailed structure of industrial returns data is better explained through flexible composite distributions. This supports the integration of such models into risk assessment practices and highlights the potential value of incorporating future techniques for heavy-tail detection to further improve model performance and risk estimation.

**Keywords**: value-at-risk, expected shortfall, composite models, financial risk

**Session 7B**

---

# POWER GRID VULNERABILITY AND CONTAINMENT STRATEGIES USING GRAPH THEORY

**Elizabeth Maritz**
Department of Mathematics and Applied Mathematics, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Recent large-scale power failures, such as those experienced in Spain, Portugal, and parts of France, have highlighted the urgent need to understand and strengthen the resilience of power infrastructure. In this paper, we model the power grid as a graph, where substations are represented by vertices and transmission lines by edges. This abstraction provides a clear framework for analysing the structural properties of the grid and its susceptibility to cascading failures. By leveraging graph-theoretic tools, we examine the underlying structure of the network to assess its robustness and identify critical points of vulnerability. Various measures are used to determine how easily failures propagate through the system. Crucially, this analysis helps pinpoint specific nodes that can serve as network isolators, or vertices whose strategic disconnection can halt cascading effects and contain local failures before they escalate into wider blackouts. Understanding which components most affect the overall connectivity of the grid enables better-informed decisions in the planning and reinforcement of infrastructure. This

work bridges abstract mathematical theory with practical challenges in infrastructure resilience, demonstrating how tools from graph theory can provide actionable insights into real-world systems.

**Keywords**: Graph theory, power grid, cascading failures, network isolators

**Session 7A**

---

## MODELLING THE PROBABILITY OF DEFAULT TERM STRUCTURE USING DIFFERENT METHODOLOGIES UNDER IFRS 9

**Kgotso Rudolf Moremoholo & Sandile Shongwe**
Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

To mitigate credit risk, banks are required to set aside a specific amount as a safety net to absorb the expected loss on banks' loan portfolio called loan loss provisions (LLPs) or provisions for bad debts. As of January 2018, in South Africa, banks had to adopt International Financial Reporting Standard 9 (IFRS 9) as the financial reporting standard. Unlike, its predecessor, IFRS 9 accelerates the recognition of losses by requiring provisions to cover both already-incurred losses and some losses expected in the future by calculating the expected credit loss (ECL). To evaluate if the obligor's credit quality has deteriorated, the IFRS 9 standard requires banks to compare the obligor's probability of default (PD) at the inception phase of the loan and at the reporting date. Thus, three methodologies are explored in this study (i.e., survival analysis, Markov chain, and machine learning) for computation of the PD. This study fills a research gap where no study has compared more than two methods for PD term structure so that we may quantify time to default and allow prediction of the obligor's credit future behaviour. For illustration purpose, we use the mortgage loan portfolio from Freddie Mac, and it is observed that the PD structure from Markov chain's is either aggressively increasing or decreasing; those of survival models tend give more control on the model (because we have the ability to choose which variables that can go into the model) and finally, machine learning model provides better prediction ability than the other models (but requires larger data for training and more resources than the other models).

**Acknowledgements**
My Supervisor, Mr Sandile Shongwe.

**Keywords**: Credit risk, expected credit loss

**Poster Sessions and Session 7C**

---

## MODEL AVERAGING AND GRID MAPS IN MODELLING HEAVY-TAILED INSURANCE DATA

**Lira Benedict Mothibe & Sandile Shongwe**
Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

Model selection for heavy-tailed data remains a significant challenge due to the inherent complexity and extreme variability of such distributions, which frequently result in infrequent but severe outcomes

that traditional models struggle to capture accurately. Recent studies demonstrate that conventional modelling approaches often fail to represent the tail behaviour of heavy-tailed distributions, leading to inadequate risk assessments and financial forecasts. In a recent paper's analysis of Danish fire claim and South African taxi claims data, composite models, (formed by merging two distributions at a threshold) and mixture models, (constructed as convex combinations of distributions) were evaluated using a 'single-best model' approach, with the top 20 models in each category assessed via model selection criteria and risk metrics. The findings indicate that composite models generally yield superior risk estimates; however, the absence of model uncertainty considerations limits the accuracy of model selection. In another paper, some researchers applied various standard distributions to South African Industrial Index data, identifying the inverse Burr and transformed beta distributions as best for loss returns and gain returns, underscoring the necessity of appropriate model selection for reliable risk and performance assessment. Distribution ranking was systematically conducted using goodness-of-fit tests, with lower information criterion values indicating better fits. These results highlight the critical need for robust, systematic approaches to model selection and the explicit consideration of model uncertainty to improve risk estimation and decision-making in insurance and industrial contexts. Interesting results that are different from the above-mentioned papers were observed.

**Keywords**: composite models, mixture models, model uncertainty, goodness-of-fit.

**Session 7B**

---

## THE TREE OF KNOWLEDGE?

**Versace Sepeesa, Christiaan Budde & Renier Jansen**
Department of Mathematics and Applied Mathematics, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

What if knowledge is not made of answers, but of relationships? Not a pile of truths, but a living structure - branching, looping, connecting - where meaning is found not in isolation, but in how things hold together. Category theory is often described as abstract, distant and "too general". But at its heart lies a simple, almost tender idea: that understanding grows through connections. It begins with objects and arrows — things, and the ways they relate. From the steps in an algorithm to the unfolding of a thought, category theory teaches us that even the simplest things can form a pattern of meaning. Consider the world of logic. Propositions are not just claims we make; they are moments of belief, doubt, or hope. A proof between two propositions isn't just a cold path of deduction - it's a journey. It's the work of moving from one idea to another with care and rigour. Category theory sees this movement as essential: every proof is an arrow, every composition of proofs a new path toward understanding. If this idea is a bit tricky to see, perhaps take something lighter: the world of games. Each game – Chess, Sudoku or Blackjack – can be seen as an object. The ways we modify or reinvent them – changing the rules, combining two games, turning a board game into a drinking game – are morphisms, i.e., arrows between them. Suddenly, we're not just playing – we're navigating a category of creativity. Even here, meaning lives in transformation, not just structure. In the classroom, in personal reflection, in everyday decision-making – we continuously build and follow such arrows. We are all, in a quiet sense, category theorists. And perhaps, when we pause to notice how ideas relate, we catch a glimpse of something deeper: a Tree of Knowledge not rooted in control or certainty, but in the gentle practice of relating one truth to another.

**Acknowledgements**
Department of Mathematics and Applied Mathematics (UFS)

**Keywords**: category theory, knowledge, logic games

**Poster Sessions and Session 7C**

## FITTING NUMEROUS STATISTICAL DISTRIBUTIONS TO QUANTIFY THE RISK OF THE TOP 3 CRYPTOCURRENCIES

**Lulo Sifumba, Moses Maluleke, Nthabeleng Mahlale & Sandile Shongwe**
Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

The cryptocurrency market has experienced remarkable growth, with its total capitalisation now estimated at approximately $3.55 trillion (ZAR63.42 trillion). The sheer size of the cryptocurrency market surpasses the GDP of South Africa (i.e., US$410.34 billion / ZAR7.33 trillion) and all African countries combined (i.e., $2.9 trillion / ZAR51.76 trillion). Given its importance, it's essential to examine the statistical properties of the top 3 cryptoassets, i.e. Bitcoin (BTC), Ethereum (ETH) and Ripple (XRP). Analysing these assets can provide valuable insights into their behaviour, potential investment opportunities, up-side and down-side risks. In this paper, we fit 22 light- to heavy-tailed distributions to the BTC, ETH and XRP loss and gain returns separately to capture their intricate features by computing the goodness-of-fit performance measures and the corresponding actuarial risk measures (value-at-risk and tail value-at-risk). The analysis provides important information about their general variation and tendency in the last 5 years that investors can use to make rational decisions moving forward. For instance, employing the dual-objective ranking system, the best-performing distributions for the loss returns of BTC are generalised Pareto, Burr, Pareto, transformed beta, and transformed gamma. Notably, these distributions are heavy-tailed, indicating that BTC losses exhibit extreme values and heavier-tails. In contrast, the best-performing distributions for gain returns of BTC are gamma, Weibull, transformed gamma, Burr, and beta. These moderately medium-to heavy-tailed distributions suggest that BTC gains are less prone to extreme values compared to losses. Relatively similar patterns were observed in the returns of ETH and XRP. Our findings confirm that losses exhibit higher kurtosis and skewness than gains, thus, we recommend that investors consider holding a short position in the long run, given the higher risk associated with losses. However, in the short run, investors must closely monitor candlestick trends and make informed decisions based on underlying patterns.

**Keywords**: Actuarial risk measure, Cryptocurrency, Financial market, Value-at-risk

**Poster Sessions**

## C*-ALGBEBRAS AND THE STANDARD MODEL

**Eduard Stoffberg & Christian Budde**
Department of Mathematics and Applied Mathematics, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

C*-algebras are mathematical structures that were initially introduced to formalise aspects of quantum mechanics, but their reach extends far beyond the original quantum physics into various branches of mathematics, physics, and computer science. One of the most intriguing features of C*-algebras is their deep connection to geometry, particularly in the context of non-commutative geometry. In this framework, the standard notion of a classical space, described by commutative C*-algebras, is generalised to include noncommutative spaces, which are described by non-commutative C*-algebras. This shift leads to a novel way of understanding both spacetime and physical phenomena. One of the most striking applications of C*algebras comes from their role in formulating the Standard

Model of particle physics. Through the work of Alain Connes and others, it has been shown that the Standard Model can be interpreted as a manifestation of a non-commutative geometry. Specifically, spacetime itself is modelled as a non-commutative space, and the algebra of internal symmetries of the Standard Model is encoded in a finite non-commutative C*-algebra. By combining these elements using a framework called the spectral action principle, one can derive the gauge fields, the Higgs sector, and even gravity as components of a unified description. This presentation will explore the fundamental role of C*-algebras in formulating the Standard Model. I will discuss how the algebraic structures of C*-algebras provide a powerful language to describe both the geometry of spacetime and the interactions that govern the fundamental particles. The aim is to present a clear overview of this approach, highlighting its contributions to modern physics and the way it bridges abstract mathematical ideas with real-world phenomena.

**Keywords**: C*-algebras, the Standard Model

**Session 7C**

---

## COMPARATIVE ANALYSIS AND OPTIMISATION OF MACHINE LEARNING MODELS ON STRUCTURED TABULAR DATASETS

**S.F. Stumpfe & S.C. Shongwe**
Department of Mathematical Statistics and Actuarial Science, University of the Free State, Bloemfontein, South Africa

### ABSTRACT

Machine learning models are increasingly applied across diverse industries to automate predictions, classify outcomes, and optimise many decision-making processes. Environments that require and have access to structured tabular data, such as insurance, finance, and housing, choosing the most appropriate model is highly dependent on both the nature of the data and the performance-cost trade-off. Recent developments in deep learning have opened new opportunities to model such data more effectively, though practical comparisons across model types remain limited, due to the time-consuming nature of the more advanced models. This study addresses the problem of how to systematically compare and optimise machine learning models for regression and classification tasks on structured datasets that vary in observation, feature size and domains. We evaluate baseline models – Linear Regression and Logistic Regression – against advanced models, including Support Vector Machines, XGBoost, and Multi-Layer Perceptrons, as well as task-specific neural networks: TabNet for regression and a ResNet-inspired deep neural network for classification. Each model is assessed under "default" and optimised settings, with tuning efforts focused on hyperparameters such as tree depth, kernel choice, and layer configuration. Performance is benchmarked across datasets representing varying structural conditions (small/large observations × small/large variables), using metrics like RMSE, accuracy, training time, and error type analysis. Our findings aim to offer a practical guideline for model selection in real-world applications, revealing which models scale best with data size and where optimisation returns begin to plateau or hamstring a model due to overfitting. This research contributes a comparative framework valuable to both data scientists and domain experts who require interpretable, efficient, and scalable machine learning solutions for structured data.

**Keywords**: machine learning, model optimisation, comparative analysis, predictive modelling

**Session 7C**

---

# GENERAL INDICES OF GRAPHS

**Elize Swartz & Tomas Vetrik**
Department of Mathematics and Applied Mathematics, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Graph theory is the study of mathematical structures, namely graphs, which can be used to describe pairwise related objects. A graph is a set of points (called vertices), some of which are connected by line segments (called edges). Graph theory has a wide range of applications, since graphs can be used to represent many types of networks, for example transportation networks, social networks, computer networks or electrical grids. Further applications of graph theory can also be found in chemistry where a graph can represent bonds between atoms in a molecule or crystal. A topological index is a mathematical formula which can be applied to any graph. Some of the first topological indices, also known as molecular descriptors, were defined and used by chemists to characterise and measure the degree of molecular branching. These indices can be used to predict various molecular properties such as the boiling point, reactivity or molecular volumes without the need for expensive laboratory experiments. We study general indices (namely the general Randic index and the general sum-connectivity index). Our results on general indices generalise and extend some known results on particular indices. Several known results of other researchers are special cases of our results, since results on classical indices can be obtained when using specific values of parameters in general indices. The aim of our study is to investigate classes of graphs which have extensive applications in chemistry (such as acyclic structures and unicyclic graphs). We characterise graphs which have the minimum or maximum values of general indices.

**Keywords**: general index, topological index, graph theory, chemical structure

**Session 7A**

## FROM CONFLICT TO COLLABORATION: IMPROVING INTERPROFESSIONAL COMMUNICATION IN CONSTRUCTION PROJECTS

**Tascha Bremer, Liezl le Roux & Minke Kruger**
Department of Quantity Surveying and Construction Management, Bloemfontein, South Africa

### ABSTRACT

This study explores the communication dynamics between Architects and Quantity Surveyors, with the aim of identifying and promoting evidence-based communication strategies to bridge the persistent relational gap between these two key construction professionals. It aligns with the conference theme by emphasising the application of communication science to foster collaboration, reduce project inefficiencies, and promote sustainable construction practices. Poor communication has been identified as a critical factor contributing to project delays, cost overruns, and deteriorating professional relationships. Given the interdependent nature of their roles, an effective communication framework is essential for successful project delivery. This research investigates the causes of communication breakdowns and the resulting conflicts, highlighting how fear of stakeholder disagreement and varying professional perspectives hinder the adoption of collaborative communication methods. Data will be gathered through interviews with various professionals as well as case studies based on the topic of communication. The South African construction industry's Quantity Surveying and Architecture specialists will be the target demographic, and random sampling will be used to establish the sample size. The results obtained will be analysed using statistical software and presented as tables and graphs. The findings conclude that the accuracy of cost estimates is significantly influenced by project characteristics, the consultants involved, the estimation process, and external factors. Additionally, implementing effective communication is often time-consuming due to limited resources, with key constraints including fear of conflict, large workforce size, unclear information, diverse stakeholder needs, complex team dynamics, and the intricacies of construction processes. To support this, industry professionals and organisations should invest in modern communication technologies and provide adequate training on their use. Regular debriefing sessions after each project phase can help identify strengths and areas for improvement, allowing teams to refine communication strategies for future projects.

**Keywords:** architect, quantity surveyor, communication, relationship

**Poster Sessions**

---

## SPATIAL JUSTICE AND SERVICE DELIVERY IN FORMER QWAQWA HOMELAND: A GEOSPATIAL ANALYSIS OF STUDENT ACCOMMODATION

**Simphiwe Mabaso, S. Mbambo & Z. Mncube[3]**
Department of Geography, University of the Free State, Phuthaditjhaba, South Africa

### ABSTRACT

This study explores the intersection of spatial justice and service delivery in student accommodation within the former QwaQwa homeland, South Africa. Despite the adoption of progressive national policy frameworks such as the Spatial Planning and Land Use Management Act (SPLUMA) and the National Development Plan (NDP) 2030, historically marginalised regions like QwaQwa continue to face

persistent infrastructural and developmental challenges. This study aims to evaluate how spatial inequalities in service delivery affect students access to adequate housing in the former QwaQwa homeland, using Geographic Information Systems (GIS) to reveal patterns of infrastructural disparity. Using GIS, this research will conduct a spatial analysis of the distribution of off-campus student accommodations in QwaQwa. The process will begin with digitizing student housing units using high-resolution satellite imagery from Google Earth Pro. Through purposive sampling, five housing units from each section in QwaQwa will be selected and digitized to ensure a representative spatial analysis across the study area. These sections include Phuthaditjhaba, Bluegumbosch, Clubview, Mphatlalatsane, Botjhabelo and Makwane. In addition, GPS will be used to capture location points of student housing units during fieldwork. Proximity analysis through buffer zones will be conducted to assess access to essential services such as water, electricity, social amenities, retail facilities, and transport routes. This will highlight the aspects of service delivery among different accommodation areas. Moreover, qualitative data, through surveys to evaluate student perceptions and lived experiences related to service, will be collected. Findings are expected to reveal if there are any spatial inequalities that student face when it comes to access to services. By aligning with Sustainable Development Goal 11, which promotes inclusive, safe, and sustainable human settlements, the study contributes to global conversations on spatial justice and equitable urban development. Ultimately, the research will offer practical insights to support evidence-based planning, improve student housing, and guide policy interventions.

**Keywords**: Spatial justice, service delivery, student accommodation, Geographic Information Systems (GIS)

**Session 3A**

---

# THE INFLUENCE OF GOVERNMENT FUNDING ON PERSONAL RESPONSIBILITY IN THE REVITALISATION OF SOUTH AFRICAN TOWNSHIP ECONOMIES THROUGH SHARED PROPERTY RIGHTS?

**Yandisa Bavulele Mashalaba & Boitumelo Philadelphia Maleka**
Department of Urvan and Regional Planning, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

This study investigates the extent to which government funding influences perceptions and practices of personal responsibility in the revitalisation of South African township economies through shared property rights. Despite government funding and infrastructure development in South African townships, there has been limited corresponding investment from the private sector and individual property owner. Shared property ownership models, such as sectional title schemes, offer a framework for collective responsibility whereby individual units are privately owned while common areas are jointly maintained. This model presents potential for sustainable urban revitalisation through co-investment by property owners. Using Moshoeshoe Road in Mangaung Township as a case study, this research employs an embedded mixed-methods approach, integrating qualitative observations with quantitative data from 89 respondents. The qualitative component involves site visits and land use surveys to examine existing housing typologies and structural conditions within the selected township whereas the quantitative component includes the administration of structured survey questionnaires to a sample of 89 randomly selected respondents. The study examined respondent's source of income and their attitude toward investing in sectional title schemes. The calculated Pearson correlation coefficient between these variables is -0.247, indicating a weak inverse relationship. This suggests that as reliance on certain income sources increases, particularly state-supported income such as social grants and pension grants, respondents are less inclined to view their own investment in sectional title schemes

favourably. This reveals a trend wherein beneficiaries of government financial assistance exhibit greater reluctance toward engaging in property investment models based on shared ownership. Using Hendrik Goudappel's theory of urbanistics, and with a particular focus on the intersection of public policy and private property investment, these findings indicate that current government funding mechanisms may inadvertently discourage individual investment in property maintenance and development, thereby undermining local economic revitalisation. It concludes that, while public sector support remains important, fostering a culture of private initiative and shared property rights can be a critical strategy for sustainable township transformation.

**Keywords**: Urban Revitalisation, Township, Economy, Shared property rights, Sectional Title

**Session 3A**

---

## EVALUATING FLOOD DISASTER MANAGEMENT IN EMFULENI LOCAL MUNICIPALITY: POLICY ANALYSIS AND REFINEMENT

**Zinhle Mbongo[1], E.T. Busayo[2], M.M. Hansen[1] & Z. Mncube[1]**

[1]Department of Geography, University of the Free State, Phuthaditjhaba, South Africa

[2]Department of Architecture and Planning, University of the Witwatersrand, Johannesburg, South Africa

### ABSTRACT

Floods are the most frequent catastrophic natural disasters on Earth. Their impacts on the environment and the socio-economic livelihoods of communities are highly destructive, requiring effective disaster management policies and strategies for sustainable development. This study explored how the Sedibeng District Disaster Risk Management Policy Framework was practised and implemented in the Emfuleni Local Municipality in South Africa, aiming to enhance the existing policy framework with a tailored approach that addresses flood disasters holistically. The study employed critical realism alongside a mixed-methods research design, which involved conducting questionnaires with affected community members as well as in-depth semi-structured interviews with disaster management personnel and town planners. The data was analysed thematically, and the results showed that floods mainly resulted in property damage and were primarily due to poor or a lack of drainage systems. Additionally, there is a lack of skills and knowledge regarding flood management. Moreover, the Disaster Management division has recently incorporated GIS and remote sensing, while facing challenges in coordination with the Development and Planning division. The study provides Emfuleni Local Municipality with its own framework adapted from the existing policy framework, incorporating a flood risk map for the area. This research suggests a holistic approach to flood management by involving communities, relevant stakeholders, and other divisions in policy refinement.

**Keywords**: floods, disaster management, policies

**Session 3B**

---

## ASSESSING FLOOD EARLY WARNING SYSTEMS FOR FLOOD RISK REDUCTION IN MOKGARENG VILLAGE, NORTH-WEST PROVINCE

**Eustace Mokhua**

Disaster Management Institute of Southern Africa (DiMTEC), University of the Free State, Bloemfontein, South Africa

**ABSTRACT**

This study assessed the effectiveness of flood early warning systems (FEWS) in Mokgareng, North-West Province, South Africa, using a post-positivist framework and mixed methods. Data from semi-structured questionnaires revealed low community awareness of FEWS and poor use of communication channels like SMS, radio, and TV, despite widespread mobile phone access. Residents trusted local leaders more than municipal systems, which suffered from inconsistent messaging and weak community engagement. Financial barriers and unreliable communication infrastructure further limited effective warning dissemination. The study concluded that Mokgareng's FEWS needs significant improvement, especially in communication infrastructure and in building trust between authorities and residents. Recommendations include developing inclusive, transparent systems that leverage digital tools and address the needs of vulnerable groups, such as the elderly and those without access to modern communication technologies. These findings align with broader challenges in South Africa, where EWS effectiveness is often hindered by similar issues of communication, trust, and accessibility.

**Acknowledgements**

Dr Raphela-Masuku

Keywords: Flood Early Warning Systems, Dissemination, Digital tools

**Session 3B**

---

# GEOSPATIAL ANALYSIS OF INFORMAL SETTLEMENT SUSCEPTIBILITY TO MULTI-HAZARDS IN ETHEKWINI, SOUTH AFRICA

**Zachariah Mshelia & Johanes Belle**

Disaster Management Training and Education Centre for Africa (DiMTEC), University of the Free State, Bloemfontein, South Africa

**ABSTRACT**

Informal settlements are highly vulnerable to multiple natural and anthropogenic hazards due to their uncontrolled growth, poor infrastructure, and socioeconomic marginalisation. Rapid urbanisation has increased the number of informal settlements in hazard-prone areas of South Africa's eThekwini Metropolitan Municipality, increasing their vulnerability to landslides, flooding, and fires. This study applies a geospatial approach to assess the susceptibility of informal settlements in eThekwini to multi-hazards, with the aim of supporting evidence-based risk reduction and urban planning strategies. Through a review of the literature, field observations, and expert consultations, key hazard factors for flood, landslide, and fire susceptibility were identified. These include aspect, slope, elevation, land use/cover, drainage density, land surface temperature, road proximity, population density, river proximity, soil, vegetation cover, rainfall, and historical fire occurrence. Each factor was given a weight based on its relative importance using the Analytic Hierarchy Process (AHP), which also used consistency analysis and a pairwise comparison matrix to guarantee the accuracy of the assessments. To create a composite multi-hazard susceptibility map, the weighted layers were combined in a GIS environment using spatial multi-criteria decision analysis. The results reveal varying degrees of susceptibility across the municipality, with several informal settlements located in high to very high-risk zones. These findings provide critical spatial insights for disaster risk reduction, highlighting priority areas for intervention, infrastructure improvement, and relocation planning. The study demonstrates the effectiveness of integrating AHP with geospatial techniques in assessing multi-hazard risks and

offers a replicable framework for urban resilience planning in similarly vulnerable urban settings across the Global South.

**Keywords**: informal settlement, multi-hazards, GIS, eThekwini

**Session 3B**

---

# EXPLORING CARGOTECTURE AS AN ALTERNATIVE DEVELOPMENT MODEL FOR INNOVATIVE, SUSTAINABLE AND AFFORDABLE STUDENT HOUSING PROVISION IN RURAL HOMELAND UNIVERSITIES IN SOUTH AFRICA

**Njabulo Nkululeko Phewa[1], Sanele Mbambo[1] & Rajab Matamanda[2]**

[1]Department of Geography, University of the Free State, Phuthaditjhaba, South Africa

[2]Department of Urban and Regional Planning, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

Universities experience a growing challenge in the provision of student accommodation. The challenge has been a result of the lack by university institutions to provide new housing units using traditional means of brick and mortar and, in some cases, poorly constructed units through traditional building methods and materials. Cargotecture refers to repurposing and recycling containers for sustainable living through building accommodations for human habitation. This paper aims to explore the feasibility of cargotecture as a sustainable and affordable alternative for student housing in South Africa. The fundamental objective is to evaluate the practicality and adaptability of cargotecture building solution in the provision of rural student accommodation. The paper will be an extract of a broader PhD study. Empirically, data will later be available because the study is still in the proposal stage. This paper will be developed from a critical review of literature that will be coupled with empirical data that will be collected qualitatively. Data will be collected through interviews at the Qwaqwa Campus from students residing off-campus and on-campus, and the findings later used to inform the broader study. The review will include local case studies of Johannesburg, Newtown cargotecture student accommodation. Furthermore, review Umhlanga Junction Extension (UJE) container student housing in Brixton, Johannesburg. Other international case studies including Keetwoven (Netherlands), La Havre (France) and more precedent studies will be reviewed to explore the feasibility of cargotecture innovation. Preliminary results show that cargotecture building solutions are more affordable compared to traditional brick and mortar. They are more resistant to different climatic conditions, eco-friendly, can accommodate energy-efficient utilities, have guaranteed quality and provide improved aesthetic modern designs. The findings of this paper are expected to enhance debates and policy considerations towards more innovative and sustainable solutions in addressing the student accommodation crisis in developing countries and South Africa particularly.

**Keywords**: Cargotecture, Sustainable innovation, Affordable student housing, Purpose-Built Student Accommodation (PBSA), Historically Disadvantaged Institutions (HDI's)

**Session 3B**

---

# ASSESSING THE EFFECTIVENESS OF HOUSEHOLD SOLID WASTE MANAGEMENT PRACTICES AND THEIR IMPACTS ON THE LOCAL ENVIRONMENT AND COMMUNITIES: THE CASE OF PHUTHADITJHABA AND MAKWANE IN THE FREE STATE PROVINCE OF SOUTH AFRICA

**Pulane Portia Pudumo, M. Hansen & G. Mukwada**
Department of Geography, University of Free State, Phuthaditjhaba, South Africa

## ABSTRACT

Solid waste management is a significant challenge in under-resourced communities across South Africa, where formal municipal systems are often lacking or deficient. In rural and peri-urban areas like Phuthaditjhaba and Makwane in the Free State province, households encounter unique difficulties in waste disposal due to geographical isolation, disparities in service delivery, and patterns of informal settlement. These contextual realities highlight the need for locally relevant approaches to sustainable waste management. This study aims to evaluate household solid waste management practices and their impact at the community level in Phuthaditjhaba and Makwane. The broken window theory alongside the waste management hierarchy framework is used to guide the study with the following objectives. (1) To map out the distribution of household solid waste disposal sites. (2) To create a suitable landfill site map and a waste pick-up point transportation map. (3) To assess the effectiveness of current household solid waste management practices, including waste disposal, collection, treatment, and community engagement. (4) To examine the environmental and public health impacts of household solid waste management practices. Quantitative data were analysed using statistical methods, while qualitative data offered insight into household behaviour and municipal insights. Additionally, GIS and remote sensing techniques were utilised to map waste disposal sites, and transportation routes map and to identify suitable landfill sites. These spatial tools complemented survey data by revealing geographic disparities in waste infrastructure and environmental impacts. With a sample size of 300 households (224 from Phuthaditjhaba and 76 from Makwane), the results showcase significant contrasts between urban and rural communities: while formal waste collection is limited in rural areas, informal waste systems often led by the community demonstrate notable efficiency. Waste management is generally more effective in rural areas compared to urban environments, where formal waste management systems are implemented. In conclusion, the results suggest that formal policies could benefit from integrating these localised informal practices into official frameworks.

**Acknowledgements**
NRF for funding and the Centre for Global Change

**Keywords**: environmental health, household solid waste, public health

**Session 3A**
(***moved from Session 9C***)

# INTRODUCTION OF TECHNOLOGY IN THE UPGRADING OF EMERGING HUMAN SETTLEMENTS

**Thomas Stewart[1] & Anita Venter[2]**

[1]Department of Urban and Regional Planning, University of the Free State, Bloemfontein, South Africa

[2] Centre for Development Studies, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

This study aims to identify approaches to be followed for the introduction of new and innovative technologies in the development of emerging human settlements. The significance of the study lies in enhancing the use of technologies with obvious extensive need and value, that are currently reluctantly embraced by practitioners and residents alike. There are technologies that span the entire human settlements development process, ranging from remote sensing and drone enhanced planning to domestic services, the construction process, and the integration of the internet. This presentation is based on an initial exploration of the relevant literature. The theoretical framework resulting from this literature review will guide the methodology to be followed for the collection of data. Both a practical and thorough understanding of the available technologies and the context specific needs of human settlements are necessary to consider how and which technologies may be introduced and used by stakeholders. Theories and approaches not necessarily associated with the built and human settlement environment, such as the Capabilities Theory of Sen, theories associated with the introduction and acceptance of technology; Systems Theory; theories pertaining to social behaviour and the role environmental factors play are presented in the context of human settlements. There is value in this research for the practice of emerging settlement upgrading; the academic community; and practitioners involved in the introduction and development of innovative and appropriate technologies for use in the development of human settlements in general. Finally, the research aims to identify those universal principles and approaches which could apply to the introduction of technology and innovation in the development of primarily emerging human settlements.

**Keywords**: Technologies; emerging human settlements; built environment

**Session 3A**