UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE

PRIS 2024

POSTGRADUATE RESEARCH & INNOVATION SYMPOSIUM

DATE:
29 & 30 October 2024
(Wednesday and Thursday)

VENUE:
Coastlands Hotel,
Musgrave Durban

THEME:
ENERGY SUSTAINABILITY

pris.ukzn.ac.za

INSPIRING GREATNESS

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE

The College of Agriculture, Engineering and Science would like to express its appreciation to the following external partners who have supported Postgraduate Research and Innovation Symposium 2024.

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Professor Keshlan Govinder, Astrophysics Research Centre, School of Mathematics, Statistics and Computer Science

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Professor Julia Sibiya, School of Agricultural, Earth & Environmental Sciences (Acting Dean and Head of School)

Professor Mogie Singh, Nano-Gene and Drug Delivery Group, School of Life Sciences

Professor Parvesh Singh, Organic Synthesis and Medicinal Chemistry, School of Chemistry and Physics

Professor Rob Slotow, Centre for Functional Biodiversity and Oppenheimer Fellow in Functional Biodiversity, School of Life Sciences

Professor Jeff Smithers, uMngeni-uThukela Water Chair of Water Resources, Research and Innovation, School of Engineering

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Professor Serestina Viriri, Computer Vision and Machine Learning Research Lab, School of Mathematics, Statistics and Computer Science (Dean and Head of School)

Professor Hongjun Xu, Centre of Excellence Radio Access and Rural Technologies, School of Engineering

The College of Agriculture, Engineering and Science would like to express its appreciation to the following Exhibitors at the 2024 College Postgraduate Research and Innovation Symposium:

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The College of Agriculture, Engineering and Science would like to express its appreciation to the following Chairs, Assistant Chairs, Moodle Co-ordinators and Judges of the 2024 Postgraduate Research and Innovation Symposium:

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Dr Ntuthuko Mkhize

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Moodle Co-ordinator: Dr Hloniphile Sithole Mthethwa

Judges:

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Moodle Co-ordinator: Dr Tshephiso Papo

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ORAL PRESENTATIONS

Chair: Professor Kuveneshan Moodley
Assistant Chair: Professor Nishani Harinarain
Moodle Co-ordinator: Mrs Rosanne Els

Judges:

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Chair: Professor Rituparno Goswami
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Judges:

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FLASH PRESENTATIONS

Chair: Professor Rituparno Goswami
Chair: Professor Nishani Harinarain
Assistant Chair: Professor Sergey Shindin
Assistant Chair: Dr Joy Adu
Moodle Co-ordinator: Mrs Rosanne Els

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Prof Knowledge Chinhamu	Dr Simbarashe Fashu	Dr Mohamed Fayaz Khan
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MESSAGES OF SUPPORT

Welcome to PRIS 2024 – the fourteenth College of Agriculture, Engineering and Science Postgraduate Research and Innovation Symposium. We are striving to ensure that the research carried out by our postgraduate students is relevant to society and contributes to the wellbeing of South Africans. This event highlights the cutting-edge research conducted by our postgraduate students and provides them with an opportunity to present their work to peers, academic staff and research partners. I would like to thank and congratulate the large number of postgraduate students who have shown the courage and enthusiasm to present their work today. The standard of proceedings is very similar to what students can expect at national and international conferences. Many students have used occasions such as this to hone their presentation skills and have gone on to win awards at international conferences. Behind every postgraduate student is a supervisor or supervisory team, who challenges, encourages and today will be sharing in your success – we owe you a debt of gratitude. Finally, we are grateful to all the sponsors whose generous contributions made this day possible, and we continue actively to seek ongoing collaboration and partnerships with industry and with all relevant role players.

Professor Nana Poku, Vice-Chancellor and Principal, UKZN

The research community from the College of Agriculture, Engineering and Science continues to set the pace in terms of research outputs produced across the university. An important part of UKZN's Strategy is the emphasis it places on growing the impact of the research that is produced at UKZN. Impact can be measured in terms of the influence our research has on the community in which we function, the manner in which it impacts the policy environment but also the citations our published research attracts from the broader research community. This requires a focus on high-impact journals and increasing the international collaborations we engage with. These two factors alone will significantly strengthen the research profile of UKZN. Please use the opportunity afforded by this event to encourage all our students and academics to build their research profiles and to focus on the quality of the research produced to ensure that UKZN becomes well-known for the transformative character of its research.

Professor Neil Koorbanally, Acting Dean of Research, UKZN

One of the most influential scientists of modern times, Albert Einstein, stated, "If we knew what it was we were doing, it would not be called research, would it?" Given the pace at which our world is changing, it is no wonder that the human race is under increasing pressure to become "experts" – to know more and more about less and less. The big challenge for us is rapidly to discover, inform and implement our small and big discoveries to make real changes. We have economic, environmental, health and cultural questions to respond to, for the benefit of the present and future generations. The mission of UKZN is to be relevant to our local communities, South Africa and the world. Our postgraduate students have made it possible for UKZN to deliver on its mission. The College Postgraduate Research and Innovation Symposium is a significant moment for UKZN to highlight the efforts and successes of our students and their supervisors. Every presentation over these two days is valuable and I encourage that you should start working on publishing your work. We are thankful to all the students who took time to share their knowledge with us. We also thank their supervisors who guided them to the point of being able to share their research with us. Without the support of our funders, partners and collaborators in research, we would not be celebrating the global recognition we currently enjoy and showcase through this special symposium.

Professor Fhatuwani Mudau, Acting Deputy Vice-Chancellor & Head of College: Agriculture, Engineering & Science, UKZN

Welcome to the fourteenth College of Agriculture, Engineering and Science Postgraduate Research and Innovation Symposium. This year, the School of Engineering is the proud host of this flagship College event and the two days we have lined up are aimed at showcasing our master's and PhD research across the College, under the banner: "Energy Sustainability". Of particular importance is communicating this research to a wider audience, demonstrating the impact it has on communities and industry. It is my hope that the event will be the catalyst for future collaborative projects with community, government and industry stakeholders.

Part of conducting scientific research is to improve the lives of mankind. These two days will provide a platform for our postgraduate students to demonstrate this to their peers, professors and to the public. I applaud all presenters who have come forward to present their research. Hosting an in-person symposium at one of our premier hotels in Durban allows students to get the full experience of attending a conference similar to a national or international format. This is an experience every postgraduate student should have. The symposium will take place in two formats, the conventional oral presentations, and flash presentations, which are a shorter, more concise version of the oral presentation. This is something that is also being practised in international conferences on various continents. As such, our students will be exposed to this way of presenting their research that will allow them to make an impact to a large audience.

Finally, I would also like to take this opportunity to thank and congratulate the supervisors and supervisory team. To both the presenters and their supervisors, well done. I look forward to an interesting two days

Professor Glen Bright, Dean and Head of the School of Engineering, UKZN

PROGRAMME

Tuesday, 29 October and Wednesday, 30 October 2024

DAY ONE: Tuesday 29 October

09:00 – 09:15 **Introduction –** Professor Neil Koorbanally: College Dean of Research
Official Welcome – Professor Nana Poku: Vice-Chancellor of the University of KwaZulu-Natal

09:15 – 09:45 **Introduction of the guest speaker** – Professor Glen Bright, Dean and Head of the School of Engineering

Keynote Lecture – Dr Mteto Nyati, Chairman of Eskom

"The Eskom Turnaround Story"

09:45 – 9:50 **Programme overview - Professor Neil Koorbanally**

10:00 – 11:20 **Session 1 – ORAL PRESENTATIONS**

Timeslot	SAEES	SCP	SE	SLS	SMSCS
10:00 – 10:20	SAEES-O-1-Buthelezi-Gugu	SCP-O-1-Adu-Peter	SE-O-1-Ayingeneye-Josiane	SLS-O-1-Alabi-Mercy	SMSCS-O-1-Gaddam-Sindhu
10:20 – 10:40	SAEES-O-2-Khumalo-Sinikiwe	SCP-O-2-Ayo-Ojo-Oluwatumininu	SE-O-2-Byamungu-Jonathan	SLS-O-2-Govender-Suveena	SMSCS-O-2-Ibrahim-Amna
10:40 – 11:00	SAEES-O-3-Lake-Simon	SCP-O-3-Bauchoo-Yastheer	SE-O-3-Jajbhay-Omaira	SLS-O-3-Jagaran-Keelan	SMSCS-O-3-Ssengonzi-Charles
11:00 – 11:20	SAEES-O-4-Mbava-Nozibusiso	SCP-O-4-Chithwayo-Aphile	SE-O-4-Naidoo-Durante	SLS-O-4-Kunene-Caroline	SMSCS-O-4-Motaung-Thato

11:20 – 11:40 **Tea**

11:40 – 13:00 **Session 2 – ORAL PRESENTATIONS**

Timeslot	SAEES	SCP	SE	SLS	SMSCS
11:40 – 12:00	SAEES-O-5-Mncube-Zandile	SCP-O-5-David-Ian	SE-O-5-Nsele-Sishosonke	SLS-O-5-Maduna-Thandiswa	SMSCS-O-5-Mthembu-Banele
12:00 – 12:20	SAEES-O-6-Muchaonyerwa-Knowledge	SCP-O-6-Dralle-Lesley	SE-O-6-Pather-Yashlen	SLS-O-6-Magwaza-S'thandiwe	SMSCS-O-6-Pillay-Shivani

12:20 – 12:40	SAEES-O-7-Nyawo-Bongizenzo	SCP-O-7-Folkard-Aaron	SE-O-7-Phumusa-Mouline	SLS-O-7-Mbambo-Phila	SMSCS-O-7-Ruvinga-Caroline
12:40 – 13:00	SAEES-O-8-Omarjee-Zahra	SCP-O-8-Juma-David	SE-O-8-Rameshwarnath-Semyn	SLS-O-8-Mthembu-Sandile	SMSCS-O-8-Sambo-Sydney

13:00 – 14:00 **Lunch**

14:00 – 15:20 **Session 3 – ORAL PRESENTATIONS**

Timeslot	SAEES	SCP	SE	SLS	SMSCS
14:00 – 14:20	SAEES-O-9-Oyebamiji-Emmanuel	SCP-O-9-Chikowe-Ibrahim	SE-O-9-Samuwi-Laston	SLS-O-9-Ndlovu-Nduduzo	SMSCS-O-9-Saruchera-Bester
14:20 – 14:40	SAEES-O-10-Phungula-Nokuzola	SCP-O-10-Mapapiro-Tariro	SE-O-10-Sithole-Bokang	SLS-O-10-Ngcongco-Khanyisile	SMSCS-O-10-Singh-Shridhar
14:40 – 15:00	SAEES-O-11-Shelembe-Sihle	SCP-O-11-Mbatha-Thandeka	SE-O-11-Mothiba-Koena	SLS-O-11-Reddy-Viloshanie	SMSCS-O-11-Tshibase-Slungile
15:00 – 15:20	SAEES-O-12-Sithole-Nkonzo	SCP-O-12-Ngcobo-Nondumiso	SE-O-12-Zakwe-Siboniso	SLS-O-12-Thekiso-Keneilwe	SMSCS-O-12-Zuma-Ntuthuko

16:00 – 17:30 **Guest Lecture: Dr Ntsapokazi Deppa**, Executive: Scientific Services, uMngeni-uThukela Water (UUW)

"Green Initiatives and Skills in the Water Sector: uMngeni-uThukela Water (UUW)'s Perspective"

18:00 – 22:00 **Gala Dinner**

Master of Ceremonies: Professor Alan Mathews

18:00 Welcome: Professor Neil Koorbanally

18:10 Entertainment

18:15 **Keynote Speaker: Professor Andrew Swanson**, Associate Professor, School of Engineering, University of KwaZulu-Natal

18:30 Entertainment

18:35 Acknowledgement of uMngeni-uThukela Water (UUW): Mr Sandile Mkhize

18:55 Acknowledgement of PRIS companies

19:05 Closing Remarks: Professor Fhatuwani Mudau, Acting Deputy Vice-Chancellor and Head: College of Agriculture, Engineering and Science

19:10 Entertainment

DAY TWO: Wednesday, 30 October

FLASH PRESENTATIONS

Timeslot	SAEES	SCP	SMSCSENG	SLS
09:00 – 13:00	SAEES-F-1-Bala-Abdulbasit	SCP-F-2-Amirthapandian-Bala	SMSCSENG-F-2-Buthelezi-Sbonile	SLS-F-1-Chabalala-Vunene
	SAEES-F-2-Chetty-Evania	SCP-F-4-Dlangalala-Celiwe	SMSCSENG-F-3-Corcos-Shimon	SLS-F-2-Dayanand-Shreya
	SAEES-F-3-Chifurira-Cornelia	SCP-F-5-Hajee-Mariam	SMSCSENG-F-5-Dlamini-Nqobile	SLS-F-3-Dlamini-Anele
	SAEES-F-4-Dlamini-Celuxolo	SCP-F-6-Hlongwane-Senzo	SMSCSENG-F-6-Gumede-Mkhululi	SLS-F-4-Doolabh-Kareshma
	SAEES-F-5-Dlamini-Siyabonga	SCP-F-7-Jili-Ncedo	SMSCSENG-F-7-Haroon-Ali	SLS-F-5-Gobey-Caitlyn
	SAEES-F-6-Ebrahim-Nazneen	SCP-F-8-Jimoh-Saheed	SMSCSENG-F-9-Joseph-Elijah	SLS-F-7-Hadebe-Asande
	SAEES-F-7-Jilajila-Senelisiwe	SCP-F-9-Madaree-Adela	SMSCSENG-F-10-Khumalo-Mandlenkosi	SLS-F-8-Hlongwane-Nothando
	SAEES-F-8-Kanonge-Grace	SCP-F-10-Madonsela-Nomaswazi	SMSCSENG-F-11-Lawton-Sahil	SLS-F-9-Idris-Almahi
	SAEES-F-11-Mkhize-Nkosikhona	SCP-F-11-Maharaj-Shamik	SMSCSENG-F-12-Malope-Ben	SLS-F-11-Ismail-Huda
	SAEES-F-12-Mkhwenkwana-Anela	SCP-F-12-Majozi-Siphesihle	SMSCSENG-F-13-Manyama-Mashako	SLS-F-12-Khwela-Sikhanyiso
	SAEES-F-13-Mncwabe-Ntuthuko	SCP-F-13-Maphalala-Aphiwe	SMSCSENG-F-14-Manyathi-Snothile	SLS-F-13-Lauchande-Vanessa
	SAEES-F-14-Moipolai-Reabetswe	SCP-F-14-Mathenjwa-Mandisa	SMSCSENG-F-16-Mngadi-Siyamthanda	SLS-F-14-Maphosa-Khethiwe
	SAEES-F-15-Mthethwa-Melusi	SCP-F-15-MedieFah-Helarie	SMSCSENG-F-17-Mnisi-Siyamthanda	SLS-F-15-Mbonambi-Sithabile
	SAEES-F-16-Mthiyane-Sfundo	SCP-F-16-Migwi-Francis	SMSCSENG-F-18-Mohammed-Anas	SLS-F-16-Moodley-Eden
	SAEES-F-18-Ndlovu-Snethemba	SCP-F-17-Moodley-Danica	SMSCSENG-F-21-Mphahlele-Ipoteng	SLS-F-17-Motaung-Mncedisi
	SAEES-F-19-Ndlovu-Samukelisiwe	SCP-F-18-Msane-Sbonelo	SMSCSENG-F-22-Mtshali-Bongiwe	SLS-F-18-Motiwala-Tehrim
	SAEES-F-21-Nkomo-Nqobile	SCP-F-19-Msomi-Mhlengi	SMSCSENG-F-24-Ncama-Samkelo	SLS-F-19-Msele-Kwanele
	SAEES-F-22-Ntonta-Sipho	SCP-F-20-Mthethwa-Lindokuhle	SMSCSENG-F-25-Ntombela-Onesipho	SLS-F-20-Ndlangamandla-Valencia
	SAEES-F-23-Nxumalo-Nzuzo	SCP-F-21-Mthimkhulu-Sakhile	SMSCSENG-F-26-Ntuli-Simiso	SLS-F-21-Nkala-Mandlenkosi
	SAEES-F-24-Nwosu-Obinnaya	SCP-F-22-Mthiyane-Wakhiwe	SMSCSENG-F-27-Ogutu-Sarah	SLS-F-22-Parusnath-Myuri
	SAEES-F-25-Oboh-Michael	SCP-F-23-Mvelase-Sabathile	SMSCSENG-F-28-Okem-Eche	SLS-F-23-Ramaloko-Winnie
	SAEES-F-27-Sebopela-Dimpho	SCP-F-24-Ndabankulu-Vuyolwethu	SMSCSENG-F-29-Omer-Salaheldin	SLS-F-25-Sappor-Raelene

	SAEES-F-28-Sigigaba-Masithembe	SCP-F-25-Ndlovu-Nkanyiso	SMSCSENG-F-31-Reddy-Emerald	SLS-F-26-Singh-Savarna
	SAEES-F-29-Sokoko-Sesethu	SCP-F-26-Ngubane-Ntombenhle	SMSCSENG-F-33-Sumbu-Kitenge	SLS-F-27-Singh-Nishthi
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	SAEES-F-33-Yacoob-Ameera	SCP-F-30-Nxumalo-Sifiso	SMSCSENG-F-37-Zondi-Mthobisi	
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		SCP-F-36-Pillay-Vishalan		
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		SCP-F-39-Saroj-Shruti		
		SCP-F-40-Seboletswe-Pule		
		SCP-F-41-Shabalala-Lizwi		
		SCP-F-42-Sikakane-Berlinda		
		SCP-F-43-Simelane-Nontobeko		
		SCP-F-44-Singh-Nijal		
		SCP-F-45-Somaru-Saniksha		
		SCP-F-46-Thethwayo-Sinenhlahla		

11:20 – 11:40 **Tea**

13:00 – 14:00 **Lunch**
14:30 – 16:00 **Networking Session: Tea and Coffee**
16:00 – 17:00 **Closing, Prize-Giving, and Lucky Draws**

Professor Neil Koorbanally, College Dean of Research
Professor Fhatuwani Mudau, Acting Deputy Vice-Chancellor and Head of College: Agriculture, Engineering and Science
Dr Sally Frost, Public Relations Manager, College of Agriculture, Engineering and Science

INDUSTRY SESSION

Wednesday, 30 October

uMngeni-uThukela Water Chair in Water Resources Research and Innovation

08:30 - 09:00	Arrival Tea and Coffee
09:00 - 09:05	Welcome
09:05 - 09:20	Keynote Address: **Dr Ntsapokazi Deppa**, Executive: Scientific Services, uMngeni-uThukela Water (UUW)
09:20 - 11:10	Flood Studies and Water Supply
11:10 - 11:50	Water Governance and Citizen Science
12:10 - 12:50	Lunch
12:50 - 15:10	Water, Effluent and Sludge Treatment
15:10 - 15:30	Tea
15:30 - 16:30	Discussion and Closing Statements

Keynote Lecture

"The Eskom Turnaround Story"

by

DR MTETO NYATI

Chairman of Eskom

South Africa has been experiencing loadshedding due to the energy crisis for over a decade. This energy crisis has negatively impacted the economy in particular small and micro businesses. A permanent solution to the problem has eluded many leaders who have attempted to solve the problem. Andre de Ruyter is the most recent Group Chief Executive of Eskom who failed dismally and declared that Eskom was a dead horse that could not be fixed. South Africa experienced a loadshedding free winter. Eskom's new Group Chief Executive Dan Marokane is forecasting a summer without loadshedding. Is this a miracle? Was the dead horse resurrected? What lessons can South Africa learn from the Eskom turnaround story?

Guest Lecture

"Green Initiatives and Skills in the Water Sector: uMngeni-uThukela Water (UUW)'s Perspective"

by

DR NTSAPOKAZI DEPPA

Executive: Scientific Services, uMngeni-uThukela Water (UUW)

How is uMngeni-uThukela Water (UUW) gearing up towards the achievement of the National Development Plan-2030 for a green economy?

The South African National Development Plan, NDP-2030, states that by 2030, South Africa's transition to an environmentally sustainable, climate-change resilient, low-carbon economy and just society must be well underway. There are appeals for environmental assets and natural resources to be preserved, enhanced and protected, in gearing up for a well-managed, just transition to an environmentally sustainable economy. Aligned to this, the next wave of innovation is predicted to include technology that improves and preserves the environment and reduces environmental degradation. This, in turn, requires a Skilled and Capable Workforce.

Gala Dinner Keynote Address

"Moving Energy in Space and Time"

by

PROF ANDREW SWANSON

Associate Professor, Electrical Engineering, UKZN

There are a number of challenges present in the field of electrical energy. At the Centre for Power and Energy Systems, we have responded to these challenges and have made a contribution to the field. Some of the current and upcoming projects at the Centre are presented from integration of renewable energy to improving the efficiency of the moving energy and ensuring that it can be done reliably. This will encourage postgraduate students to see that you can contribute to the larger challenges no matter how small the contribution.

DR MTETO NYATI

Biography:

Dr Mteto Nyati is the chairman of Eskom. Previously he was the Group Chief Executive of Altron and Chief Executive Officer of MTN South Africa

Mteto is also the executive chairman of BSG, a homegrown consulting and technology company that specialises in strategy execution. In BSG he holds a 40% shareholding through his investment vehicle, Wazo Investments.

Mteto is author of the number one bestseller, Betting on a Darkie, a book about his life as a shopkeeper's son, family man and business leader at local and multinational corporates.

He mentors and coaches senior executives including CEOs as well as up and coming business professionals.

In 2021, the University of Johannesburg's College of Business and Economics awarded Mteto an honorary doctorate in IT Management. He is a Yale University World Fellow.

He holds a BSc in Mechanical Engineering from the University of KwaZulu Natal.

DR NTSAPOKAZI DEPPA

Biography:

Dr Ntsapokazi Deppa is the Executive: Scientific Services for uMngeni-uThukela Water (UUW) and holds a PhD in Chemistry from the University of Cape Town, focusing on research in medicinal, physical and analytical chemistry. She graduated with her MBA *cum laude* from the University of KwaZulu-Natal and began her career as a contract chemistry lecturer at the Vaal University of Technology. She proceeded to work as a chemist and later as an Analytical Manager at Tongaat Hulett for nine years. She joined UUW as the Laboratory Manager in 2016.

In her role at UUW, she provides strategic leadership in:

- Ensuring compliance with water and wastewater quality standards and regulations, which includes appropriate planning, sampling, monitoring, analysis, auditing, and treatment process rectification functions throughout the water management cycle.
- The organisation's environmental sustainability initiatives include the development and implementation of appropriate sustainability plans and ensuring that all the organisation's operations function per its environmental values.
- Research and innovation programs of the organisation that are in line with the organisation's strategic direction

PROFESSOR ANDREW SWANSON

Biography:

Prof Andrew Swanson is Associate Professor at the University of KwaZulu-Natal and a professionally registered engineer. He is responsible for research and testing in the field of high voltage engineering and has tested overhead line equipment with voltages up to 350 kV AC, 650 kV impulse and 350 kV DC according to the required high voltage standards.

He is more recently interested in renewable energy use, supply to the grid and storage including the various standards applicable for the connection to the grid and the impact on the quality of the power when connecting to the grid. He has worked in industry as an engineering consultant on railways including 3 kV DC and 25 kV AC traction power systems, earthing and bonding of railways systems, compliance with power quality standards, and low voltage systems for stations and line side equipment. He has several industrial collaborations. He has graduated a number of postgraduates and published in numerous journals, and international and local conference papers.

ORAL PRESENTATIONS

SCHOOL OF AGRICULTURAL, EARTH AND ENVIRONMENTAL SCIENCES

Chair: Professor Molla Demlie			
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10:20 – 10:40	SAEES-O-2: **Sinikiwe Khumalo** PhD 219002761	Evaluating Agronomic Value and Consumers' Acceptance of the Co-Compost Made from Human Excreta for Sustainable Agriculture	36
10:40 – 11:00	SAEES-O-3: **Simon Lake** MSc 218025969	A novel approach for mapping areas suitable for rainfed production of Bambara nut and cowpea	37
11:00 – 11:20	SAEES-O-4: **Nozibusiso Mbava** PhD 213516432	Effects of maize (*Zea mays L*.) and sorghum *(Sorghum bicolor L*.) residues and their biochar on soil CO2 emissions and carbon pools	38
11:40 – 13:00	Session Two		
11:40 – 12:00	SAEES-O-5: **Zandile Mncube** PhD 223150281	Comparison of Deep Learning Methods for Nighttime Light Patterns and Forecasting in South Africa's Largest Cities	39
12:00 – 12:20	SAEES-O-6 **Knowledge Muchaonyerwa** MSc 216019194	Assessing Mapping Techniques for Precision Weed Management Using Multispectral UAV Imagery and Google Earth Engine	39
12:20 – 12:40	SAEES-O-7: **Bongizenzo Nyawo** PhD 222130773	Hydrogeochemical Characterisation and Assessment of the Origin of Groundwater Salinity in the Hout River Catchment, Limpopo Province, South Africa	40
12:40 – 13:00	SAEES-O-8: **Zahra Omarjee** MSc 220111834	A multi-proxy palaeo-environmental record of Palmietrivier wetland, southern Cape: Insights into Holocene fire, vegetation and climate dynamics	41
14:00 – 15:20			
14:00 – 14:20	SAEES-O-9: **Emmanuel Oyebamiji** PhD 221120918	Incidence of Food Addiction in Diabetic Patients Living with Anxiety and Depression	41
14:20 – 14:40	SAEES-O-10: **Nokuzola Phungula** MSc 211523534	The Effects of Kelpak Liquid Seaweed Extracts in the Micropropagation of Two Musa Sp. (Banana) Varieties	42
14:40 – 15:00	SAEES-O-11: **Sihle Shelembe** PhD 213501181	Growth response and nutritional water productivity of taro (Colocasia esculenta L. Schott) landrace to different irrigation treatments	43
15:00 – 15:20	SAEES-O-12: **Nkonzo Sithole** MSc 217036414	Short-Term Effects of Dairy Slurry Management on Soil Fertility in Southern Kwazulu-Natal, South Africa	44

ORAL PRESENTATIONS

SCHOOL OF CHEMISTRY AND PHYSICS

Chair: Professor Werner van Zyl			
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10:20 – 10:40	SCP-O-2: **Oluwatumininu Ayo-Ojo** PhD 220052876	Behaviour of Polymeric Fluids at the Interface for Material Science Applications	45
10:40 – 11:00	SCP-O-3: **Yastheer Bauchoo** MSc 220052876	Coherent control of atomic states using photons	46
11:00 – 11:20	SCP-O-4: **Aphile Chithwayo** PhD 212541793	The Synthesis and Characterisation of Magnetic α-Fe2O3, α-Fe2O3/SiO2 and ε-Fe2O3/SiO2 Nanoparticles	46
11:40 – 13:00			
11:40 – 12:00	SCP-O-5: **Ian David** PhD 215056787	Faster Quantum Simulation of Markovian Open Quantum Systems Via Randomisation	47
12:00 – 12:20	SCP-O-6: **Lesley Dralle** PhD 209505964	Synthesis Of Canthin-6-One and Other Derivatives for Potential Use as Anti-Bacterial, Anti-Fungal and Anti-Alzheimer Agents	48
12:20 – 12:40	SCP-O-7: **Aaron Folkard** PhD 213557335	Exploring carboxylic acids as novel green porogens in tailored γ-Al2O3 supports enabling the next generation of supported catalytically active liquid metal solution catalysts	48
12:40 – 13:00	SCP-O-8: **David Juma** MSc 224098093	AL(III) N-Alkoxy Formamidine Complexes as Effective Catalysts for Ring Opening Polymerization Reactions	49
14:00 – 15:20			
14:00 – 14:20	SCP-O-09: **Ibrahim Chikowe** PhD 220110888	Mechanistic studies on the adsorption of nitrogen-containing drugs to acid-functionalised pine cellulose	50
14:20 – 14:40	SCP-O-10: **Tariro Mapapiro** PhD 221072265	Exploring the Biomolecular and Cytotoxic Activities of Novel Rhenium(I) Compounds with 2-Aminoguanidine-Derived Schiff Bases	51
14:40 – 15:00	SCP-O-11: **Thandeka Mbatha** MSc 220006971	Adsorption of heavy metals, Lead (Pb2+) and Copper (Cu2+) from wastewater samples using cannabis sativa as bio-adsorbent	52
15:00 – 15:20	SCP-O-12: **Nondumiso Ngcobo** PhD 214536863	Hemilabile N^P, N^O-donor Pd(II) and Co(II) complexes: Synthesis, elucidation, and application as pre-catalysts in ethylene oligomerization	52

ORAL PRESENTATIONS

SCHOOL OF ENGINEERING

Chair: Professor Kuveneshan Moodley			
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10:20 – 10:40	SE-O-2: **Jonathan Byamungu** MSc 219021310	Desulphurisation of Bioethanol Using Copper-Loaded Carbon Foam	55
10:40 – 11:00	SE-O-3: **Omaira Jajbhay** MSc 217016542	The Integration of Renewable Energy and Energy Storage Systems in Smart Grids Within the South African Energy Market	55
11:00 – 11:20	SE-O-4: **Durante Naidoo** MSc 217075527	Magnetic field control of heterogeneous catalysis: Application to low-pressure Fischer Tropsch	56
11:40 – 13:00	Session Two		
11:40 – 12:00	SE-O-5: **Sishosonke Nsele** MSc 216004070	Development and Evaluation of a Beverage Can Solar Air Heater for Winter Greenhouse Space Heating	57
12:00 – 12:20	SE-O-6: **Yashlen Pather** MSc 216041338	Disrupting Bound Water in Faecal Sludge to Improve Water Removal Processes	57
12:20 – 12:40	SE-O-7: **Mouline Phumusa** MSc 215076212	Simulation, Optimisation, and Economic Evaluation of a Coal-To-Liquid (CTL) Process	58
12:40 – 13:00	SE-O-8: **Semyn Rameshwarnath** MSc 211505664	Smart Transport: A Stochastic Application of Artificial Neural Networks and Embedded Sensors	59
14:00 – 15:20	Session Three		
14:00 – 14:20	SE-O-9: **Laston Samuwi** MSc 222131185	Phytochemical Extraction, Screening, and Method Development of South African Pine Barks	60
14:20 – 14:40	SE-O-10: **Bokang Sithole** MSc 210535585	The Run-of-River Hydropower Potential in the KwaZulu-Natal Tugela River	61
14:40 – 15:00	SE-O-11: **Koena Mothiba** MSc 219009770	A Digital Twin for Monitoring the Change in Quality Attributes of Fresh Tomatoes in the South African Postharvest Supply Chain	61
15:00 – 15:20	SE-O-12: **Siboniso Zakwe** MSc 219022333	Renewable Energy Generation and its Application to Regulating the Micro-Environment of Pig Housing	62

ORAL PRESENTATIONS

SCHOOL OF LIFE SCIENCES

Chair: Professor Raymond Hewer			
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10:20 – 10:40	SLS-O-2: **Suveena Govender** MSc 219063450	Microbiome Associated Antibiotic Resistance Genes in Fish from a Local River in KwaZulu-Natal, South Africa	64
10:40 – 11:00	SLS-O-3: **Keelan Jagaran** PhD 215055447	Therapeutic Potential of Ginkgo Biloba-Synthesized Solid Lipid Nanoparticles for siRNA Delivery Targeting the LRRK2 G2019S Mutation in Parkinson's Disease	64
11:00 – 11:20	SLS-O-4: **Caroline Kunene** PhD 213570208	Small-Scale Habitat Heterogeneity is More Important for Spider Alpha and Beta Diversity on an Arid Mountain	65
11:40 – 13:00	Session Two		
11:40 – 12:00	SLS-O-5: **Thandiswa Maduna** MSc 218023934	3-D functional skull morphology and acoustics signal design – a within and across species analysis of southern African horseshoe bats	66
12:00 – 12:20	SLS-O-6: **S'thandiwe Magwaza** PhD 221033135	Effects of Extraction Methods on Antioxidant and Anti-Hyperglycaemic Activity of Fucoidans from *Ecklonia Radiata*	66
12:20 – 12:40	SLS-O-7: **Phila Mbambo** MSc 217002085	Assessing the Microbial Burden of Leafy Green Fresh Produce Sourced from Local Farms, Street Vendors, and Retailers	67
12:40 – 13:00	SLS-O-8: **Sandile Mthembu** PhD 216009509	Targeting the pupylation cascade system of Mycobacterium tuberculosis for the development of novel anti-tubercular drugs	68
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14:00 – 14:20	SLS-O-9: **Nduduzo Ndlovu** MSc 221114669	Plasmid Construction for Gene editing using the CRISPR/Cas9 system	69
14:20 – 14:40	SLS-O-10: **Khanyisile Ngcongco** PhD 221121519	Green synthetic strategies for metallic nanoparticles and their biotechnological applications	69
14:40 – 15:00	SLS-O-11: **Viloshanie Reddy** PhD 983172719	Establishment Of Micropropagation and Cryopreservation Protocols for the Critically Endangered Medicinal Plant, *Siphonochilus aethiopicus*	70
15:00 – 15:20	SLS-O-12: **Keneilwe Thekiso** PhD 214549992	Environmental DNA sequencing for biodiversity detection in selected northern KwaZulu-Natal estuarine lakes	70

ORAL PRESENTATIONS

SCHOOL OF MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

Chair: Professor Rituparno Goswami			
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10:40 – 11:00	SMSCS-O-3: **Charles Ssengonzi** PhD 223152802	Optimising Energy Efficiency in 5G Network Slicing with Hierarchical Reward Weighting Using Multi-Objective Reinforcement Learning	72
11:00 – 11:20	SMSCS-O-4: **Thato Motaung** MSc 218043630	Mathematical Models of Dengue Transmission Dynamics with Intervention Strategies	73
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12:20 – 12:40	SMSCS-O-7: **Caroline Ruvinga** PhD 224194796	VGG16-Based Transfer Learning Approach for Breast Cancer Classification	74
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14:00 – 14:20	SMSCS-O-9: **Bester Saruchera** PhD 220107117	Analysing Treatment Disengagement in Breast Cancer Patients in Zimbabwe Using Geo-Additive Discrete-Time Survival Models	76
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SCHOOL OF AGRICULTURAL, EARTH AND ENVIRONMENTAL SCIENCES

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SAEES-F-4	Celuxolo Dlamini PhD 219003508	The Integration of Unmanned Aerial Vehicles (UAVs) and Machine Learning Techniques for Predicting Maize Yields for Enhanced Food Security: A Systematic Review	80
SAEES-F-5	Siyabonga Dlamini PhD 220104514	Effect Of Varying Light Intensity on Morphological and Certain Quality Parameters of Sweet Pepper	80
SAEES-F-6	Nazneen Ebrahim MSc 218015486	Investigation of Heavy Metal Pollution in Groundwaters of the Durban Region, KwaZulu-Natal Province, South Africa	81
SAEES-F-7	Senelisiwe Jilajila PhD 215080033	An Analysis of The Prevalence and Factors Influencing Food Insecurity Among Students Participating in Alcohol Consumption in the KwaZulu-Natal Province	82
SAEES-F-8	Grace Kanonge PhD 219085122	Phosphate Solubilising Bacteria and Rock Phosphate from Zimbabwe for Cowpea Productivity Improvement	82
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SAEES-F-12	Anela Mkhwenkwana MSc 224193498	Spatio-temporal monitoring of soil moisture as an indicator of drought patterns in the Tyume catchment using remote sensing techniques	84
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SAEES-F-16	Sfundo Mthiyane MSc 218030355	Quantifying the influence of woody encroachment on soil organic carbon across Bisley Nature Reserve using PlanetScope data	86
SAEES-F-18	Snethemba Ndlovu PhD 216016417	The use of unmanned aerial vehicle-derived multi-spectral data for the early detection of multi-temporal maize leaf equivalent water thickness and fuel moisture content for the improved resilience of smallholder maize farming	87
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SAEES-F-27	Dimpho Sebopela PhD 223152616	Morphometric evaluation of cattle oocytes pre- and post-cryopreservation	92
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SAEES-F-29	Sesethu Sokoko MSc 223150904	Physiological and Morphological Responses of Lucerne (*Medicago sativa* L.) Genotypes to Acidic Soils and Metal Toxicities	94
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FLASH PRESENTATIONS

SCHOOL OF CHEMISTRY AND PHYSICS

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SCP-F-6	Senzo Hlongwane PhD 210507488	Electrochemical Impedance Spectroscopy. Case of Study and Software Implementation	101
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SCP-F-44	Nijal Singh PhD 211501491	Optimising the synthesis of ONO ligands and their Cu complexes as potential catalysts for the oxidation of n-octane	125
SCP-F-45	Saniksha Somaru MSc 217012659	Schiff Base-derived Heteroleptic Copper (II) Chemotherapeutic	126
SCP-F-46	Sinenhlahla Thethwayo MSc 218005079	Development of KOH-Activated Carbon Derived from Sawdust and its Application to Teeth Whitening	127

FLASH PRESENTATIONS

SCHOOL OF ENGINEERING and SCHOOL OF MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

Chairs: Professor Rituparno Goswami and Professor Nishani Harinarain			
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SMSCSENG-3	Shimon Corcos PhD 218035334	On the Lower Vietoris Topology: Cellularity and Separation Axioms	128
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SCHOOL OF LIFE SCIENCES

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INDUSTRY SESSION:

uMngeni-uThukela Chair in Water Resources Research and Innovation

Wednesday, 30 October

(Accredited with the Engineering Council of South Africa for one CPD point)

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09:00 - 09:05	Prof Jeff Smithers	**Welcome**: uMngeni-uThukela Research Chair	
09:05 - 09:20	Dr Ntsapokazi Deppa	**Keynote**: Advancing and Inspiring Industrial Research and Innovation Through "Research and Innovation Chairs	
Flood Studies and Water Supply			
09:20 - 09:40	Sandile Dladla*** PhD 215035978 *Supervised by:* Prof J.C. Smithers Prof O.J. Gericke Dr T.R. Kjeldsen Dr U. Maharaj	Enhancing Flood Risk Assessment Through Multivariate Frequency Analysis: A South African Perspective	164
09:40 - 10:00	Demian Mukansi PhDEng 215064982 *Supervised by:* Prof. J.C. Smithers Dr. T.R. Kjeldsen Dr. K. Johnson *UUW Industry Leader:* Mr Kevin Meier	Detecting Trends in Rainfall and Flood Extremes and Non-Stationary Design Flood Estimation in KwaZulu-Natal	165
10:00 - 10:20	Khanyisile Mnguni MScEng 216009423 *Supervised by:* Prof M. Kumarasamy Prof J.C. Smithers *UUW Industry Leader:* Mr Kevin Meier Mr Mark Scott	Modelling, Assessment and Optimisation of Rules for Selected Umgeni Water Distribution Systems	165
10:20 - 10:40	Glen Phumlane Ntfonga Mkhonta MSc 219091736 *Supervised by:* Dr D. Kibirige Dr S. Gokool *UUW Industry Leader:* Ms Futhi Vilakazi	Evolution of the Coupling of Hydrologic and Hydraulic Modelling to Enhance the Predictive Accuracy of Flood Forecasting in Umgeni River, South Africa	166
10:40 - 10:50	*Tea and leg stretch*		
10:50 - 11:10	Thobani Ngwazi MSc 217043646 *Supervised by:* Prof S.K. Gurmessa *UUW Industry Leader:*	An Assessment of Radon (222Rn) Level in Aquifers Along the Umgeni Catchment: Health and Geohydrological Significance	166

	Ms Futhi Vilakazi		
Water Governance and Citizen Science			
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11:30 - 11:50	Tanisha Curtis MSc 217007840 *Supervised by:* Dr M. Graham Dr S. Ngcobo Dr J. Taylor *UUW Industry Leader:* Ms Futhi Vilakazi	An Evaluation of the State of Citizen Science for Water Quality Monitoring	168
11:50 - 12:10	Susan Risko*** PhD 217081425 *Supervised by:* Dr. C. Sutherland Dr. S. Stuart-Hill	Water Governance in uMsunduzi Catchment: Politics and Construction of Socio-Economic and Environmental Values	168
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Water, Effluent, and Sludge Treatment			
12:50 - 13:10	Nkosinathi Madlala PhD 212518283 *Supervised by:* Prof D. Lokhat *UUW Industry Leader:* Ms Megan Schalkwyk Mr Peter Thomson Ms Limakatso Biyela	Validation of Velocity Settling Model Against Experimental Measured Settling Velocity Quantified Using Post-Image Analysis of CCD Camera Toolbox	169
13:10 - 13:30	Numeerah Ally PhD 218033284 *Supervised by:* Dr B. Gumbi Dr S.T. Getahun	Standardised Methods for Analysing Emerging Contaminants in Wastewater to Enhance Water Quality Management	169
13:30 - 13:50	Oyeladun Rhoda Adegoke** PhD 220082237 *Supervised by:* Prof B. Martincigh Prof V. Nyamori *UUW Industry Leader:* Ms Megan Schalkwyk Mr Peter Thomson Ms Limakatso Biyela	Removal of sulfamethoxazole from aqueous solutions by adsorption onto biochar/graphene oxide composites	170

13:50 - 14:10	Relebogile Morake** MScEng 216005246 *Supervised by:* Dr S.S. Stringel Prof D. Lokhat Prof B. Martincigh *UUW Industry Leader:* Ms Megan Schalkwyk Mr Peter Thomson Ms Limakatso Biyela	Evaluation of Biochar and Activated Carbon Produced from Different Feedstock for Use as an Adsorbent	171
14:10 - 14:30	Akhil Ramlucken MScEng 217007409 *Supervised by:* Dr S.S. Stringel *UUW Industry Leader:* Ms Megan Schalkwyk Mr Peter Thomson Ms Limakatso Biyela	Development of Solar Thermal Drying Technologies for the Treatment of Faecal Sludge from On-site Sanitation Facilities and Sewage Sludge from Wastewater Treatment Plant	171
14:30 - 14:50	Dr J. Pocock *on behalf of* Kirthi Rampersad MScEng 217016379 *Supervised by:* Dr S.S. Stringel Dr J. Pocock *UUW Industry Leader:* Ms Megan Schalkwyk	Development of a Urine Evaporator for Innovative Non-Sewered Sanitation Systems	172
14:50 - 15:10	Yashlen Pather MScEng 216041338 *Supervised by:* Dr. J. Pocock Dr. S.S. Stringel Dr. R. Seodigeng *UUW Industry Leader:* Ms Megan Schalkwyk	Disrupting Bound Water in Faecal Sludge to Improve Water Removal Processes	173
15:10 - 15:30	***Tea and leg stretch***		
15:30 - 16:30	***Facilitate discussions and closing statements***		

* Approximate times
** Pre-recorded presentation due to schedule conflict
*** Online presentation

ORAL ABSTRACTS

SCHOOL OF AGRICULTURAL, EARTH AND ENVIRONMENTAL SCIENCES

SAEES-O-1

THE GEOTHERMAL ENERGY POTENTIAL OF THE SHU-SHU THERMAL SPRINGS (PRECURSORS OF THE GEOTHERMAL ENERGY POTENTIAL OF SOUTH AFRICA) INVESTIGATED USING ISOTOPES, GEOCHEMISTRY & UAVS

Gugu Buthelezi

217016102@stu.ukzn.ac.za

Student Number: 217016102

School of Agricultural, Earth, and Environmental Sciences

Supervised by Prof Seifu Kebede Gurmessa

The thermal springs are located in Nkandla, Kwa-Zulu Natal, emerging underneath and at the margin of the uThukela River. The aim of this work was to determine the geothermal energy potential of the Shu-Shu thermal springs, their origin and their role in heat and chemical exchange with the uThukela River. The specific objectives of the investigation included determining the origin, the extent of discharge, the depth of circulation of the thermal springs and assessing the impact the Shu-Shu thermal springs have on the surrounding surface water of the uThukela River. To investigate the geothermal energy potential of Shu-Shu thermal springs; isotopic, physio-chemical and Unmanned Ariel Vehicles (UAV) methods have been employed. Water samples were collected from the thermal springs, surrounding surface waters and rainfalls across different altitudes during wet and dry seasons.

The isotope analysis shows that the thermal springs are recharged at high altitude as they have the same isotopic signature as the rainfall in the Drakensberg Mountains. A hydrochemistry analysis performed indicates that the Shu-Shu thermal springs are sodium chloride waters dominated by ions such as SO_4^{2-}, Na^+, Cl^-, Ca^+ and SiO_2. The surface temperature of the thermal springs is 52°C. The maximum reservoir temperature was estimated to be 105°C and 134°C using the Silica-Cation geothermometer and the Na-K geothermometer equations, respectively. UAVs, along with Google Earth Engine, were used to delineate and map the surface extent of the Shu-Shu thermal springs and to investigate the geological control of occurrence.

Based on the reservoir temperature estimations using geothermometry, it can be concluded that the Shu-Shu thermal springs have a moderate-enthalpy (temperature) energy potential. The origin of the springs are controlled by dykes and fractures. The use of geophysics is recommended to further investigate the subsurface extent of the springs so as to determine the Mega Watt Power generation capacity of the springs. The association of the springs with dykes/fractures indicate the need to investigate the geothermal energy potential associated with the other dense network of fractures and dykes in South Africa.

SAEES-O-2

Evaluating Agronomic Value and Consumers' Acceptance of the Co-Compost Made from Human Excreta for Sustainable Agriculture

Sinikiwe Khumalo

219002761@stu.ukzn.ac.za

Student Number: 219002761

School of Agricultural, Earth and Environmental Sciences

Supervised by Prof Alfred Odindo

Recycling nutrients from human excreta can significantly enhance soil fertility by improving its physical, chemical, and biological properties. This study employed a completely randomized design to evaluate the effects of two mixing ratios of dewatered sewage sludge (DSS) and organic green waste (OGW) using the ratios (1DSS:3OGW and 1DSS:2OGW) and three turning frequencies (7, 14, and 28 days) on co-composting quality and stability. The experiment, conducted using a rhizotron facility at the University of KwaZulu-Natal (UKZN) using cucumber (*Cucumis sativus*) as the test crop, compared these various co-compost treatments with commercial Gromor (G) and sandy KwaDinabakubo (KD) soil. Additionally, a survey of 568 students from UKZN's Pietermaritzburg campus assessed their willingness to purchase and consume food fertilized with co-compost. All compost treatments achieved temperatures exceeding 50 °C, sufficient to inactivate pathogens [1]. Significant differences ($p<0.001$) in shoot length were observed among treatments, with the shortest shoots recorded in the KD and G media. The highest shoot dry mass (0.3046 g) was observed in the 1DSS:3OGW (7-day turning frequency), while the lowest masses (0.0692 g and 0.0949 g) were observed in the KD and G media, respectively. Of the surveyed students, 99.1% participated, with more than 60% opposing the disposal of human excreta and 86.4% believing it could be treated to eliminate health risks as observed by [2]. Around 60.6% of students were willing to purchase food fertilized using co-compost, even with an 18% increase, considering factors like quality and shelf life. However, 37.2% of those who were not willing to consume such food expressed concerns about potential disease contamination. Preference was higher for cooked, above-ground, and processed foods over raw or root crops. This study demonstrates that co-composting DSS with OGW can produce high-quality compost, enhance cucumber seedling growth, and indicate a growing consumer awareness and acceptance of using human-derived compost in agriculture.

1. Preneta, N., et al., *Thermophilic co-composting of human wastes in Haiti.* Journal of Water, Sanitation and Hygiene for Development, 2013. **3**(4): p. 649-654.

2. Simha, P., et al., *What do consumers think about recycling human urine as fertiliser? Perceptions and attitudes of a university community in South India.* Water Research, 2018. **143**: p. 527-538.

SAEES-O-3

A novel approach for mapping areas suitable for rainfed production of Bambara nut and cowpea

Simon Lake

218025969@stu.ukzn.ac.za

Student Number: 218025969

School of Agricultural, Earth and Environmental Sciences

Supervised by Mr Richard Kunz

Considering South Africa is a water-scarce region and the future climate will be warmer, there is a growing need to cultivate more water use efficient crops under rainfed conditions. Neglected and Underutilised Crops (NUCs) are considered more drought-resistant and water-use efficient than conventional crops (e.g. maize and soybean). NUCs also have the potential to improve food and nutritional security, particularly at the smallholder farming scale. The main aim of this study was to develop land suitability maps for two NUCs (Bambara nut and cowpea) under rainfed conditions in South Africa. For each NUC, maps were developed for one plant density (representing smallholder farmers) and four planting months (October, November, December and January). These maps were developed using data stored in a crop database containing yield and water use simulations produced by FAO's AquaCrop model, where the crop cycle length was reduced by frost occurrence. Using a geographic information system, selected AquaCrop output variables (e.g. relative biomass production, crop cycle length, seasonal rainfall and yield simulations) were

analysed to develop a land suitability map for each planting month, which also considered existing land use. This novel approach was developed due to the lack of information required by conventional mapping approaches, such as multi-criteria decision analysis. An analysis of the final land suitability maps showed that both NUCs are considered highly suitable for cultivation along the eastern parts of South Africa, with suitability declining inland. The database and final land suitability maps will be disseminated to farmers via an open data portal. The maps should help guide policy makers to target specific regions in South Africa for promoting increased production of these underutilised crops.

Keywords: underutilised crops, land suitability, AquaCrop

SAEES-O-4

Effects of maize (*Zea mays L.*) and sorghum (*Sorghum bicolor L.*) residues and their biochar on soil CO_2 emissions and carbon pools

Nozibusiso Mbava

213516432@stu.ukzn.ac.za

Student Number: 213516432

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Rebecca Zengeni and Prof Pardon Muchaonyerwa

The application of organic amendments such as crop residues and biochar in soil can increase soil carbon pools, reduce CO_2 emissions, and mitigate climate change. Understanding the most effective amendment for enhancing the soil carbon sink and reducing CO_2 emissions is crucial. A field trial was conducted during the summer and winter seasons of 2023 at Ukulinga research farm, University of Kwa Zulu-Natal. This study aimed to evaluate the impact of feedstock (R) and biochar (B) application from different maize (M) and sorghum (S) cultivars on soil carbon pools and CO_2 emissions when applied in soil. Feedstock and biochar from maize cultivars (SC701 & R201) and sorghum cultivars (AS8 & PAN8816) were applied in equivalent carbon rates (5 t C ha ^{1}) and incorporated into 15 m^2 and 6 m^2 plots during the winter and summer seasons, respectively. Spinach seedlings were planted and grown for 12 weeks in each season. CO_2 emissions were measured weekly using a CO_2 automated analyser from each treatment plot. After 12 weeks, spinach was harvested, and soil samples were collected for analysis of Soil Organic Carbon (SOC), Particulate Organic Carbon (POC), Permanganate Oxidizable Carbon (POXC), Microbial Biomass Carbon (MBC), and β-glucosidase activity. The application of feedstock increased CO_2 emissions compared to biochar application. Particularly, M-R201-B-Cum had the lowest CO_2 emission rate (5.88 µmol m^2 s^{-1}) which was 14% lower than that from the control, while S-PAN8816-R-Cum (33.73 µmol m^2 s^{-1}) and M-SC701-R-Cum (33.69 µmol m^2 s^{-1}) resulted to 138% and 137% higher CO2 emissions, respectively, compared to the control. Biochar application, especially cumulative application, resulted to increased SOC, POC, POXC, and MBC content in the soil compared to feedstock application. Moreover, it reduced β-Glucosidase activity. For instance, the application of S-PAN8816-R (65.423 g kg^{-1}) during the summer season resulted to the highest β-Glucosidase activity, which was a 237% increase over the control, while the residual remains of M-R201-B (10.639 g kg^{-1}) in winter displayed the lowest β-Glucosidase activity, reducing it by 59% compared to the control treatment. This study reveals that biochar has the potential of sequestering carbon, reducing CO_2 emissions, and enhancing soil carbon pools.

Keywords: Organic amendments, crop residues, biochar, soil carbon pools, CO_2 emissions, β-glucosidase activity, carbon sequestration

SAEES-O-5

Comparison of Deep Learning Methods for Nighttime Light Patterns and Forecasting in South Africa's Largest Cities

Zandile Mncube

223150281@stu.ukzn.ac.za

Student Number: 223150281

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Sifiso Xulu and Prof Michael Gebreslasie

In recent years, the NTL data has been recognized as a valuable resource in studying different socio-economic and environmental areas because it offers insights to human activities, urbanization patterns, energy consumptions, etc. Deep learning models can be used to enhance the analysis of NTL data.

Signal processing techniques such as EMD, EEMD, Wavelet models, and LSTM were applied in exploring the networks of NTL data over the period of 9 years (2014–2023). EMD and EEMD techniques decompose com-plex signals into intrinsic mode functions (IMFs) which allows for assessment of different frequency components present in the NTL data. EEMD is an extension of EMD, and it mitigates mode mixing issues by introducing white noise to the data and offering more stable decompositions. WD uses wavelets to decompose NTL data into frequency bands that facilitate in the detection of transient patterns and anomalies that exist in the data. Long short-term memory (LSTM) networks are a type of recurrent neural network (RNN) that are highly effective in capturing temporal dependencies in sequential data. The leveraging of LSTM allows for modelling of the temporal dynamics of NTL data that enable the pre-diction and rend analysis over time.

The aforementioned techniques are integrated in this study to decompose NTL signals, reduce noise and isolate significant components of the data. The temporal patterns are then modelled, and trends are predicted using LSTM networks, which are based on the decomposed signals. The results show that combining decomposition techniques and LSTM network improves the accuracy of NTL analysis and its interpretability. This form of deep learning application in NTL has not been sufficiently explored. From it we can get better understanding of the NTL trend patterns useful in different areas.

Keywords: Nighttime light, deep learning, NTL trends

SAEES-O-6

ASSESSING MAPPING TECHNIQUES FOR PRECISION WEED MANAGEMENT USING MULTISPECTRAL UAV IMAGERY AND GOOGLE EARTH ENGINE

Knowledge Muchaonyerwa

216019194@stu.ukzn.ac.za

Student Number: 216019194

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Maqsooda Mahomed

In efforts to address food security concerns through diversification of agricultural systems in sub-Saharan Africa. There has been an increase in the promotion of neglected and underutilised crops (NUCs) for smallholder farms, due to their potential to uplift the standard of living in rural communities. The success of these efforts is dependent on effectively addressing factors that contribute to poor yield margins. The adoption of new technological advancements, such as unmanned aerial vehicles (UAV) and Google Earth Engine (GEE)(an open-access cloud computing platform), have demonstrated the potential of improving farming practices through precision agriculture (PA). Taro is one of the NUCs typically grown by the smallholder farmers, and poor weed management is among the major contributors to poor

yields. This study used the taro and weed interaction as proxies to develop a model that utilizes available technological infrastructure to enhance farming productivity. The aim was to identify a pragmatic mapping approach that can assist with reliable prescription maps to implement sustainable management practices. A total of three supervised classification techniques (traditional pixel-based image (PBIA), and two object based image analysis (OBIA) approaches) were tested on multispectral images with a spatial resolution of 0.07 m, using machine learning algorithms available in GEE (random forest (RF), gradient tree boost (GTB, support vector machine (SVM), and classification and regression tree (CART)). The first OBIA comprised of clusters from a segmentation process, while the latter included textural properties generated from a grey level co-occurrence matrix (GLCM). The GTB outperformed other classifiers across the different techniques. OBIA-GLCM was the most reliable classification algorithm with an overall accuracy OA of 96 %, while PBIA and OBIA without textural properties obtained 89.71 %, and 92.64 %. The study revealed that the multispectral UAV imagery processed using GEE can provide reliable prescription maps for smallholder farms.

Keywords: Pixel-based image analysis (PBIA), Object-based image analysis (OBIA), unmanned aerial vehicle (UAV), Google Earth engine (GEE), machine learning (ML)

SAEES-O-7

HYDROGEOCHEMICAL CHARACTERISATION AND ASSESSMENT OF THE ORIGIN OF GROUNDWATER SALINITY IN THE HOUT RIVER CATCHMENT, LIMPOPO PROVINCE, SOUTH AFRICA

Bongizenzo Nyawo

222130773@stu.ukzn.ac.za

Student Number: 222130773

School of Agricultural, Earth and Environmental Sciences

Supervised by Prof Molla Demlie

The Hout River Catchment, located in the Limpopo province of South Africa, is drained by the ephemeral Hout River, which flows only during the rainy season. Due to an increasingly decreasing trend in rainfall, surface water availability in the catchment has decreased. As a result, the demand for groundwater has increased for domestic, agricultural, and other commercial purposes. This over-pumping has stressed the groundwater resource including water quality deterioration because of rising salinity levels in the groundwater, potentially affecting its suitability for diverse uses, including agriculture. To sustainably manage the groundwater resource in the Hout River catchment, this study investigated the sources of this groundwater salinity and traced its origin. A total of 36 groundwater samples were collected across the study area from April to May 2024 and analysed for major ions including calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), chloride (Cl), bicarbonate (HCO3), sulfate (SO4), nitrite (NO2), and nitrate (NO3), trace metals and environmental isotopes (δ2H and δ18O). Additionally, in-situ physio-chemical groundwater parameters, including Electrical Conductivity (EC), pH, Temperature (T), Total Dissolved Solids (TDS), and Salinity were measured using a multi-parameter water analyser. The groundwater in the catchment is characterised by the following major hydrogeological facies, namely, mixed calcium-magnesium chloride (Ca-Mg-Cl), calcium-magnesium bicarbonate (Ca-Mg-HCO3) and mixed sodium potassium bicarbonate (Na-K-HCO3) facies or water types. The salinity ranges between 0.06 and 1.74 PSU indicating brackish water. Analysis of all available data converges reveal that the groundwater hydrochemistry and, hence, its salinity is mainly controlled by water-rock interaction and ion exchange processes.

Keywords: hydro-geochemical processes; hydro-geochemical assessment; water-rock interactions

SAEES-O-8

A multi-proxy palaeo-environmental record of Palmietrivier wetland, southern Cape: Insights into Holocene fire, vegetation and climate dynamics

Zahra Omarjee

220111834@stu.ukzn.ac.za

Student Number: 220111834

School of Agricultural, Earth, and Environmental Sciences

Supervised by Prof Jemma Finch, Prof Trevor Hill, and Dr Donovan Kotze

Palaeoecology is the study of past ecosystems with regard to vegetation and climate systems. Global climate change is increasingly complex, and is known to have differing impacts on ecosystems. The historical ecological response of wetlands and ecosystems to fluctuations in climate is therefore important, as these changes can be used to predict current/future patterns of change. This study uses fossil pollen to reconstruct the vegetation history of a wetland system. Sedimentary charcoal analysis and grain size is used to reconstruct fire history and wetland formation history respectively. Our knowledge of ecosystem climate dynamics in the southern hemisphere has yet to be fully explored in the context of modern climate change using palaeoenvironmental proxies. South Africa's southern Cape is a climatically and ecologically dynamic region with palaeoecological significance.

This study aims to reconstruct the vegetation, fire, and wetland formation history of the Palmietrivier wetland. The wetland, near to the locality of Herbertsdale, is located in the southern Cape, within the fynbos biome, and is characterised by year-round rainfall and an arid climate, sensitive to environmental change. A sediment core spanning the past 4800 years is examined for pollen (to reconstruct vegetation history), charcoal (fire history) and grain size (wetland depositional history). The pollen record indicates a cyclical pattern of fynbos taxa abundance (Ericaceae, Anthospermum and Restionaceae), separated by high abundances of *Xyris*. The charcoal sequence indicates increased local fire occurrences within or periods of increased fynbos abundance and fewer fire occurrences during periods of abundant *Xyris.* The highest abundances of fynbos elements occur from 0-900 years before present. At 400 yBP, the highest abundance of Ericaceae and Cyperaceae with Cyperaceae remaining relatively high throughout the record. The pollen abundances and change in grain size at this time, could indicate a depositional event with increased moisture availability or some disturbance event marked by increased disturbance indicators *Amaranthaceae* and *stoebe*. The grain size analysis indicates that the wetland moves towards a siltier environment from a sandy/mineralogenic one. This study is tied to the regional variability of the southern African climate, and provides a unique insight into southern Cape palaeoecology

SAEES-O-9

INCIDENCE OF FOOD ADDICTION IN DIABETIC PATIENTS LIVING WITH ANXIETY AND DEPRESSION

Emmanuel A. Oyebamiji

221120918@stu.ukzn.ac.za

Student Number: 221120918

School of Agricultural, Earth & Environmental Sciences

Supervised by Dr Blessing N. Mkhwanazi

This research explored the incidence of Anxiety, Depression, and food addiction (FA) among people with diabetes.

One hundred and one patients who are being managed for diabetes mellitus at University College Hospital were recruited; participants completed a questionnaire on Dietary habits, the general anxiety disorder scale (GAD-7), the primary health questionnaire (phq-9), and the modified Yale food addiction scale (mYFAS).

Results demonstrated that over 80% of the respondents met the mYFAS criteria for food addiction.

Results also showed that all the participants are depressed and have a high anxiety disorder scale, which reveals an association between Food addiction and Depression, Food addiction and Anxiety, Food addiction with BMI, and diabetes types.

In contrast, Anxiety has an association with the HbA1c of the respondents. The results also show an association between eating habits and depression state, such as the frequency of fast food and vegetable consumption.

These results, implicating Food addiction in the development of Depression and Anxiety, have important space for potential future treatment methods of diabetes where Food addiction risk could be routinely checked in patients with diabetes, and if present, treatment should commence immediately rather than attempting to treat the potential consequences of Food Addiction

Keywords: Food Addiction, Depression, Diabetes Mellitus, Anxiety.

SAEES-O-10

THE EFFECTS OF KELPAK LIQUID SEAWEED EXTRACTS IN THE MICROPROPAGATION OF TWO *MUSA SP.* (BANANA) VARIETIES

Nokuzola Patience Phungula

211523534@stu.ukzn.ac.za

Student Number: 211523534

School of Agricultural, Earth, and Environmental Sciences

Supervised by Professor Samson Tesfay

The high cost of tissue culture reagents has pointed out the need of constant research studies that will address the cost of culture while maintaining the commercially viable standard of crop production (1). The presence of cytokinins , auxins, gibberellins and betaines in seaweed derived products has led to the popularity of these biostimulants in crop production (2) as they are organic based, affordable and known for their beneficial effects of promoting root formation , improve plant growth and yield (3). Thus, the enrichment of culture media with biostimulants might improve the costs in tissue culture methods (1).

The study evaluated the effects of Seaweed Extracts on shoot and root initiation and proliferation in the micro propagation of *Musa species* (banana). The modified Murashige and Skoog media was used as the control media and for the positive control the MS was supplemented with 20µM Benzylaminopurine (BAP) and 10µM Naphthaleacetic acid (NAA) (5) . For the different experimental treatments, three levels of Kelpak liquid seaweed extracts T1 (5%), T2 (10%) and T3 (20%) were added to MS media.

The various growth parameters of *in vitro*-grown plants including the number of shoots per explant, number of roots per explant, plant biomass (fresh weight), shoot height and root length were collected and recorded. All statistical analysis was performed using the R statistical software. The significant differences between the treatments and the control were determined using Analysis of Variance (ANOVA) at a significance level $P \leq 0.05$. The preliminary results suggest that a combination of MS and 10% (T3) of kelpak seaweed extracts has positive response in rooting of micropropagated banana plants. Further studies investigating a combination of PGR's and seaweed extracts could address both multiplication and the rooting of micropropagation of banana plants is recommended.

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SAEES-O-11

Growth response and nutritional water productivity of taro (*Colocasia esculenta* L. Schott) landrace to different irrigation treatments

Sihle Shelembe

213501181@stu.ukzn.ac.za

Student Number: 213501181

School of Agricultural, Earth & Environmental Sciences

Supervised by Prof Tafadzwanashe Mabhaudhi

Taro (*Colocasia esculenta*) is a vital drought-tolerant crop with the ability to produce corms of high nutritional quality, a possible solution crop to food insecurity [1,2]. However, it still occupies low levels of utilisation and research in South Africa [3]. Information on crop water use and nutritional water productivity (NWP) is susceptible, limited, and unavailable to farmers; thus, to address food and nutrition insecurity, crop and water productivity (WP) must consider nutrition [2]. The study determined the effect of different water levels on growth response and NWP of a taro landrace under controlled environmental conditions; a study was conducted at the University of KwaZulu-Natal during the season of 2018/19.

The eddo type taro landrace *Umbumbulu* (UM) was collected from rural areas of Umbumbulu in KwaZulu-Natal. The experiment design was arranged in a randomised complete block design (RCBD), where main plots were allocated to two water regimes – 30% and 100% of crop water requirement (ETa) replicated three times. The results revealed that growth parameters of UM landrace were higher at 100% compared to 30% ETa, and this translated negatively on yield where yield and yield parameters were lower under water stress conditions; however, NWP were all higher at 30% than 100% ETa.

Therefore, for taro to become a possible solution to food insecurity in South Africa, it is essential to develop more studies investigating the crop's variety of landraces in terms of agronomy management practices and water use on yield quality of the neglected underutilised crop species (NUCS) [3]. Future research ought to present more experimental data and investigate the effects of extra variables, including agronomic management techniques (planting date and plant density) and climate conditions on water use and NWP of UNCS [4].

Keywords: *Taro (Colocasia esculenta), water use, growth response, nutritional water productivity*

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SAEES-O-12

SHORT-TERM EFFECTS OF DAIRY SLURRY MANAGEMENT ON SOIL FERTILITY IN SOUTHERN KWAZULU-NATAL, SOUTH AFRICA

Nkonzo Sithole

217036414@stu.ukzn.ac.za

Student Number: 217036414

School of Agricultural, Earth and Environmental Sciences

Supervised by Professor Pardon Muchaonyerwa

The dairy industry generates large quantities of organic waste, which presents disposal challenges to avoid result in air, soil and water pollution. Application of dairy slurry onto agricultural land could be a sustainable strategy for managing the organic waste that returns carbon, nitrogen, and phosphorus to the soil, with potential improvements in soil quality and crop productivity. Therefore, there is a need to understand the effect of the dairy slurry application on pasture nutrient composition and soil quality in South African soil since the practice reduces volumes of waste in slurry dams while also recycling nutrients. The objective of this study was to evaluate the impact of the application of dairy slurry on soil quality over an increasing period of time.

The study was conducted on the Springfontein dairy farm fields where dairy slurry (DS) was applied on a short-term basis to determine the effects of dairy slurry application strategy on soil chemical properties. The study determined the short-term effect of the application and overflow of dairy slurry on soil quality parameters. The treatments were (i) fields that received DS application, (ii) fields that received DS overflow, and (iii) no DS application in history (control). Soil samples were collected from the 0–15 cm depth and were analyzed.

Soil quality parameters analyzed were pH, electrical conductivity (EC), acid saturation, clay content,) exchangeable calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na), soil organic carbon (SOC), water holding capacity (WHC), bulk density (BD), extractable P, extractable manganese (Mn), copper (Cu), zinc (Zn), and boron (B).

The study findings showed that dairy slurry application strategies decreased Mn, Al, and Fe levels in the soil and increased soil pH, exchangeable K and Na, available P, SOC, and extractable Zn levels when compared with the control. It can be concluded that dairy slurry application increased soil fertility by increasing soil pH, SOC, P, and K availability and could be an alternative waste management strategy to decrease the amount of slurry from the slurry dam and recycle nutrients for soil improvement.

ORAL ABSTRACTS

SCHOOL OF CHEMISTRY AND PHYSICS

SCP-O-1

A high capacity and selective molecularly imprinted polymer for preconcentration of polycyclic aromatic hydrocarbons

Peter Adu

222129037@ukzn.ac.za

Student Number: 222129037

School of Chemistry and Physics

Supervised by Professor Bice Martincigh

There has been an increase in the release of potentially harmful chemicals from human activities, like agriculture and industrial processes, into the environment. As a consequence, the environment has been adversely affected. These are the concerns of the analytical chemist. The most frequently used method for the determination of these chemical compounds is gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS), which entail a traditional sample preconcentration procedure, such as solid phase extraction (SPE). The problem associated with traditional SPE adsorbents is their low selectivity and low adsorption capacity. Molecularly imprinted polymers (MIPs) offer high efficiency SPE adsorbents that have been widely applied due to their high adsorption capacity, high selectivity, low cost, and easy preparation.

In this study, a high capacity and selective MIP with anthracene (ANT) and phenanthrene (PHN) as templates was synthesised by a precipitation polymerisation method. The MIP was prepared via thermally-initiated free radical polymerisation, using methacrylic acid (MAA) as the functionalised monomer, ethylene glycol dimethacrylate (EGDMA) as the cross linker, 2,2'-azobisisobutyronitrile (AIBN) as the initiator, and toluene as the porogenic solvent. For comparative studies, a non-imprinted polymer (NIP) was also prepared by the same procedure and with the same reagents but without the addition of the template molecules.

The MIP and NIP obtained were characterised and adsorption studies were performed.

The results of the adsorption studies showed that the MIP has better adsorption capacity and a high selectivity towards an analogous polycyclic aromatic hydrocarbon template molecule.

SCP-O-2

Behaviour of Polymeric Fluids at the Interface for Material Science Applications

Oluwatumininu Ayo-Ojo

220052876@stu.ukzn.ac.za

Student Number: 220052876

School of Chemistry and Physics

Supervised by Dr Nkosinathi Dlamini

Polymeric fluids are integral to a wide range of applications, including photovoltaics and material science, due to their unique interfacial properties. This study focuses on a binary mixture of two high-density polyethylene (HDPE) polymers, differentiated by their distinct chain architectures and varying chain lengths.

Utilising the Coarse-Grained Bead-Spring Model, we explored the behaviour of both linear and cyclic polymers, representing open-chain and loop topologies, respectively. Molecular Dynamics (MD) simulations were conducted on this mixture within a system confined between two oppositely attractive walls. The study systematically examined how variations in polymer architecture and chain length influenced the interfacial phenomena. Understanding these interfacial behaviors is critical for enhancing the performance of polymeric fluids in applications such as coatings, adhesion, and surface modification.

SCP-O-3

Coherent control of atomic states using photons

Yastheer Hurriraj Bauchoo

217043438@stu.ukzn.ac.za

Student Number: 217043438

School of Chemistry and Physics

Supervised by Prof Thomas Konrad

The purpose of this work is to apply a control technique [1] in order to prepare an atom in a desired state using a sequence of interactions with single photons. The current scheme employs an atom which is trapped in a Fabry-Perot cavity.[2] An atom has a lambda configuration i.e. it is a 3-level atom which has 2 ground states and 1 excited state, for example, a Rubidium-87 atom. The photon is first prepared in a superposition of its polarisation states, which is swapped into a superposition of the ground states of the lambda system by a sequence of operations. In this talk, I will describe in detail the physics of the atom-photon interaction.

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SCP-O-4

The Synthesis and Characterization of Magnetic α-Fe_2O_3, α-Fe_2O_3/SiO_2 and ε-Fe_2O_3/SiO_2 Nanoparticles

Aphile Chithwayo

212541793@stu.ukzn.ac.za

Student Number: 212541793

School of Chemistry and Physics

Supervised by Dr Colani Masina

Nanotechnologies have significantly grown in many research areas such as biomedical, electronics, space science, chemistry, physics, and many others [1]. Particular attention has been drawn to nanotechnologies due to the properties of nanostructured materials. Novel properties arise at the nanoscale as the surface-to-volume ratio increases [1]. Some novel properties include mechanical, optical, magnetic, electrical, and chemical reactivity. Nanotechnologies also find uses in solar cell design, pigments, microwave absorption, catalysis, environment protection, gas sensors, magnetic storage, clinical diagnosis, and treatment [1]. The magnetic properties of these nanomaterials have drawn attention as

they have been shown to be the best preference for applications, especially highly magnetic elements [1]. These nanoparticles require a particle size of less than 100 nm, a narrow size distribution, and a high coercive field.

This work aims to (a) establish a reproducible synthesis route for magnetic iron oxide nanoparticles, (b) employ characterisation techniques using Transmission Electron Microscopy (TEM) to look at the morphology, the Mössbauer Spectroscopy to confirm the magnetic state of the nanoparticles, the Vibrating Sample Magnetometer (VSM) to take magnetic measurements of the magnetic field dependence on isothermal magnetisation. A pure phase of α-Fe_2O_3 nanoparticles and α-Fe_2O_3/SiO_2 nanoparticles were successfully synthesised. Upon synthesising ε-Fe_2O_3 nanoparticles, a mixture of two phases ε/α-Fe_2O_3/ SiO_2 was produced. The XRD pattern and Mössbauer spectroscopy analysis revealed the formation of pure α-Fe_2O_3 and α-Fe_2O_3/ SiO_2 phases, which were roughly spherical, with an average crystallite size of approximately 26 nm and 124 nm, respectively. The Magnetization measurements at room temperature showed that pure α-Fe_2O_3 was weakly ferromagnetic with a coercive field of 0.35 kOe, and α-Fe_2O_3/SiO_2 presented an unusually high coercivity field of 10 kOe. The XRD pattern and room temperature Mössbauer spectrum of the ε-Fe_2O_3/ SiO_2 sample showed the presence of two distinct iron oxide phases corresponding to the α-Fe_2O_3 and ε-Fe_2O_3 phase. The shape of the particles ranged from ellipse-like to roughly spherical nanoparticles with an average crystallite size of about 18nm. The relatively large coercivity field of 15.5 kOe was observed, consistent with the ε-Fe_2O_3 phase and its ferrimagnetic nature. The α-Fe_2O_3/SiO_2 and ε/α-Fe_2O_3/SiO_2 nanoparticles are suitable for applications in recording heads, microwave devices, water purification, sensors, magnetic shielding, clinical diagnosis, and treatment due to their magnetisation parameters.

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SCP-O-5

Faster Quantum Simulation of Markovian Open Quantum Systems Via Randomisation

Ian Joel David

215056787@stu.ukzn.ac.za

Student Number: 215056787

School of Chemistry and Physics

Supervised by Prof Ilya Sinayskiy and Prof Francesco Petruccione

When simulating the dynamics of open quantum systems with quantum computers, it is essential to accurately approximate the system's behaviour while preserving the physicality of its evolution. Traditionally, for Markovian open quantum systems, this has been achieved using first and second-order Trotter-Suzuki product formulas or probabilistic algorithms. In this work, we introduce novel non-probabilistic algorithms for simulating Markovian open quantum systems using randomisation. Our methods, including first and second-order randomised Trotter-Suzuki formulas and the QDRIFT channel, not only maintain the physicality of the system's evolution but also enhance the scalability and precision of quantum simulations. We derive error bounds and step count limits for these techniques, bypassing the need for the mixing lemma typically employed in Hamiltonian simulation proofs. We also present two implementation approaches for these randomised algorithms: classical sampling and quantum forking, demonstrating their gate complexity advantages over deterministic Trotter-Suzuki product formulas. This work is the first to apply randomisation techniques to the simulation of open quantum systems, highlighting their potential to enable faster and more accurate simulations.

SCP-O-6

SYNTHESIS OF CANTHIN-6-ONE AND OTHER DERIVATIVES FOR POTENTIAL USE AS ANTI-BACTERIAL, ANTI-FUNGAL AND ANTI-ALZHEIMER AGENTS

Lesley Dralle

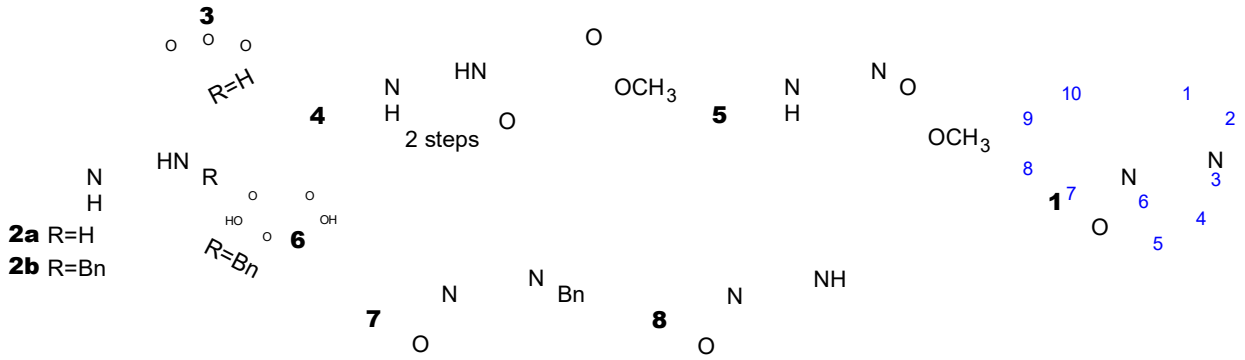
209505964@stu.ukzn.ac.za

Student Number: 209505964

School of Chemistry and Physics

Supervised by Professor Ross Robinson

Polycyclic heteroaromatic molecules encompass a vast discipline in science and the elimination of harsh reaction conditions has allowed access to an ever-increasing array of such compounds. Canthin-6-one **1**, with its four-ring system falls in this class. It contains the synthetically diverse β-carboline core which confers structural flexibility allowing for plethora of useful modifications. [1] Canthin-6-one **1** is easily accessible from tryptamine **2a** utilising either a Bischler-Napieralski cyclisation of **5** [2] or a Pictet-Spengler cyclisation of **2b** [3].



Modification of the parent **1** at C4 and C5 affords four natural product derivatives and halogenation at C5 allows for Suzuki cross couplings to afford a vast number of synthetic analogues. Alternatively, modifications can be introduced earlier in the synthesis by altering the acid anhydrides **3** (Bischler-Napieralski route) or iodination of **7** or **8** (Pictet-Spengler route).

Biological testing of the natural and synthetic analogues will be performed to determine their viability as anti-fungal, anti-bacterial, anti-cancer and anti-Alzheimer agents. The zebrafish (*Danio rerio*) model will be used to assess cell permeability and acute, developmental and multi-organ toxicity of the compounds.

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SCP-O-7

Exploring carboxylic acids as novel green porogens in tailored γ-Al_2O_3 supports enabling the next generation of supported catalytically active liquid metal solution catalysts

Aaron Luke Folkard

213557335@stu.ukzn.ac.za

Student number: 213557335

School of Chemistry and Physics

Supervised by Prof Holger B. Friedrich

Typical heterogeneous catalysts are prone to deactivation mainly from coke deposition and sintering of the active metal. Supported catalytically active liquid metal solutions (SCALMS) catalysts have shown promising results in improving activity and longevity for catalytic applications.[1] In literature, it has been shown that the Ga droplet size in SCALMS is an important component that is affected by surface morphology and roughness.[1-3] Existing SCALMS catalysts are prone to Ga droplet agglomeration. To alleviate Ga agglomeration, a tailored support material is required to immobilise the Ga droplet within a porous network.

Often an overlooked component of catalyst design, this contribution explores novel synthesis routes for macroporous γ-Al_2O_3. By designing supports with ideal roughness, pore size and pore volume, the next generation of tailored SCALMS can be achieved. Our approach to synthesise γ-Al_2O_3, using modified sol-gel methods with carboxylic acids, creates supports of varying porosity profiles.

This contribution will discuss the pore network of different carboxylic acid porogens, as well as the location of the decorated Ga droplet relative to the various γ-Al_2O_3 pore networks (Fig. 1). We will also explore which pore size range is best suited to the next generation of SCALMS catalyst.

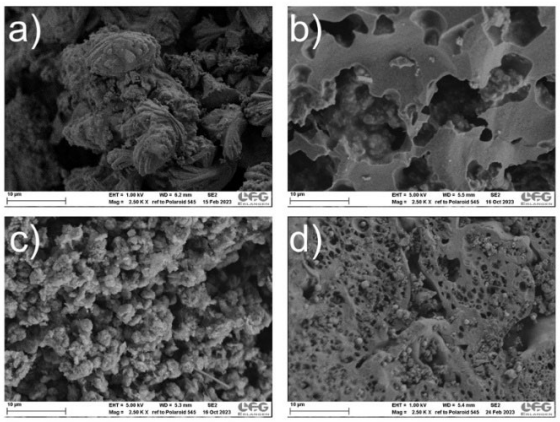

Figure 1: SEM micrograph showing the macropore network of a) Al-Citric acid, b) Al-Malonic acid, c) Al-Oxalic acid and d) Ga-Pt decorated Al-Citric acid.

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SCP-O-8

AL(III) N-ALKOXY FORMAMIDINE COMPLEXES AS EFFECTIVE CATALYSTS FOR RING OPENING POLYMERIZATION REACTIONS

David Juma

224098093@stu.ukzn.ac.za

Student Number: 224098093

School of Chemistry and Physics

Supervised by Prof Bernard Owaga

Polyesters obtained from renewable sources are fast replacing petrochemical-based plastics due to their biodegradability and biocompatibility. They have hitherto been applied in agriculture, medicine, pharmaceutical[1], and packaging industries. Coordination insertion, among many other methods, is the most reliable method because it leads to the production of polymers with high molecular weights and low poly-disparity2. However, in a homogenous catalytic system, trace metal complexes are found mixed with polymers. This reduces the quality of the polymers and their utility in a biological system because of the toxicity of the metal complexes. The flexibility of Diarylformamidine ligands to coordinate either as monodentate or as chelating ligands render their respective complexes very promising for application in catalysis3. N-Hydroxy-N,N'-Diarylformamidine complexes4 have been reported by our research group to be significant initiators in ring opening polymerization. In this work, we explore the use of novel N-alkoxy-N,N'-diarylformamidine derivatives as ligands in Cu(II)-based complexes. This report details the synthesis, characterisation, and catalytic performance of Cu(II) complexes in the ring-opening polymerisation of ε-caprolactone.

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SCP-O-9

Mechanistic studies on the adsorption of nitrogen-containing drugs to acid-functionalised pine cellulose

Ibrahim Chikowe

220110888@stu.ukzn.ac.za

Student Number: 220110888

School of Chemistry and Physics

Supervised by Prof Muhammad D. Bala

Wood waste from Malawi in the form of Pinus *spp* sawdust was treated with citric acid (CA) and acetic acid (AA) to obtain CATSC and AATSC cellulose materials, respectively. The two acid-modified cellulosic products were tested for the adsorption of nitrogen-containing drugs (levofloxacin, doxycycline, primaquine, sulphamethoxazole, and chloroquine) in aqueous environments. For characterisation, the materials were analysed using FTIR and by BET, XRD, SEM, STEM and TGA for structural analyses. Adsorption tests for active pharmaceutical ingredients (APIs) were performed using the batch method. The adsorption data were analysed using Langmuir, Freundlich, and Temkin's isotherm models. The FTIR results showed an increase in surface functional groups and charges (hydroxyl, -OH, and carboxyl, -COOH groups) in CATSC and a decrease in AATSC due to the dissolution of some cellulose molecules and extractives. BET results showed a higher surface area in AATSC than in CATSC. The results showed the Temkin model and pseudo-second-order models as the best fit for the experimental data, with R^2 test values that were closest to 1. The highest adsorption efficiency of 100% was reported for both CATSC and AATSC materials at different conditions. The highest adsorption capacity of 22 mg/g was reported in chloroquine for CATSC material and 17 mg/g in chloroquine for the AATSC material. Regression analysis and factor analysis/principal component analysis assisted QSAR studies corroborated the mechanism of adsorption studies. The data showed that the adsorption of the materials

may have occurred under the influence of hydrogen bonding and electrostatic forces of attraction, which were higher in the CATSC than in the AATSC material due to the presence of COOH. The acidic functionality engages in strong hydrogen bonding and exerts stronger electrostatic forces of attraction than the OH functional group. The data was affected by the different states of the APIs at different pH values, which resulted in positive, neutral, or negatively charged active species. Based on the results, the CATSC and AATSC materials are suitable sustainable and green adsorbents for the studied APIs. This property may also be extrapolated to structurally related APIs.

SCP-O-10

EXPLORING THE BIOMOLECULAR AND CYTOTOXIC ACTIVITIES OF NOVEL RHENIUM(I) COMPOUNDS WITH 2-AMINOGUANIDINE-DERIVED SCHIFF BASES

Tariro Talent Mapapiro

221072265@stu.ukzn.ac.za

Student Number: 221072265

School of Chemistry and Physics

Supervised by Prof Irvin Noel Booysen

Currently, greater emphasis is placed on designing new rhenium compounds that contain bio-vectors, which improves the selectivity index towards cancerous cells over healthy cells. [1] Herein, we report the synthesis and characterization of the novel 2-aminoguanidine-derived Schiff base rhenium(I) compounds: *fac*-[Re(CO)$_3$(Hguabs)Br]Br (**1**) (Hguabs·Cl = 2-((benzothiazole)methyleneamino)guanidine chloride) and *fac*-[Re(CO)$_3$(guaquin)Br] (**2**) (guaquin = 2-((quinolin-2-yl)methyleneamino)guanidine). [2] It is foreseen that the anticancer effects of guanidine and benzothiazole moieties in **1** may synergistically facilitate drug target-specificity and interactions. The *in vitro* cytotoxicities of **1** and **2** were assessed in various cancerous and non-tumorigenic cell lines. Both compounds showed activities in the low micromolar (μM) range in all cell lines tested.

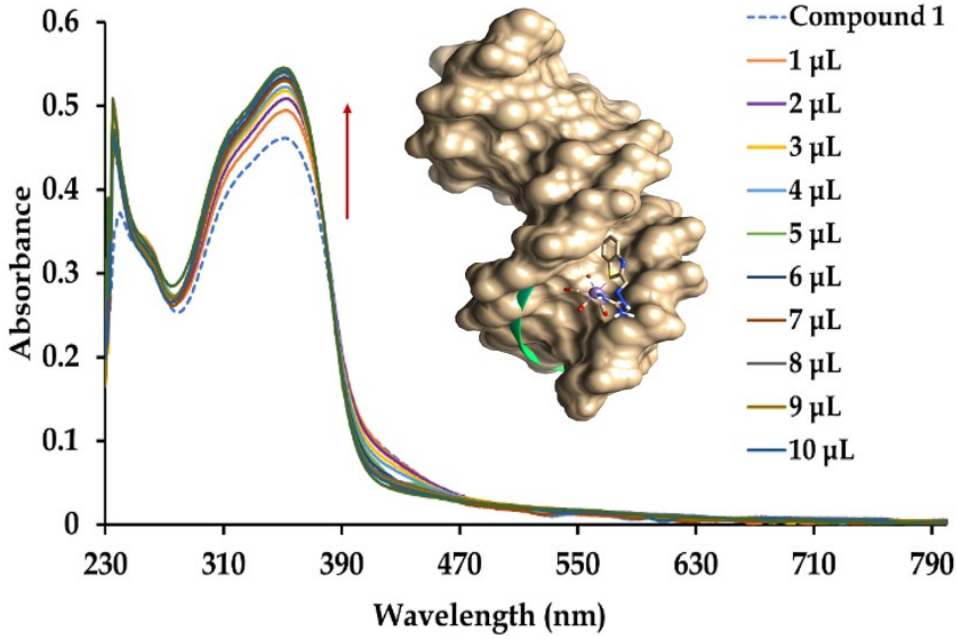

Figure 1: *The affinities of cytotoxic 2-aminoguanidine-derived Schiff base rhenium(I) compounds towards Calf Thymus Deoxyribonucleic acid (CT-DNA).*

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SCP-O-11

Adsorption of heavy metals, Lead (Pb^{2+}) and Copper (Cu^{2+}) from wastewater samples using cannabis *sativa* as bio-adsorbent

Thandeka Mbatha

220006971@stu.ukzn.ac.za

Student Number: 220006971

School of Chemistry and Physics

Supervised by Dr Precious Nokwethemba Mahlambi and Dr Sandisiwe Zondo

The remediation of heavy metals as pollutants in aqueous streams is a pressing concern, driven by their persistence and recalcitrant nature in the environment [1]. Conventional treatment plants are neither cost-effective nor eco-friendly thus, produce substantial amounts of hazardous sludge [2]. Agricultural waste materials, with their distinctive biochemical composition, wide availability and low-cost, present a viable solution for heavy metals decontamination [3]. Thus, in this study, cannabis *sativa* was employed as agro-waste to decontaminate lead ions (Pb^{2+}) and copper ions (Cu^{2+}) from wastewater samples via adsorption process. It was employed as raw cannabis (RC), glycine cannabis (GC) and sodium bicarbonate cannabis (SBC). This material was characterized by FTIR, SEM, TEM, BET and XRD. The FTIR results showed that hydroxyl, carbonyl and alkyl groups facilitated a strong adsorption efficiency. The effects of contact time, pH, initial concentration and temperature were successfully evaluated, yielded favourable outcomes. The % removal efficiency of RC, GC and SBG was 91.77% Cu and 98.29% Pb; 93.12% Cu and 98.90% Pb; and 92.96% Cu and 98.70% Pb, respectively. Thermodynamic studies indicated that the adsorption process was exothermic for RC and GC however, non-spontaneous and endothermic for SBC. Based on the attained results, cannabis *sativa* was observed to be more effective and efficient for heavy metals removal, given a sufficient adsorption time of 10 min.

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SCP-O-12

Hemilabile N^P, N^O-donor Pd(II) and Co(II) complexes: Synthesis, elucidation, and application as pre-catalysts in ethylene oligomerization

Nondumiso L. Ngcobo

214536863@stu.ukzn.ac.za

Student Number: 214536863

School of Chemistry and Physics

Supervised by Prof. Stephen O. Ojwach

Oligomerization of ethylene is one of the fundamental chemical processes that produce higher olefins. These higher olefins are components of valuable functionalized fine chemicals, intermediates, and starting materials for important domestic and industrial chemicals. [1] The demand for linear α-olefins is growing faster in the C_4-C_{10} range than in the C_{12+} range. Moreover, selective production of shorter-chain olefins has prompted much research, specifically concerning catalyst design. [2] So, hemilabile ligands which have the potential to detach from metal centres were prepared in this study. These ligands provide avenues to increase stability, allow access to active sites, and lead to

different reactivity in catalysis. [3] The (imino)phosphine ligands (**L1-L5**) and (imino)naphthalenol ligands with hemilability potential (**L6-L9**) were prepared via condensation reaction and treated with $Pd(COD)Cl_2$ or $Pd(COD)CH_3Cl$ or $CoCl_2$ precursor to give ten complexes **PdL_1-PdL_6** and **CoL_4-CoL_7**. Solid-state structures of complexes **PdL_1**, **PdL_3**, **PdL_4**, **and PdL_6** established the P^N bidentate coordination mode of the ligands while **PdL_2** established P^N^N tridentate coordination (**Figure 1**). The cobalt (II) complexes afforded tri-chelated solid-state structures. The oligomerization reactions of ethylene with these Pd(II) and Co(II) pre-catalysts activated with either $EtAlCl_2$ and MMAO as co-catalysts afforded active pre-catalysts, produced mainly C_4 and C_6 oligomers.

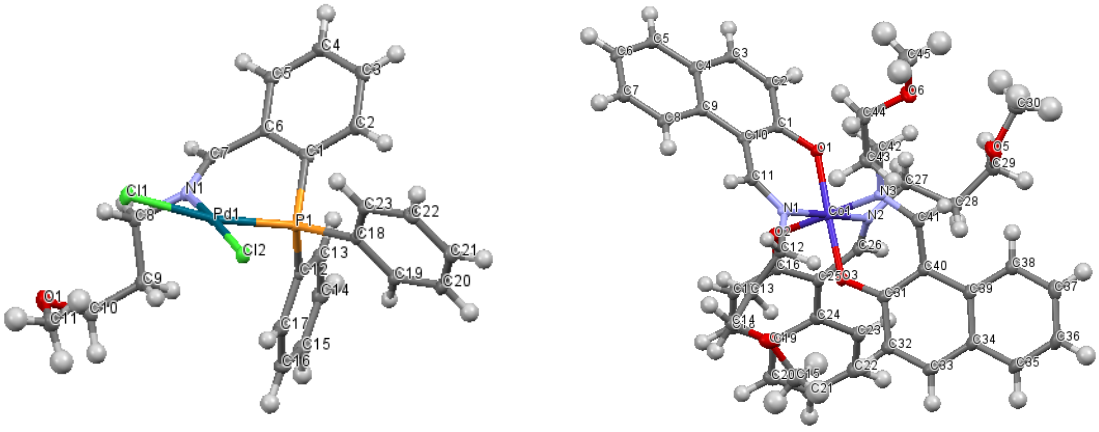

Figure 1: Molecular structures of palladium(II) **PdL_4** and cobalt(II) complexes **CoL_4**.

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Keywords: hemilabile structures, reactions, metal, catalyst.

ORAL ABSTRACTS

SCHOOL OF ENGINEERING

SE-O-1

LIGNIN FROM STEAM EXPLODED SUGARCANE BAGASSE AS AN ADHESIVE IN SUGARCANE BAGASSE-BASED PARTICLEBOARDS

Josiane Ayingeneye

214581080@stu.ukzn.ac.za

Student Number: 214581080

School of Engineering

Supervised by Prof Annegret Stark

Safer and bio-based renewable resources are emerging rapidly to alleviate the depletion of non-renewable fossil resources and the environmental pollution related to their overexploitation. The local and global abundance, cost-effectiveness, and chemical composition of sugarcane bagasse (SCB) make it a reliable and sustainable renewable resource for numerous high-value-added bio-based fuels, chemicals, and materials.

In this study, steam exploded SCB, a downstream solid residue from furfural production, has been fractionated into its cellulose and lignin components via organosolv methods using single- or multi-stage extraction at various temperatures with fifteen organic solvents of different relative polarities. The resulting enriched cellulose delignified solid residue was hydrolyzed into glucose monomers while the extracted lignin was structurally and thermally analyzed before being applied as an adhesive in SCB-based particleboards. Lignin was applied at different concentrations i.e. 0%, 2.5%, 7.5%, and 12.5% of the total weight of the utilized SCB.

Tetrahydrofuran gave the highest yields of extracted lignin, irrespective of the extraction set-up and extraction temperature, when compared to other organic solvents under otherwise constant conditions. The shortest extraction time was achieved using multi-stage extraction at elevated temperatures. Hence, a lignin yield of 24% could be obtained. On the other hand, the glucose yield from hydrolysis of the remaining cellulose-rich fraction was dependent on the extraction set-up and solvent chosen, and ranged between 17 and 42%. This finding indicates that the market prices for the downstream products from both lignin and glucose will determine the most suitable solvent for the extraction. The extracted lignins obtained with various solvents were analysed using NMR spectroscopy, leading to the conclusion that the lignin contains a high percentage of G monomers (coniferyl alcohol derivatives; 51.6 - 62.4%) compared to H and S contents. The abundance of phenolic hydroxyl groups (1.05 - 1.99 mmol/g lignin) emphasizes the phenolic characteristics of extracted lignins.

Lignin extracted with tetrahydrofuran was successfully applied as an adhesive in the production of SCB-based particleboards. For that purpose, SCB was first pretreated with sulfuric acid. It was found that the addition of lignin enhances the adhesion strength. Excitingly, with the addition of 12.5% lignin resulted in excellent water absorption, thickness swelling, and modulus of elasticity, which are comparable to commercial wood-based particleboards, however, the modulus of rupture was somewhat lower. The best lignin-based particleboards produced in this study met the standard industry requirements for the thickness swelling and modulus of elasticity. Overall, this study highlighted the potential for the diversification of the product portfolio of sugar mills.

SE-O-2

DESULPHURISATION OF BIOETHANOL USING COPPER-LOADED CARBON FOAM

Jonathan Koko Byamungu

219021310@stu.ukzn.ac.za

Student Number: 219021310

School of Engineering

Supervised by Professor David Lokhat

Bioethanol has recently attracted attention as a sustainable and clean energy source that can be used as an alternative to traditional fossil fuels. It is produced from renewable biomass sources such as corn and sugarcane. With the recent global initiatives to lower greenhouse gas emissions and dependence on limited resources, biofuels in general, have increasingly been used to supplement more polluting fuels. A significant challenge associated with biofuels, similar to fossil fuels, is sulfur contamination, which is known to have detrimental effects on both human health and the environment.

Sulfur compounds are typically removed through traditional processes such as hydrodesulfurization or extractive desulphurisation, which can either be energy-intensive, expensive, or inefficient. Newer non-hydrodesulphurization-based methods, such as bio-desulphurization or adsorptive desulphurisation, have been explored more recently. The present work focuses on adsorptive desulphurisation for sulfur removal from a liquid biofuel. This process involves the use of solid sorbents that selectively adsorb, physically or chemically, sulfur compounds from the solution. According to [1], ideal sorbents should be selective, be stable, low cost, and have high sulfidation capacity. A new, cheap, promising adsorbent was developed to investigate the desulphurisation of biofuels. The adsorbent support material, carbon foam, is prepared using the method developed by [2]. Leveraging the adsorption properties of copper nanoparticles, these particles are loaded onto the support material, using wet impregnation, and investigated for desulphurisation as suggested by [3]. Standard solutions of ethanol and a known sulfur compound, propanethiol, are first prepared and used to validate the adsorption capabilities of the prepared sorbents. The sorbents will then be tested for desulphurisation of industrial bioethanol samples collected from an AlcoNCP (Pty) distillery in Durban, South Africa.

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SE-O-3

The Integration of Renewable Energy and Energy Storage Systems in Smart Grids within the South African Energy Market

Omaira Jajbhay

217016542@stu.ukzn.ac.za

Student Number: 217016542

School of Engineering

Supervised by Dr Mohamed Fayaz Khan

The shift from fossil fuels to renewable energy is crucial for environmental sustainability and economic stability. Traditional power systems, originally designed for unidirectional power flow, now face challenges with the integration of Distributed Generation, requiring new approaches to system protection and fault recovery. Smart grids (SGs) have emerged as a solution, incorporating advanced technologies to predict customer consumption patterns and ensure efficient electricity delivery.

Smart grids improve demand-side management and response by predicting electricity needs and optimizing transmission, surpassing traditional grids [1]. Advancements like IoT, 5G, big data, and machine learning enhance smart gird potential, integrating with smart sectors like vehicles, buildings, and cities. Research on integrating renewable energy sources (RESs) and energy storage systems (ESSs) in SGs is crucial for transitioning to sustainable systems. While RESs help decarbonize and stabilize grids, their intermittence poses challenges, requiring coordinated efforts between RESs, ESSs, and the grid to ensure reliability [2].

Optimization techniques have widely been applied for smart grid planning and operation problems. With the power system deregulation, random load fluctuation and the integration of uncertain RES, many practical challenges have emerged [3]. Hence, new optimisation strategies are applied to improve the technical and economic efficiency of the smart grid.

In summary, the proposed topic for presentation at PRIS 2024 addresses the pressing challenges in renewable energy integration and smart grid optimisation, offering an overall review of advanced forecasting models and optimization techniques for smart grids. The proposed presentation aims to enhance the awareness of integration of renewable energy sources and energy storage in smart grids, especially within the current South African energy market.

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SE-O-4

Magnetic field control of heterogeneous catalysis: Application to low-pressure Fischer Tropsch

Durante’ Naidoo

217075527@stu.ukzn.ac.za

Student Number: 217075527

School of Engineering

Supervised by Professor David Lokhat

The initial step in any catalytic reaction is the adsorption of reactant molecules. The strength of the adsorption and orientation of the adsorbed molecules correlate well with the activity and selectivity of the catalyst. Most industrial catalysts are composed of various transition metals supported on relatively inert oxides. The interaction between reactant molecules and metallic active sites is governed by the electronic structure of the catalyst. This determines the adsorption strength and geometry. Modification of the electronic structure of the catalyst can alter the adsorption parameters of the reactant. This can be used to control the catalytic performance. In this study, low-pressure Fischer-Tropsch was carried out in a lab-scale fixed bed reactor system using an iron-based catalyst. The reactor was

surrounded with an electromagnet and the effect of the induced electromagnetic field on the product distribution and yield was evaluated. The first prototype comprised a four-coil pair, concentric circle Helmholtz coil, providing a highly concentrated magnetic field parallel to the flow of reactants through the reactor vessel. The second was a Helmholtz cage that was able to exert three individual axes of magnetic field, and was also used to create an isolated, high intensity magnetic field system around the reaction zone, by activating all the coils in the cage at once. The magnetic field was shown to have a significant effect on methane selectivity and yield of higher alkanes.

SE-O-5

DEVELOPMENT AND EVALUATION OF A BEVERAGE CAN SOLAR AIR HEATER FOR WINTER GREENHOUSE SPACE HEATING

Sishosonke Nsele

216004070@stu.ukzn.ac.za

Student Number: 216004070

School of Engineering

Supervised by Dr Alaika Kassim

Ensuring clean energy, food, and water is among the 17 United Nations sustainable development goals for 2030. Greenhouse farming which addresses the impact of climate change and evolving dietary needs, it facilitates year-round quality food production. However, winter operations in greenhouses are energy-intensive, relying on carbon-based fuels that contribute to climate change, deplete fossil fuels, and increase operational costs. Heating and cooling systems account for 65-85% of energy consumption in greenhouse farming, highlighting the need for affordable, clean solutions. This paper explores using discarded and recycled aluminium beverage cans to harness solar energy for heating air in an agricultural greenhouse during the South African winter. The aluminium cans served as the absorber plate in a solar air heater, whose performance was evaluated. A double-pass aluminium beverage can solar air heater was designed and constructed for this purpose. Performance tests determined the optimal angle and assessed the necessity of the second channel. Winter tests at tilt angles of 26°, 31°, and 36° showed that the heater could raise ambient air temperature to a maximum of 128.8 °C in the second channel, though not at the outlet, which dropped to 95.97 °C. This temperature drop is attributed to the temperature gradient and system leakages. The mean efficiencies of the overall system, the first pass and second pass channels were 156%, 208%, and -74%, respectively, indicating that the second channel's heat loss reduced overall efficiency. These results, achieved with the collector tilted 31° to the horizontal facing true north, suggest that a single-pass beverage solar air heater offers more useful temperature output and heat and better performance than a double-pass configuration. The achieved overall system temperature and efficiency make the heater suitable for home heating and agricultural drying.

Keywords: Solar air heaters, Discarded aluminium beverage cans, Temperature differences, Instantaneous efficiency, Single pass, Double pass

SE-O-6

Disrupting Bound Water in Faecal Sludge to Improve Water Removal Processes

Yashlen Pather

216041338@stu.ukzn.ac.za

Student Number: 216041338.

School of Engineering

Supervised by Dr Jonathan Pocock, Dr Santiago Septien Stringel and Ms Reneiloe Seodigeng

Faecal sludge (FS) solids are a valuable resource rich in nutrients and organics which could provide circular economic opportunities for local communities as a fertilizer or fuel. The high-water content of FS matrices (usually above 75%

water by mass) remains a challenge in FS management systems. Although unbound water can be removed relatively easily, water within the sludge that is bound physically, chemically, mechanically or intracellularly to the solid phase - termed as bound water (BW), is a limiting factor in FS management systems due to the additional energy required for its release. Releasing BW influences the overall dewaterability of the sludge [1]. Sludge is easier to dewater and dry and benefits from improved flowability and reduced stickiness. Transportation and treatment costs decrease significantly due to a decrease in volume of the sludge. Additionally, pathogen inactivation occurs as the water content decreases due to a decrease in water activity [2], improving the overall health and safety of all personnel in every step of the waste management process (collection, transportation, treatment and disposal). There is a need to improve BW removal processes in a sustainable, yet cost effective, manner. This project continues with lab-scale experimentation following a literature review in which a number of promising treatments were determined, and the key BW disruption mechanisms found were extracellular polymeric substance (EPS) degradation [3], and cell lysis [4]. Selected treatments include Microwave (MW) radiation, Lime treatment, Enzyme treatment, cyclic freeze-thawing and mechanical shearing. These are benchmarked at lab-scale against key performance indicators in dewatering, drying and rheology. The experiments at the WASH R&D Centre (University of KwaZulu-Natal) are conducted with faecal sludge collected from onsite sanitation facilities, which included Ventilated Improved Pit (VIP) latrines, Urine Diverting Dry Toilets (UDDT) and Septic Tanks (ST) located in the eThekwini Municipality (Durban, South Africa), as well as fresh faeces supplied by donors at the University of KwaZulu-Natal. Initial experimentation has begun and will utilize treatments applied to other sludges from literature followed by more extensive testing on the most promising treatments to determine the optimum conditions for the South African sanitation landscape.

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SE-O-7

SIMULATION, OPTIMISATION, AND ECONOMIC EVALUATION OF A COAL-TO-LIQUID (CTL) PROCESS

Mouline Phumusa

215076212@stu.ukzn.ac.za

Student Number: 215076212

School of Engineering

Supervised by Prof Amir H. Mohammadi

The global energy industry faces the challenge of providing adequate, affordable energy while ensuring environmental sustainability. Rapid population growth and industrialization drive increased energy demand, particularly in developing economies like South Africa. South Africa's energy sector is heavily dependent on coal, given its shortage of oil and gas but abundant coal reserves. The country consumes approximately 30 billion liters of petroleum annually, 79% being gasoline and diesel. Gasoline and diesel are mostly imported while a small fraction is synthetic fuel from coal and natural gas. Recently, South Africa's imports of refined petroleum products surged due to the decline in

refinery capacity the country had. The present situation of risky due to declining oil reserves and geopolitical issues. In light of the above the Coal-to-liquids (CTL) technology is expected to play an even more critical role in ensuring energy security, leveraging abundant domestic coal reserves to reduce reliance on imports and mitigate fuel shortages. The technology is mature and commercially available in South Africa.

However, the long–term sustainability of the mainstream CTL processes is compromised by high carbon emissions, low energy efficiency, and high operational costs. Given the importance of CTL to South Africa, it is imperative to upgrade the process and align it with the climate policies of today. The process typically involves two important steps, syngas production (Air separation, gasification, and acid gas removal) and synfuels production (Fischer – Tropsch and product upgrading). The syngas generation step represents the largest capital investment, accounting for about 60% of the overall plant costs, and is less energy efficient. While numerous studies have been conducted on the CTL process, there is still a gap as the studies often focus on a specific unit of the process (gasifier or Fischer Tropsch reactor) rather than the system as a whole. Co-generation of electricity and liquid fuel is suggested to improve the process energy efficiency as well as lowering the cost of the liquid fuel product. Also, Carbon Capture and Utilisation (CCU) are expected to lower the CO_2 emissions from the CTL. The impact of the configurations with co-generation of electricity and CCU on the plant cost and process efficiency remains to be studied.

In this study, a plant-wide model of the CTL process is simulated using the Aspen Plus® commercial software, with the overarching goal of optimizing key process variables, performing heat integration, and evaluating different configurations to maximize process efficiency and minimize CO_2 emissions. Sensitivity analyses are conducted to assess the robustness of the optimized solutions and to examine the impact of key design parameters (such as operating conditions of key equipment, oxygen/coal ratio, steam/coal ratio, temperature, and pressure). The economic evaluation provides a critical assessment of the CTL process's feasibility and competitiveness within the broader energy landscape. The optimal configuration is selected based on economic measures such as the net present value (NPV), internal rate of return (IRR), and break-even oil price. The outcomes of this study are expected to inform policy decisions, guide industrial implementations, and foster a deeper understanding of the intricate dynamics involved in the integration of CTL technologies into the global energy portfolio. As the world navigates through a pivotal era of energy transition, this research stands as a crucial contribution toward ensuring a resilient, diversified, and sustainable energy future.

SE-O-8

Smart Transport: A Stochastic Application of Artificial Neural Networks and Embedded Sensors

Semyn Rameshwarnath

211505664@stu.ukzn.ac.za

Student Number: 211505664

School of Engineering

Supervised by Prof Mohamed Mostafa

Pavement structural collapse is attributed to cumulative factors resulting in strength and stability reductions, during the estimated asphalt pavement design life. For example, Resilient Modulus of the underlaying layers in a pavement structure is reduced if the associated moisture content results in an increase of the saturation content. Subsequently, the structural carrying capacity of the asphalt pavement is decreased. However, engineers in South Africa do not have access to pavement in-service data to monitor such reduction. This is due to lack of road embedded sensing systems in the country and therefore, there is a need to use prediction models. This study attempts to indicate relationships between real in-service asphalt road data, collected under service conditions and pavement deterioration, to facilitate predictive analytics via stochastic artificial neural network techniques.

The research leverages Data Science principles and data from the FHWA Long Term Pavement Performance (LTPP) project. The prepared input data was introduced to the Artificial Neural Network (ANN), with an 80/20 train-test split. Data inputs comprise recorded humidity, temperature, and traffic loading among others, with recorded asphalt

pavement rutting response as ANN targets. The ANN model was created in the Jupyter Notebook development environment using the Python language.

The anticipated results are expected to comprise visual representations of the inputs vs recorded real world and predicted asphalt responses. The predictions from the ANN model are expected in the "neighbourhood" of the real world recorded values, with irregular variance – indicative of desired acceptable non-linearity from ANN model predictions. Resultantly, the model predictions are expected to indicate a cumulative relationship of model inputs and pavement distress response, within an acceptable model accuracy.

Keywords: pavement, data science, artificial neural network, asphalt, python

SE-O-9

PHYTOCHEMICAL EXTRACTION, SCREENING, AND METHOD DEVELOPMENT OF SOUTH AFRICAN PINE BARKS

Laston Samuwi

222131185@stu.ukzn.ac.za

Student Number: 222131185

School of Engineering

Supervised by Prof Annegret Stark

South Africa has large and widely spread pine forests, which cover over 660 000 hectares of land with several species that include *P. pinaster, P. radiata*, and *P. roxburg*. The most common species, however, are *P. elliottii, P. patula* and *P. taeda* [1]. Maritime pine (*P. pinaster*) bark extract is described in the US pharmacopeia 35 [2], and composed of a mixture of phenolic compounds, phenolic or cinnamic acids and their glycosides. Pycnogenol is the trademark name of the natural maritime pine extract that was developed in Geneva, Switzerland. The most well-studied potential uses for pycnogenol exploit its highly protective properties against several diseases such as cardiovascular dysfunctions, kidney diseases, hepatic dysfunctions, cancer, digestive and retinal disease [3]. Can the three locally prevalent pine species: *P. elliottii, P. patula,* and *P. taeda*, be used to produce a pine bark extract that complies with USP35? This would support the Circular Economy and increase the local wood industry's product portfolio, because pine bark is currently a waste of the forestry industry. Additionally, there is a growing interest in natural plant-based remedies as a source for commercial products on both the local and international markets.

The overall study aimed to extract pine barks from locally grown pine trees. In this presentation, the foundational work is presented: An HPLC method for the determination and quantification of the main components in pine bark: catechin, caffeic acid, ferulic acid and taxifolin, was developed and validated. The concentrations of active components in *P. elliotti* were determined to be 4.0; 7.9; 0.5 and 7.1 mg catechin, caffeic acid, ferulic acid and taxifolin, per gram bark, respectively. Pine bark extracts of *P. elliottii* were submitted to the analytical protocol of the USP35 Pharmacopeia, allowing for the conclusion that the local pine bark extract would comply to USP.

Having this proof-of-concept, the need to pursue systematic experiments for extraction arises. Particularly, the determination of the optimal extraction conditions and plant configuration is required. Solvent recycling loops, effluent treatment, the capacity and solvent inventory required to achieve an industrially relevant pine bark extract output, as well as mass and energy balances of a proposed process will be considered in future work.

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SE-O-10

THE RUN-OF-RIVER HYDROPOWER POTENTIAL IN THE KWAZULU NATAL TUGELA RIVER

Bokang Sithole

210535585@stu.ukzn.ac.za

Student Number: 210535585

School of Engineering

Supervised by Prof Muthukrishnavellaisamy Kumarasamy

The widespread rolling blackouts in South Africa since late 2007 have highlighted the country's energy crisis, where supply fails to meet demand, particularly impacting economic development, job creation, and agricultural production in rural areas. A sustainable approach to power generation is needed, and small-scale run-of-river (RoR) hydropower plants offer a viable, cost-effective, and environmentally friendly solution. These plants generate over 97% of renewable energy worldwide and can provide cheap, clean electricity, thus supporting regional economic development, especially in developing countries.

This study focuses on the Tugela River Catchment in KwaZulu Natal, South Africa, where hydrological studies have traditionally concentrated on drought and flood management, neglecting the hydropower potential. The study aimed to generate power for small-scale hydropower plants with capacities between 1 and 10 MW. Using hydrographs, flow duration curve modelling, and Geographic Information System (GIS) at 26 gauged sites, the study assessed the hydropower potential of the region. The power potential was calculated, assuming an overall plant efficiency of 84%, and results showed that most gauging stations in the Tugela River Catchment are suitable for small-scale hydropower development. The findings reveal that 4% of stations fall below the desired capacity output, 33% are within range, 17.7% exceed the output, and 44% significantly surpass the required capacity.

The study concludes that small-scale RoR hydropower is economically viable for domestic and farming needs in rural areas, offering a clean alternative to fossil fuels. It highlights the potential use of hydropower in supporting farming initiatives, aquaculture, and hydroponic systems. Despite limitations like missing flow data and incomplete environmental consideration, the study recommends expanding meteorological and hydrological networks for more accurate assessments, ongoing research, and adopting flow duration curve approaches nationwide. The study emphasizes continuous monitoring, environmental impact assessments, and community engagement for sustainable hydropower development, proposing capacity-building initiatives and integrated planning to ensure projects benefit local communities and align with sustainable practices.

SE-O-11

A DIGITAL TWIN FOR MONITORING THE CHANGE IN QUALITY ATTRIBUTES OF FRESH TOMATOES IN THE SOUTH AFRICAN POSTHARVEST SUPPLY CHAIN

Koena Mothiba

219009770@stu.ukzn.ac.za

Student Number: 219009770

School of Engineering

Supervised by Prof Tilahun Seyoum

Food losses are a significant global issue, particularly in the postharvest stages of the supply chain. Tomatoes, as the most important vegetable worldwide, are susceptible to postharvest losses, with Sub-Saharan Africa experiencing some of the highest losses. In South Africa, where tomatoes rank as the second most important vegetable crop, postharvest losses are estimated at 10.2%. The opportunity to reduce these losses lies in understanding and monitoring quality attributes, such as color and texture, which are pivotal from the consumer's perspective.

A Digital Twin (DT) is a groundbreaking technology poised to revolutionise how we approach to solve this challenge. A DT is not just a virtual replica; it is a dynamic, real-time simulation of a physical object, enriched with continuous sensor data. By reflecting the lifecycle of the product, DTs offer unparalleled insights that outpace existing technologies such as Internet of Things (IoT), Artificial Intelligence (AI), big data, and Computer Vision Systems (CVS). This project proposes to harness the power of DTs to address the persistent issue of unreliable, outdated data, which continues to hinder efforts to reduce postharvest losses. Traditional methods are often destructive and labor and time-intensive, while advanced technologies such as cloud storage, and AI, though promising, have yet to be fully integrated into a comprehensive solution. The DT presents an opportunity to consolidate these technologies into a unified system that not only meets but exceeds current recommendations.

This project is designed to fill a critical gap in digital agricultural technology use in the postharvest supply chain. While DTs have found applications across various domains, none have specifically targeted the monitoring of quality attributes in fresh produce during the postharvest supply chain. This project aims to develop an experimental DT system tailored to this precise need. The project is more than just an academic pursuit; representing a significant advancement in tackling the challenges that have traditionally hindered agricultural DT implementations, including the lack of a standardised DT concept and the complexities of data and system integration.

The aim of this project is to create a DT system capable of monitoring and assessing the quality of tomatoes along the South African postharvest supply chain. By leveraging computer vision, image processing, and machine learning, this DT will provide real-time data analysis, enabling the tracking of key quality attributes such as decay and color. Focusing on critical stages such as transportation and storage, the project aims to develop advanced image processing algorithms, create a robust feature extractor, and train a machine-learning model that can classify tomatoes with respect to quality. Additionally, a 3D model to represent the geometry of tomatoes, ensuring that the DT remains synchronised with the physical produce along the supply chain will be developed.

SE-O-12

RENEWABLE ENERGY GENERATION AND ITS APPLICATION TO REGULATING THE MICRO-ENVIRONMENT OF PIG HOUSING

Zakwe Siboniso

219022333@stu.ukzn.ac.za

Student Number: 219022333

School of Engineering

Supervised by Prof Tilahun Workneh

The heavy dependence on non-renewable energy in agriculture, especially in livestock farming, has caused considerable environmental harm, contributed to climate change, raised operational costs, and lowered profit margins for farmers. Therefore, this project covers green energy for cooling and heating systems in pig farming to advocate a shift towards renewable resources. The project will build a prototype experimental pig house with natural ventilation and an evaporative cooling system, heating powered by renewable energy. The systems will be evaluated for the effectiveness of maintaining optimum micro-environmental conditions that include temperature, relative humidity and airflow rate with respect to five distinct age groups: newborn piglets, weaner pigs, nursery pigs under natural shade or trees (6–8 weeks), grower stage pigs after removal from the shaded areas until approximately 110 days old body weight <55 kg) and finishing-stage animals when they relocate into acclimatization shoes at high-stock density watering yards. This field study is conducted in the Pietermaritzburg region, having low average relative humidity that will increase the effectiveness of the evaporative cooling technique. The success of these systems may contribute to sustainable

agriculture, less impact on the environment and increased profitability while fostering renewable energy in rural communities.

ORAL ABSTRACTS

SCHOOL OF LIFE SCIENCES

SLS-O-1

PRELIMINARY ASSESSMENT OF THE ANTIBACTERIAL AND ANTI-QUORUM SENSING POTENTIAL OF ENDOPHYTIC BACTERIA FROM *Kigelia africana*

Mercy Alabi

223152256@stu.ukzn.ac.za

Student Number: 223152256

School of Life Sciences

Supervised by Prof Johnson Lin and Prof Hafizah Chenia

The global health burden resulting from the increasing prevalence of multidrug-resistant pathogenic bacteria requires the development of new therapeutics. Although medicinal plants have been used and researched extensively for novel antimicrobial compounds, a major challenge involves the loss of biodiversity due to the over-harvesting of medicinal plants. Bacterial endophytes inhabiting medicinal plants have been identified as producers of secondary metabolites with host protective properties, targeting competitor bacteria and potential pathogens. This study, therefore, aimed to explore the antibacterial potential of endophytic bacteria from *Kigelia africana*.

Previously biobanked endophytic bacterial isolates from *K. africana* were subcultured on International Streptomyces Project-2 medium and bacterial isolates were morphologically characterised and their Gram reactions and cellular characteristics assessed. The bacterial isolates (n=226) underwent primary screening for antibacterial activity against six clinical strains (*Acinetobacter baumannii* ATCC 19606, *Escherichia coli* ATCC 35218, *Enterococcus faecalis* ATCC 51299, *Pseudomonas aeruginosa* ATCC 27853, *Staphylococcus aureus* ATCC 25923, and *S. aureus* ATCC 43300) using the cross-streak method. They were also screened for Gram-negative and autoinducer-2 quorum sensing inhibition using the colony agar-overlay method, using *Chromobacterium substugae* CV017, *Chromobacterium violaceum* ATCC 12472 and *Vibrio campbellii* BB 120 as biosensors.

Bacterial isolates differed in their colony characteristics and pigmentation. Results of the cellular characterization of bacterial isolates revealed that there were more Gram-positive (77.9%) than Gram-negative bacteria (22.1%) and more rods (95.0%) than cocci (5.0%). A total of 22 (9.7%) bacterial isolates were graded to have exhibited at least strong inhibitory activity against one or more clinical isolates tested. A higher percentage of inhibitory activity was observed against Gram-positive bacteria (100%) than against Gram-negative bacteria (31.8%). Twelve (5.3%) endophytic bacterial isolates exhibited quorum sensing inhibition against at least one of the quorum sensing biosensor organisms. A higher quorum sensing inhibition was observed against the short-chain acyl homoserine lactone (2.7%) compared to the long-chain acyl homoserine lactone (0.4%).

Hence, in the quest for alternative effective antibacterial agents, endophytic bacteria from *K. africana* present promising potential for the production of novel compounds that can be of pharmaceutical use.

SLS-O-2

MICROBIOME ASSOCIATED ANTIBIOTIC RESISTANCE GENES IN FISH FROM A LOCAL RIVER IN KWAZULU-NATAL, SOUTH AFRICA

Suveena Govender

219063450@ukzn.ac.za

Student Number: 219063450

School of Life Sciences

Supervised by Prof Sandi Willows-Munro, Prof Stefan Schmidt and Dr Matthew Burnett

The presence of antibiotic-resistant microbes (ARMs) in the microbiome of a vertebrate indicates potential resistance to antibiotics. Consumption of wildlife or livestock with antibiotic resistant bacteria can lead to the establishment of antibiotic resistance genes within the human gut microbiome, decreasing the effectivity of antibiotic treatment. Antibiotic residues have been detected in the effluent of wastewater treatment plants (WWTPs) and freshwater systems in KwaZulu-Natal. The impact this has on wild aquatic populations is not well understood. This study aimed to detect the presence of ARMs and antibiotic-resistant genes (ARGs) in the microbiomes of four species of free-swimming fish (*Cyprinus carpio*, *Labeobarbus natalensis*, *Oreochromis mossambicus* and *Clarias gariepinus*) in the Msunduzi River, using both phenotypic and genotypic methods. Singular and multi-drug resistant isolates of opportunistic pathogenic bacteria (such as *Morganella morganii, Esherichia coli, Pseudomonas fluorescens*, *Stenotrophomona maltophilia* and *E faecium*) were detected from three fish species (*C. gariepinus*, *C. carpio* and *L. natalensis*). Worryingly, resistance against tetracycline and third generation ß-lactam antibiotics (such as cephalosporins and ampicillin) were detected in several bacterial isolates from all three fish species. Feeding behaviour potentially affected the presence of ARMs as sediment-feeder fish species (*C. carpio* and *C. gariepinus*) yielded chloramphenicol, trimethoprim, fluoroquinolone, and carbapenem-resistant bacteria. Resistance to aminoglycosides, carbapenems, and cephalosporins were only detected in bacterial isolates from *C. carpio*. Whole-genome sequencing of phenotypically profiled ARMs will be conducted to confirm the antibiotic genotype profile correlates with the phenotype resistance profile. The results of this study highlight the occurrence of antibiotic-resistant bacteria and resistance-encoding genes in microbiomes of wild fish populations, aligning with the OneHealth initiative in identifying antibiotic-resistant gene reservoirs in wild animal populations and the importance of mitigation strategies to prevent the distribution of antibiotic-resistant genes between wild populations, humans, and livestock.

SLS-O-3

Therapeutic Potential of Ginkgo Biloba-Synthesized Solid Lipid Nanoparticles for siRNA Delivery Targeting the LRRK2 G2019S Mutation in Parkinson's Disease

Keelan Jagaran

215055447@stu.ukzn.ac.za

Student Number: 215055447

School of Life Sciences

Supervised by Professor Moganavelli Singh

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by the loss of dopaminergic neurons and the presence of Lewy bodies. A significant genetic contributor to PD is the LRRK2 G2019S mutation, which leads to increased kinase activity and cellular dysfunction. Current treatments for PD are primarily palliative, necessitating an innovative gene delivery system adapted to a curative function. This study aimed to develop a therapeutic strategy using siRNA and gene silencing to target the LRRK2 G2019S mutation and mitigate its pathogenic effects.

We initially demonstrated a proof of principle study using Ginkgo biloba extract (GBE)-functionalized sphingomyelin-cholesterol solid lipid nanoparticles (GBE-PLL-SLNPs). These SLNPs were successfully bio-synthesized using

Ginkgo biloba leaf extract, facilitating a dual therapy with favourable properties from the GBE and lipid components. Safety and efficiency were assessed through Caspase, MTT, and cellular uptake assays on wild-type SH-SY5Y cells, confirming biocompatibility and efficient internalization, with cell viability exceeding 90%.

In the second phase, we evaluated the therapeutic efficacy of GBE-PLL-SLNPs and compared them with H_2O-PLL-SLNPs in LRRK2 G2019S mutated SH-SY5Y cells. GBE-PLL-SLNPs reduced ROS (+) levels by 51.39%, compared to a 31.27% reduction by H_2O-PLL-SLNPs. The multi-colour DNA damage assay showed that GBE-PLL-SLNPs decreased total DNA damage by 49.90%, whereas H_2O-PLL-SLNPs achieved a 33.17% reduction. Additionally, GBE-PLL-SLNPs reduced kinase activity by 52.65%, surpassing the 40.02% reduction by H_2O-PLL-SLNPs. Lastly, a 47.31% reduction was noted in the mitopotential assay on the transformed SH-SY5Y cells. The gene silencing efficiency of GBE-PLL-SLNPs was particularly notable, effectively silencing the LRRK2 G2019S gene and resulting in a significant reduction in kinase activity and associated cellular dysfunction.

The consistent efficacy of GBE-PLL-SLNPs is attributed to the bioactive components in Ginkgo biloba extract, which provide additional antioxidant and DNA repair benefits. These components enhance the nanoparticles' properties, facilitating better cellular uptake and siRNA delivery, confirming the dual therapeutic capabilities of GBE and siRNA. The treatment effectively mitigated the pathogenic effects of the LRRK2 G2019S mutation. These findings suggest that GBE-PLL-SLNPs are a highly effective therapeutic delivery vehicles for managing PD, particularly in cases involving the LRRK2 G2019S mutation. The results highlight the potential of GBE-PLL-SLNPs as a promising treatment for PD, emphasizing the importance of natural extract-based therapies in advancing personalized medicine. This innovative approach highlights environmental safety, reduced toxicity, and cost-effectiveness of using Ginkgo biloba extract, making advanced therapies more accessible and sustainable for a broader range of neurodegenerative and genetic disorders.

SLS-O-4

SMALL-SCALE HABITAT HETEROGENEITY IS MORE IMPORTANT FOR SPIDER ALPHA AND BETA DIVERSITY ON AN ARID MOUNTAIN

Caroline Kunene

213570208@stu.ukzn.ac.za

Student Number: 213570208

School of Life Sciences

Supervised by Dr Caswell Munyai

Different biogeographic principles have been proposed to explain the high biodiversity found on temperate and tropical mountains, but not so much on arid mountains as arid mountain systems remain understudied. The aim of the study, therefore, is to understand what process's structure spider alpha and beta diversity across an arid mountain in the Limpopo province. Standardised pitfall surveys were conducted in nine game reserves at different distances from each other within the Waterberg mountains. In each game reserve, at different elevations (900 masl, 1000 masl, 1200 masl, 1400 masl, 1600 masl and 1800 masl) the North and South aspect were identified and their open and closed habitats were sampled.

A total of 1831 spider specimens were collected. They belong to 30 families and 153 species. Gnaphosidae, Salticidae and Lycosidae were the most abundant families respectively while Asemesthes ceresicola, Stenaelurillus guttiger, Pardosa Crassipalpis and Ibala arcus were the most abundant species respectively. Spider richness did not follow any clear pattern with elevation. Spider richness and activity were influenced by structural complexity, both were significantly higher in open habitats compared to the closed habitat. Spider activity on the other hand was also influenced by geographical distance. The shorter the geographic distance, the more nested the habitats were while the larger the geographic distance, the more important turnover became. Turnover was significantly higher for open sites while species loss was significantly higher for closed sites with increasing geographic distance. The Southern aspect had significantly larger turnover, while the Northen aspect had significantly larger species loss with geographic distance.

These results suggest that there is a trade-off as temperature decreases and rainfall increases perhaps resulting in constant productivity and consequently constant spider richness on the Waterberg Mountain. Small scale process's structure spider communities on this mountain, and open savanna habitats especially on the Southern parts of the mountain promote spider activity suggesting that it would be more important to conserve microhabitats on the Waterberg mountains.

SLS-O-5

3-D functional skull morphology and acoustics signal design – a within and across species analysis of southern African horseshoe bats

Thandiswa Maduna

218023934@stu.ukzn.ac.za

Student Number: 218023934

School of Life Sciences

Supervised by Dr Anna Bastian

Horseshoe bats have an interestingly similar and simple echolocation call design initiated by the Frequency-Modulated component (FM) followed by Constant-Frequency component (CF) then Frequency-Modulated component (FM). However, the peak frequency of the CF component varies greatly, ranging from 25-280 kHz. The variability exists both within and across species, making this specific family of bats a central subject to study signal divergence and/ or convergence. The variation in the peak frequency of the CF component is shaped by different selection forces such as climate (signal transmission), prey size (wavelength), or body size (allometry); which have been studied extensively and revealed an interplay between them. Furthermore, this variation can also be a result of the structures (nasal capsule) that emit these acoustic signals. The nasal capsule act as filters for the sound waves produced by the vocal cords (source-filter theory). Therefore, the present study investigates the relationship between the variation in skull morphology and echolocation call frequency of horseshoe bats in southern Africa. The objective was to analyze skull features/shape within and across species, to determine if the same morphological features co-vary with signal frequency and thus may represent adaptive signal-shaping filters in bats. Bat skulls from the existing database and museums were scanned at NECSA and reconstructed into 3-dimensional object files using dragonfly software; then used to analyze the skull shape and size through geometric morphometrics. The preliminary results showed that variation in the size of skull morphology (nasal capsule) is related to the differences in echolocation call frequency. Further statistical analysis (Canonical Variate Analysis and Correlation) is still being conducted to investigate the relationship between skull morphology and echolocation call frequency; and whether there is a pattern in which the size of nasal capsule can be used as predictor of echolocation call frequency. The within and across species analysis of this study will provide a broad view of the correlation that exists between skull morphology and acoustic signal design in southern African bats, which has never been done before.

SLS-O-6

EFFECTS OF EXTRACTION METHODS ON ANTIOXIDANT AND ANTI-HYPERGLYCAEMIC ACTIVITY OF FUCOIDANS FROM *ECKLONIA RADIATA*

S'thandiwe N. Magwaza

221033135@stu.ukzn.ac.za

Student Number: 221033135

Supervised by Prof Shahidul Islam

Fucoidans, bioactive sulfated polysaccharides, are found in various brown seaweed species. This study investigated the impact of extraction methods on the antioxidant and anti-hyperglycemic activities, yield, phenol, sugar, and fucose

content, and functional groups of fucoidans from *Ecklonia radiata*. The seaweed (*E. radiata*) was extracted using three methods including (A) HCl, at room temperature for 24 hours, (B) 85% Ethanol, at room temperature for 12 hours, and (C) 0.5% EDTA, at 70°C, for 3 hours. The antioxidant activity was measured through estimating total antioxidant capacity, phenol content, DPPH and hydroxyl radicals scavenging activity, as well as ameliorative effects against glucotoxicity in the serum. The anti-hyperglycaemic activity were assessed using carbohydrate digesting enzymes (α-amylase and α-glucosidase) inhibitory assays. The percentage yield, phenol, sugar and fucose content was higher for the method A (7.06%; 48.01±0.98%, 52.03±2.18%, 56.91±2.2%) than method B (0.81%, 7,03±1.01%, 3.6±1.98%, and 56.91±2.2%) and C (4.23%, 35.1±0.67%, 11.11±2.01%, and 13.04±0.98%). The antioxidant and anti-hyperglycaemic activities were also followed similar trend in this experiment. Functional group analysis revealed that the presence of a sulfated ester group, which is similar to commercial fucoidan. The highest antioxidant activity of fucoidan from *E. radiata* was found in the extracted obtained by using method A (HCl, room temperature for 24 hours,), which was influenced by its sulfate content. Therefore, the HCl extraction method of fucoidan from *E. radiata* can be considered as a better method than ethanol and EDTA, particularly for its antioxidative and antihyperglycemic potentials. Further ex vivo and in vivo studies are required to confirm the results of this study.

SLS-O-7

ASSESSING THE MICROBIAL BURDEN OF LEAFY GREEN FRESH PRODUCE SOURCED FROM LOCAL FARMS, STREET VENDORS, AND RETAILERS

Phila Mbambo

217002085@stu.ukzn.ac.za

Student Number: 217002085

School of Life Sciences

Supervised by Professor Stefan Schmidt and Dr Maike Claussen

The contrast between the energy input in large-scale commercial and small-scale farms affects energy sustainability in agriculture. While large-scale commercial farms are more likely to use energy-dependent mechanical methods, such as automated irrigation, harvesting, and processing, small-scale farms, on the other hand, typically utilize manual, low-energy consuming methods, reducing energy input. Distributing fresh produce to consumers via retailers will consume more energy, however, directly selling fresh produce on farms, via farmer markets, or street vendors might be less energy-demanding.

This study aimed to assess the microbial quality of fresh produce representing both the small-scale farming and the retail sector. Thus, the general microbial burden was assessed, establishing the aerobic plate count (APC, the enumeration of aerobic heterotrophic bacteria associated with a given fresh produce quantity), while the presence of the hygiene indicator *E. coli* was verified using tryptone bile glucuronide agar. In addition, the presence of antibiotic-resistant bacteria was determined using plate count agar with an added cephalosporin antibiotic.

Produce from small-scale farmers, such as kale and spinach, had aerobic plate counts ranging from 4.26 – 7.11 log CFU per gram, matching similar produce from retailers ranging from 5.22 to 7.44 log CFU/g, whereas fresh produce from street vendors had counts between 5.15 and 6.52 log CFU per gram. Notably, retail store spinach reached a maximum APC of 7.44 log CFU per gram, while spinach collected at small-scale farms reached a maximum APC of 6.24 log CFU per gram. However, in both small-scale and retail fresh produce, antibiotic-resistant Pseudomonadota were detected, while *E. coli* was usually below the level of detection.

Selected antibiotic-resistant isolates from small-scale farming and retail sources were further analysed taxonomically by MALDI-ToF-MS to assign these to the genus level. The results suggest that small-scale farming, while potentially less energy-demanding, can achieve produce quality matching that of retailers.

SLS-O-8

Targeting the pupylation cascade system of Mycobacterium tuberculosis for the development of novel anti-tubercular drugs

Sandile Mthembu

216009509@stu.ukzn.ac.za

Student Number: 216009509

School of Life Sciences

Supervised by Prof Raymond Hewer and Dr Alexandré Delport

The increased prevalence of drug resistant *Mycobacterium tuberculosis* (*Mtb*) strains, which renders traditional treatment options ineffective, necessitates the development of novel anti-Tubercular drugs that possess innovative modalities. The endogenous protein-recycling pupylation cascade system in *Mtb* presents an enticing new target for drug development. Our work seeks to identify the first described small-molecule ligands capable of selectively targeting the pupylation cascade system of *Mtb.*

To this effect, the pupylation integral protein pup ligase (PafA) was recombinantly expressed, purified, and characterised from BL21 (DE3) *Escherichia coli* cells. An optimised PafA thermal shift assay was subsequently recruited to screen PafA against small-molecule compounds, each pre-screened for aggregation activity, from the DiverSET CHEMBRIDGE compound library.

Results

Seven Hit-compounds from the chemical library were detected significantly binding PafA ($P < 0.05$), all inducing a > 5 °C increase in PafA melting temperature (Tm) upon binding. Further screening of the compounds within a cellular environment confirmed three of the compounds to have the highest propensity to bind PafA, each resulting in a > 6 °C increase in PafA aggregation temperature (Tagg).

Conclusions

Through screening and experimental evaluations, compounds were identified as successful PafA-binders evidenced by the increased stability of the protein in the presence of the respective compounds.

Keywords: Pupylation; PafA;

SLS-O-9

Plasmid Construction for Gene editing using the CRISPR/Cas9 system

Nduduzo Bhekokuhle Ndlovu

221114669@stu.ukzn.ac.za

Student number: 221114669

School of Life Sciences

Supervised by Dr Nontuthuko E. Maningi and Dr John Osei Sekyere

Pyrazinamide is a first-line drug used in treating Tuberculosis. Mutations in the *pnc*A gene have been associated with failure to produce pyrazinamidase, leading to drug resistance. Pyrazinamidase is an enzyme produced by the *pnc*A gene, and converts Pyrazinamide to pyrazinoic acid which is the active form of the drug. The CRISPR/Cas9 system is a natural adaptive system in organisms that has been used to modify the DNA of organisms. The study therefore aims to understand how mutations in the *pnc*A gene lead to drug resistance against Pyrazinamide. DNA was extracted from *Mycobacterium tuberculosis* isolates that had been revived on 7H9 media. Whole-genome sequencing of the isolates was done using the Illumina sequencing platform. Bioinformatic analysis was done using Resfinder to detect possible

mutations. The wild-type *pnc*A gene was then amplified and inserted into the pUC19 plasmid using Gibson assembly cloning. The rDNA was subsequently transformed, and confirmation done via conventional PCR and gel electrophoresis. The CHOPCHOP web interface was used to detect target sites for CRISPR mediated engineering. Mutations in the *pnc*A gene were created using the NEB-Q5 SDM kit, and the cells were subsequently transformed. Confirmation was done via conventional PCR and gel electrophoresis. The CRISPR plasmid to edit the mutations was constructed using Circular Polymerase Extension Cloning (CPEC). The results of the sequencing detected the L151S mutation in the *pnc*A gene. The *pnc*A gene was successfully inserted into the pUC19 plasmid, while the G132R, V139A and K96T mutations were successfully inserted into the *pnc*A gene. In conclusion, there is a need to study different mutations in the *pnc*A gene and understand how there may lead to drug resistance. The CRISPR/Cas9 system is an important system that can be used in the modification of the DNA of organisms.

SLS-O-10

Green synthetic strategies for metallic nanoparticles and their biotechnological applications

Khanyisile Ngcongco

221121519@stu.ukzn.ac.za

Student Number: 221121519

School of Life Sciences

Supervised by Dr Karen Pillay and Dr Anushka Govindsamy

Increasing industrial activity is posing a challenge to the supply and availability of safe water for living organisms. The textile, printing and food industries are known for releasing wastewater containing dyes into the environment causing pollution to natural water bodies. These dyes are mostly toxic and have a negative impact on the environment and human health. The exploration of metal nanoparticles for the removal of dyes in wastewater has become a hot topic over recent years as an alternative to the conventional methods for dye degradation. Nanoparticles being an integral part for the foundation of nanotechnology are nanomaterials with sizes between 1-100 nm possessing a unique set of physicochemical properties such as their small sizes and morphologies, large surface area to volume ratio and magnetization. However, the hazardous effects of their production have become a setback due to the toxic reagents required for synthesis, high cost of production, high energy consumption and pollution during synthesis. This has highlighted the need for alternative nanoparticle synthetic strategies that will not be harmful to the environment. The synthesis of nanoparticles using green synthesis methods has opened a door to create easy, cost-effective approaches towards producing nanoparticles while also being considerate of the environment.

The study aimed to use a green synthetic strategy to synthesise metal nanoparticles. The study involved the green synthesis of silver and gold nanoparticles using aqueous extracts of *Aloe ferox Mill.* Aloe plants are known for their therapeutic and curative properties. The phytochemicals present in the extract acted as reducing and stabilizing agents for nanoparticle synthesis. The biosynthesised metal nanoparticles were characterised using ultra-violet visible spectroscopy (UV-vis), transmission electron microscopy and energy dispersive X-ray spectroscopy (TEM-EDX) analysis and zeta potential. UV-vis spectroscopy analysis of the silver and gold nanoparticles showed characteristic peaks at the wavelengths of 430 nm and 550 nm, respectively. The size, shape and elemental composition of the metal nanoparticle samples were confirmed using TEM-EDX analysis. The zeta potential analysis showed that the metal nanoparticles were moderately stable and moderately dispersed. The biosynthesized metal nanoparticles were used as catalysts for the degradation of methyl orange. The nanoparticles exhibited up to ±50 % methyl orange degradation in 10 minutes. The p-iodonitrotetrazolium chloride (INT) colorimetric assay was used to determine the antibacterial activity of the nanoparticles against *Escherichia coli, Enterococcus faecalis*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. The biosynthesised metal nanoparticles displayed promising antibacterial activity.

SLS-O-11

ESTABLISHMENT OF MICROPROPAGATION AND CRYOPRESERVATION PROTOCOLS FOR THE CRITICALLY ENDANGERED MEDICINAL PLANT, *Siphonochilus aethiopicus*

Viloshanie Reddy

983172719@stu.ukzn.ac.za

Student Number: 983172719

School of Life Sciences

Supervised by Dr Shakira Shaik and Dr Dalia Varghese

The Zingiberaceae species, *Siphonochilus aethiopicus*, is a sought-after traditional medicinal plant in South Africa, and has led to its 'critically endangered' status. The main active ingredient, siphonochilone, present in the rhizomes and roots, has further prompted interest by the pharmaceutical industry. Vegetative propagation via separated rhizomes containing buds is the only feasible method due to poor seeding, and this also complicates long-term storage through seed banking. Hence, *S. aethiopicus* not only requires an alternate long-term ex situ conservation strategy, but also a micropropagation protocol. Therefore, this study aimed to first establish a micropropagation protocol using shoot apices derived from in vitro cultured rhizome buds, and then a vitrification-based cryopreservation protocol using those explants. A further aim was to compare siphonochilone content in micropropagated clones and vegetatively propagated plants.

Following decontamination, rhizome-derived bud explants were cultured on full-strength Murashige and Skoog (MS) basal salts and vitamins, 30 g l^{-1} sucrose, 5 mg l^{-1} 6-benzylaminopurine (BAP) and 4 g l^{-1} Gelrite® to promote development of shoot apices which were subsequently excised and multiplied on the same medium for 42 days. Elongation was achieved using the same medium for 28 days but with BAP reduced to 0.1 mg l^{-1}. The elongation medium was then supplemented with 1 mg l^{-1} indole-3-acetic acid (IAA) to promote rhizogenesis for another 28 days. Rooted plantlets were successfully acclimatised (100%) after 42 days and yielded 15 plants per explant while vegetatively propagated plants yielded 2 plants per separated rhizome. Siphonochilone content, quantified using Gas Chromatography-Mass Spectrometry (GC-MS), was similar in rhizomes for micropropagated and vegetatively propagated plants but significantly higher in roots of micropropagated clones.

Droplet vitrified shoot apices that were first cultured on gelled MS medium with 0.09 M sucrose for 48 h and then with 0.3 M sucrose in the dark for 24 h, followed by immersion in a cryoprotection mixture (10 min); then a loading solution (5 min) followed by PVS2 (10 min), showed the highest viability (58%) and survival (67%) following rapid cooling, cryostorage. Recovery, using the established micropropagation protocol up to the elongation stage, was 60%. Shoots are currently undergoing in vitro rooting; which will be followed by GC-MS analysis of siphonochilone in the rhizomes of regenerated and acclimatised plants. This study has successfully developed strategies to mass propagate and conserve *S. aethiopicus*, and also demonstrated the presence of siphonochilone in clones. Nonetheless, further research is necessary to improve cryostored explant recovery rates.

SLS-O-12

Environmental DNA sequencing for biodiversity detection in selected northern KwaZulu-Natal estuarine lakes

Keneilwe Thekiso

214549992@stu.ukzn.ac.za

Student Number: 214549992

School of Life sciences

Supervised by Dr Tshoanelo Miya

Environmental DNA (eDNA) Shotgun metagenomic sequencing entails the comprehensive sequencing of all the DNA present in a sample from a body of water. This approach offers a holistic view of the biodiversity inherent in a sample, providing insights into the potential presence of rare or uncultivable organisms. Despite its many advantages, however, the use of eDNA metagenomics in South Africa as an assessment tool for biodiversity is lacking. The aim of this study was to assess the efficiency of eDNA metagenomics in surveying diverse life forms across the entire tree of life in three estuarine lakes situated in the northern KwaZulu-Natal province. To achieve this water samples were collected from three estuarine lakes and vacuum filtered using 0.45 µm nylon membrane filters. The DNeasy Blood and Tissue kit was used to extract DNA from the filters and sample extracts underwent shotgun sequencing on the Illumina MiSeq platform. Analyses of the resulting sequence data produced a total of 22 624 431 raw reads which resulted in 930 amplicon sequencing variants (ASV) after filtering and clustering. DADA2 was used to assign taxonomic assignment of the ASVs produced. These results indicate that the eDNA metagenomic sequencing approach can efficiently detect the biodiversity present to the species in South African estuarine environments.

ORAL ABSTRACTS

SCHOOL OF MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

SMSCS-O-1

Electromagnetic Simulation and Performance Enhancement of the Redesigned HIRAX Feed Antenna

Sindhu Gaddam

221117109@stu.ukzn.ac.za

Student Number: 221117109

School of Mathematics, Statistics & Computer Science

Supervised by Prof Kavilan Moodley

The Hydrogen Intensity and Real-time Analysis experiment (HIRAX)[1][2] is a pioneering radio telescope array aimed at mapping large-scale structures in the universe and probing the mysteries of dark energy. A crucial element of HIRAX[3] is its feed antenna, designed to capture cosmic signals with good precision. This presentation will cover the recent redesign of the HIRAX feed antenna, focusing on overcoming the limitations of the original design to improve return loss and radiation pattern characteristics.

Utilising advanced electromagnetic simulation tools, particularly CST Microwave Studio, we optimized the antenna's geometry, resulting in significant performance enhancements. The redesign process involved rigorous simulations, iterative adjustments and optimization to fine-tune the antenna's parameters. I will discuss the challenges we encountered, including impedance matching and polarization purity, the innovative design solutions we implemented, and the simulation results that highlight the substantial improvements in performance.

The outcomes of this redesign not only elevate the capabilities of the HIRAX project but also provide valuable insights for future advancements in radio astronomical instrumentation. This talk will demonstrate how the improved feed antenna design enhances signal fidelity, contributing to more accurate cosmic mapping and a deeper understanding of the universe's large-scale structure.

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SMSCS-O-2

Mathematical Model of Immune Response to Hepatitis C Virus (HCV) Disease

Amna Ibrahim

216075883@stu.ukzn.ac.za

Student Number: 216075883

School of Mathematics, Statistics and Computer Science

Supervised by Dr Hermane Mambili-Mamboundou

This paper presents a mathematical model to comprehensively analyze the dynamics of Hepatitis C Virus (HCV) infection. The nonlinear ordinary differential equations (ODEs) system integrates hepatocyte cells, Hepatitis C virus, immune cells, and cytokines. We establish the well-posedness of the model in a biologically feasible region, determine the reproductive number $\Re 0$ using the next-generation method, and conduct some sensitivity analysis for the reproductive number. Conditions for both the disease-free and the endemic equilibrium stability are derived. We investigate the system's behavior under various immune response scenarios: a weak immune response, the absence of T helper cell support, and a strong immune response. Among other results, the lack of Interleukin−2 cytokine Significantly influences the activation of CTL cells. Our results show the significance of T helper cells, Interferon−γ, and Interleukin−2 cytokines for a more accurate representation of infection dynamics and highlight the critical role of a potent immune defense in combating HCV. This study contributes to a deeper understanding of HCV infection dynamics and the pivotal role of immune responses in shaping the course of the disease.

SMSCS-O-3

Optimising Energy Efficiency in 5G Network Slicing with Hierarchical Reward Weighting using Multi-Objective Reinforcement Learning

Charles Ssengonzi

223152802@stu.ukzn.ac.za

Student Number: 223152802

School of Mathematics, Statistics, and Computer Science

Supervised by Professor Paul Kogeda

As the global push to monetise 5G network slicing intensifies, optimizing resource allocation in sites and data centres has become crucial for mobile network operators. This study focuses on enhancing base station throughput and energy efficiency in a 5G multi-slice environment, given its significant impact on overall network sustainability and operation costs. We introduce a novel algorithm that incorporates Hierarchical Reward Weighting (HRW) within a dynamic multi-objective reinforcement learning (DMORL) framework to address this challenge. HRW allows dynamic adjustments to reward weights, balancing conflicting objectives, throughput and energy consumption in real-time. The algorithm divides the resource allocation problem into high-level and low-level decision processes. The high-level

agent manages inter-slice resource allocation, while lower-level agents handle intra-slice allocation, distributing resources to mobile users in enhanced Mobile Broadband (eMBB) and Ultra Low latency communication (uRLLC) slices. Our results, validated in a dynamic multi-objective gaming environment, demonstrate significant improvements in balancing throughput and energy efficiency, offering valuable insights for 5G and beyond network slicing strategies compared to traditional approaches.

Keywords: 5G, Multi-Objective Optimization, Multi-Objective Reinforcement Learning, Energy efficiency, Network slicing, Throughput, latency.

SMSCS-O-4

Mathematical Models of Dengue Transmission Dynamics with Intervention Strategies

Thato Setjhaba Motaung

218043630@stu.ukzn.ac.za

Student Number: 218043630

School of Mathematics, Statistics and Computer Science

Supervised by Dr Hloniphile Sithole Mthethwa

Prioritizing control implementation for dengue prevention and control for efficiency is crucial to the government, decision-makers, and policymakers, particularly in resource-limited communities where the disease is endemic. In this paper, a compartmental model is presented to investigate the effects of preventive and control measures on dengue disease transmission. The vaccination is included as a control measure in the population and vector control measures to eradicate the dengue in the society. Qualitative analysis of the model is carried out to minimize dengue spread and the control using Mathematical Modelling theory. We study the demographic factors that influence equilibrium prevalence, and perform a sensitivity analysis on the basic reproduction number. Among several intervention measures, the effects of two potential control methods for dengue fever are estimated: introducing Open space spraying method to the mosquito population and introducing vaccines to the human population. Numerical implementation is carried out on the model and the results of simulation showed that an efficient control of dengue disease relies on the combination of human preventive and vector control measures. Keywords: Dengue; Dengue Mathematical Models, basic reproduction number, vaccination, vector control.

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SMSCS-O-5

The study of extended radio galaxies in MERGHERS fields

Banele Mthembu

22208203@stu.ukzn.za

Student Number: 222082013

School of Mathematics, Statistics, and Computer Science

Supervised by Dr Kenda Knowles (RU/SARAO) and Dr Precious Sikhosana

Radio galaxies play an important role in the formation of structures in the Universe. Studying the physical properties of both classical radio galaxies (FRI and FRII), as well as their more morphologically complex counterparts (NATs, WATs, BTs, X-shaped, etc.), can help in understanding their specific role and how their local environment affects their properties, and vice versa. The MERGHERS survey is carrying out targeted observations of galaxy clusters using MeerKAT's L- and/or UHF bands. The wide-field images contain many instances of extended radio galaxies across all morphologies.

This project aims to catalogue and study the extended radio galaxies in the 21 cluster fields from the first tier of MERGHERS data, investigating their environmental link and studying their spectral properties. The project will investigate the statistics of the radio galaxies and their relationship to their environment (field versus cluster), study the spectral properties of the sources by producing in-band spectral index maps, or other frequency data where available, and investigate the environmental impact on sources with non-classical morphologies.

SMSCS-O-6

A Multi-Class Quantum Kernel-Based Classifier

Shivani Mahashakti Pillay

217039130@stu.ukzn.ac.za

Student Number: 217039130

School of Mathematics, Statistics and Computer Science

Supervised by Prof Ilya Sinayskiy, Dr Edgar Jembere and Prof Fracesco Petruccione

Multi-class classification problems are fundamental in many varied domains in research and industry. A popular strategy for solving multi-class classification problems involves first transforming the problem into many binary classification problems. However, this requires the number of binary classification models that need to be developed to grow with the number of classes. Recent work in quantum machine learning has seen the development of multi-class quantum classifiers that circumvent this growth by learning a mapping between the data and a set of label states. This work presents the first multi-class SWAP-Test classifier inspired by its binary predecessor and the use of label states in recent work. With this classifier, the cost of developing multiple models is avoided. In contrast to previous work, the number of qubits required, the measurement strategy, and the topology of the circuits used is invariant to the number of classes. In addition, unlike other architectures for multi-class quantum classifiers, the state reconstruction of a single qubit yields sufficient information for multi-class classification tasks. Both analytical results and numerical simulations show that this classifier is not only effective when applied to diverse classification problems but also robust to certain conditions of noise.

This work is published and can be found here:

Pillay SM, Sinayskiy I, Jembere E, Petruccione F. A Multi-Class Quantum Kernel-Based Classifier. Advanced Quantum Technologies. 2024 Jan;7(1):2300249.

SMSCS-O-7

VGG16-BASED TRANSFER LEARNING APPROACH FOR BREAST CANCER CLASSIFICATION

Caroline Ruvinga

224194796@stu.ukzn.ac.za

Student number: 224194796

School of Mathematics, Statistics and Computer Science

Supervised by Prof Serestina Viriri

In Africa and around the world, breast cancer ranks among the top causes of mortality for women. For patients to receive better treatment outcomes, early identification and diagnosis of breast cancer are essential. The paper describes a transfer learning approach for improving breast cancer diagnostic accuracy that is based on the VGG16 Convolutional Neural Network. In the pas a majority of breast cancer detection and classification techniques have faced many difficulties. These difficulties include delayed diagnosis caused by the need for multiple expert reviews to reach an accurate diagnosis, as well as manually created computer-aided classification techniques that resulted in incorrect diagnoses and subpar treatment plans. However, the advancement of deep learning models has led to the creation of an autonomous feature extraction technique that significantly improves the classification accuracy of breast cancer. Recent studies have demonstrated that deep learning-based models can quickly attain accuracy levels that are comparable to those of manually constructed computer-aided categorization methods. This paper presents the use of histology images in the deep learning approach to construct a classifier for breast cancer. The classifier is built upon the VGG16 deep learning algorithm. Highlights on the classifier development process using a transfer learning approach are outlined. The preprocessing techniques data augmentation, hyper parameter tuning employed in order to achieve a higher accuracy are detailed. The classifier was trained, validated, and tested on the Break His public dataset and achieved an accuracy of 97%.

SMSCS-O-8

MODELLING CHILDHOOD MALARIA: CASE STUDY OF LIBERIA (MIS 2022)

Sydney Lethukuthula Sambo

219034847@stu.ukzn.ac.za

Student Number: 219034847

School of Mathematics, Statistics and Computer Science

Supervised by Dr Faustin Habyarimana and Prof Shaun Ramroop

Malaria is among the leading public health problems in Sub-Saharan countries. The main objective of this study were to find the prevalence of malaria among children under five years of age in Liberia and identify the factors that influence the transmission of malaria among children under five years of age in Liberia. The study used 2022 Liberia Malaria indicator Survey data. The sampling was done based on multistage sampling with unequal probability of selection. In order to account for complexity of sampling design, the survey logistic regression model was used to fit the data where the response variable was the presence or the absence of malaria.

A total of 2887 children was considered in the study and 10% tested positive to malaria. The study considered many variables in the analysis and Region, Cluster altitude, Type of toilet facility, Age in months (for children) and Mothers highest educational level were found as the risk factors associated with malaria infection among children aged between 6 months to 59 months in Liberia.

The result from the study suggests that the proper use of toilet facilities, proper education among the parents and other preventative measures, along with factors like the number of rooms in a house, are linked to a reduction in malaria incidence. These findings from this study may be used by public health planners, policymakers, and other relevant organizations in making informed decisions about the prevention of malaria, particularly about children under the age of five.

Keywords: 2022 Liberia MIS, Malaria, Children under five years

SMSCS-O-9

ANALYSING TREATMENT DISENGAGEMENT IN BREAST CANCER PATIENTS IN ZIMBABWE USING GEO-ADDITIVE DISCRETE-TIME SURVIVAL MODELS

Bester Saruchera

220107117@stu.ukzn.ac.za

Student number: 220107117

School of Mathematics, Statistics and Computer Science

Supervised by Professor Henry Mwambi and Dr Oliver Bodhyera

Breast cancer is among the most common cancers affecting women globally and treatment adherence is crucial for improving patients' health outcomes. Treatment disengagement (TD), a reflection of the level of development and quality of the healthcare system, remains highly prevalent in developing countries, with patients disengaging from health facilities at various points of care. The objective of this study is to investigate the risk factors associated with TD in Zimbabwe using a geo-additive discrete time survival model. By incorporating fixed, non-linear and spatial varying effects, we account for the heterogeneity in patient and clinical characteristics and regional disparities on healthcare quality and accessibility. We utilized data from a retrospective study of diagnosed breast cancer patients enrolled at Parirenyatwa Radiotherapy unit in Zimbabwe between 2015 and 2019. Inference is fully Bayesian, based on the computationally efficient Markov chain Monte Carlo techniques. The study revealed significant spatial variations in TD among regions, highlighting provinces with higher risks of TD. Older patients, those with larger tumours, and longer durations between onset and diagnosis, were likely to disengage from treatment. This study contributes to the understanding of TD dynamics and offers valuable insights that can inform targeted interventions and resource allocations to mitigate TD, particularly in high-risk regions. We recommend that policymakers prioritise the establishment of province-specific treatment centres in order to mitigate the risk of TD and improve patient follow-up care.

SMSCS-O-10

LLM Supply Chain Provenance: A Blockchain-based Approach

Shridhar Singh

217008024@stu.ukzn.ac.za

Student Number: 217008024

School of Mathematics, Statistics, and Computer Science

Supervised by Mr Luke Vorster

The rapid advancement of Large Language Models (LLMs) has underscored the critical need for robust mechanisms to ensure data integrity and supply chain provenance. Traditional LLM architectures often lack robust mechanisms for provenance tracking and data transparency. Without transparency into the data used to train these models, the risk of bias, misinformation, and security vulnerabilities is amplified. This research explores the potential of Blockchain Technology (BCT) to address these challenges by establishing a secure and verifiable record of the LLM's data supply chain. By simulating a Blockchain-based LLM architecture, we investigated how to track critical data points within the LLM data supply chain, such as data source and categorisation, embeddings utilised, and the model itself, to identify potential biases and manipulation. Our findings demonstrate that Blockchain-based LLMs can significantly enhance LLM transparency, accountability, and trust by providing a verifiable and immutable record of the model's input-output data streams. Through a custom-designed Blockchain architecture, we explored how to secure data provenance within the LLM data supply chain, prevent unauthorised access, and mitigate the risk of data tampering. With results demonstrating the feasibility of using Blockchain to establish a secure and transparent LLM development process, this research contributes to the growing body of knowledge on LLM governance and security, offering valuable insights

for practitioners and policymakers. By addressing the critical issue of data provenance within the LLM data supply chain, we aim to foster a more responsible and ethical development of LLMs.

SMSCS-O-11

λ - Symmetries

SLUNGILE TSHIBASE

220064962@stu.ukzn.ac.za

Student Number: 220064962

School of Mathematics, Statistics and Computer Science

Supervised by Prof Keshlan Govinder

Lies symmetries are a very useful method to solve differential equations. While it can be applied to a wide variety of equations, it is not universal. As a result, many extensions to the classical method have been devised in order to increase its applicability. In this study, we investigate a particular generalisation called lambda-symmetries (sometimes referred to as C-¥ symmetries). We show how they arise and demonstrate the usefulness of this approach by reducing the order of ordinary differential equations that could not be reduced via classical Lie point symmetries, via these lambda-symmetries.

SMSCS-O-12

On the Perfectness of the Higson-Type and Other Compactifications

Ntuthuko Zuma

218043316@ukzn.ac.za

Student Number: 218043316

School of Mathematics Statistics and Computer Science

Supervised by Dr Simo S Mthethwa

In this talk, perfect compactifications of topological and metric spaces will be discussed. The Stone-Čech compactification of a completely regular space and the Freudenthal compactification of a rim-compact space are examples of perfect compactifications of topological spaces. We will examine the perfectness of the Higson compactification, Higson-type compactifications, and the Smirnov compactification.

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FLASH ABSTRACTS

SCHOOL OF AGRICULTURAL, EARTH AND ENVIRONMENTAL SCIENCES

SAEES-F-1

CHARACTERISATION OF GROUNDWATER QUALITY USING INDICES AND STATISTICS IN THE KLIP RIVER COALFIELDS, SOUTH AFRICA

Abdulbasit Bala

219087401@stu.ukzn.ac.za

Student Number: 219087401

School of Agricultural, Earth and Environmental Sciences

Supervised by Mr Minenhle Siphesihle Ndlovu and Prof Molla Demlie

This research aimed to analyse water quality and the severity of heavy metal pollution, the potential pollution sources, and the human health risk of the groundwater in the Klip River Coalfields. 42 groundwater and 10 surface water samples were collected from various monitoring boreholes from coal mine locations. The south of the study area reported the highest Electrical Conductivity. The hydrochemical facies of the groundwater are Na-HCO_3 and undergoes mixing and dissolution. The heavy metal pollution index (HPI) of groundwater samples varied from 1.16-252.39 and classed as low to high pollution. 2.4 % of the samples exceeded the maximum admissible limits for drinking purposes. The groundwater water quality indices result 28.3 % of the samples are poor to very poor quality. The hazard quotient (HQ) for groundwater samples in decreasing order of significance: Ni > Mn > Cu > Fe > Pb > Cr and Ni >Cu > Mn > Fe > Cr > Pb for children and adults, respectively. Hazard index (HI) for groundwater samples ranged from 0.001-5.06 for children and from 6.94 $x10^{-4}$-3.17 for adults. The surface water HQ in decreasing order is Mn > Ni > Fe > Pb> Cu and Mn > Ni > Fe > Cu > Pb for children and adults, respectively. HI for surface water ranged 0.01-0.70 for adults and 0.02-1.10 for children. Multivariate statistical analyses describe that the trace metals were released into the groundwater by mineral dissolution and anthropogenic activities. Water resources in the study areas are mainly polluted by mining activities.

SAEES-F-2

A comparative analysis of Multi-spectral and RGB-acquired UAV data for Land Cover Mapping of Smallholder Farms

Evania Chetty

219051491@stu.ukzn.az.za

Student Number:219051491

School of School of Agricultural, Earth and Environmental Science

Supervised by Dr Maqsooda Mahomed

Smallholder farms play a pivotal role in ensuring food security, particularly in developing nations. However, they generally encounter several challenges which impede their capacity to produce optimally. The adoption of precision agriculture (PA) practices has the potential to improve the sustainability and productivity of

these farms. With unmanned aerial vehicles (UAVs) often being utilised to facilitate this process, in this study, we aimed to explore the potential of adopting a relatively cost-effective UAV-based approach to classify and map agricultural land within a smallholder farm. For this purpose, the Google Earth Engine cloud-computing platform was leveraged to process and analyse the UAV-acquired imagery over a smallholder farm setting situated in the KwaZulu Natal province of South Africa. Several machine learning-based classification approaches were utilised to map croplands using either RGB or multi-spectral data. The results of these investigations demonstrated that the random forest classifier, particularly in probabilistic mode yielded superior results in comparison to a traditional nonbinary classification approach. Model performance of the final classification revealed an area under the curve receiver operating characteristics (AUC ROC) value of 0.75 was achieved utilising UAV RGB data which is slightly below the 0.77 AUC ROC value obtained by the multi-spectral counterpart. Despite the classification accuracy using RGB data being lower, this difference was fairly minimal and demonstrates the potential of using data acquired from these sensors for cropland mapping in smallholder farms. This is particularly noteworthy as these sensors are relatively more affordable and may be more accessible, which presents a viable opportunity to resource-poor and data-scarce farming systems to facilitate PA practices which in turn can transform their agricultural practices, optimise resource use and enhance agricultural productivity.

SAEES-F-3

A new strategy in modelling Maputaland Coastal Plain wetlands: Prediction of groundwater levels using Long-Short Term Memory Model

Cornelia Chifurira

221121346@stu.ukzn.ac.za

Student Number: 221121346

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Erwin Sieben

The Maputaland Coastal Plain (MCP) in South Africa is home to diverse wetlands that provide essential ecosystem services to local communities, support aquatic species, and boost tourism. However, it is concerning that these wetlands are among the most threatened ecosystems in the country, facing significant risks from climate change and anthropogenic factors, particularly land-use changes. This study aims to forecast groundwater levels in the wetlands of the Maputaland Coastal Plain. The presence of surface water and groundwater is crucial for the health of these wetlands. We collected groundwater level data from 25 boreholes located within and around the MCP wetlands over a five-year period, with readings taken every 30 minutes. For analysis, this data was aggregated into daily intervals. Kurtosis statistics revealed that the groundwater level data exhibited heavier tails than a normal distribution and demonstrated seasonality. We employed a Long Short-Term Memory (LSTM) model, a machine learning technique, to forecast future groundwater levels and generate 30-day predictions ahead of time. The model's performance was evaluated using the Mean Absolute Error metric, and it provided reasonable forecasts for groundwater levels in the MCP area. This study contributes to our understanding of the relationship between groundwater levels and the size of wetlands in the Maputaland Coastal Plain, highlighting the importance of monitoring and preserving these vital ecosystems.

SAEES-F-4

The Integration of Unmanned Aerial Vehicles (UAVs) and Machine Learning Techniques for Predicting Maize Yields for Enhanced Food Security: A Systematic Review

Celuxolo Dlamini

219003508@stu.ukzn.ac.za

Student Number: 219003508

School of Agricultural, Earth, and Environmental Sciences

Supervised by Prof John Odindi, Prof Onisimo Mutanga and Dr Trylee Matongera

The recent developments of Unmanned Aerial Vehicles (UAVs) equipped with smart sensors have demonstrated a remarkable potential to accurately predict maize yield, surpassing existing satellite-based remotely sensed data. In addition, the development of machine learning algorithms, inspired by artificial intelligence, has proven valuable in accurate maize yield estimation than traditional statistical approaches. Using the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) from the Web of science and Scopus scientific databases, this review analyses the temporal and spatial distribution of relevant studies with a focus on evaluating both the progress and challenges in the adoption of UAV systems and machine learning approaches for maize yield prediction. The review identified noticeable gaps in literature for studies conducted in the global south and small-scale farming systems. Despite the remarkable potential provided by advanced deep machine learning approaches for accurate estimations, there is a dearth in literature on maize yield prediction. The progress in yield estimation is further compounded by a comprehensive integration of multi-source datasets with UAV-remotely sensed data to improve the accuracy of maize yield predictions and address limitations associated with estimations solely based on the latter. Moreover, studies on the optimal maize phenological stage for accurate yield estimation remain contradictory. Considering the immense contribution of small-scale farming systems towards food security in the global south, embracing cutting-edge UAV-remote sensing technology and deep learning approaches in this region is necessary. This review provides a better understanding of opportunities provided by UAV-derived data and robust machine learning approaches in predicting maize yield and enhancing food security in the ever-changing climate.

Keywords: Maize Yield; Unmanned Aerial Vehicles; Grain Yield; Above Ground Biomass; Machine Learning; Food Security

SAEES-F-5

EFFECT OF VARYING LIGHT INTENSITY ON MORPHOLOGICAL AND CERTAIN QUALITY PARAMETERS OF SWEET PEPPER

Siyabonga Dlamini

220104514@stu.ukzn.ac.za

Student number: 220104514

School of Agricultural, Earth and Environmental Sciences

Supervised by Professor Isa Bertling

Sweet pepper (*Capsicum annuum*) is one of the most important commercially cultivated crop plants in the *Solanaceae* family. This fruit vegetable crop is recognised as a source of ascorbic acid (Vitamin C) and special carotenoids. Carotenoids in pepper play a significant role in the prevention of various diseases, such as cancer, cataracts, and heart disease. The present study was conducted to enhance the quality of sweet

peppers by exposing the fruit to extra lights that was harvested through reflection of aluminium foil, an environmentally friendly method. Two treatments; namely control and aluminium exposed plants were tested, the experiment was replicated three times and the plants were arranged in a complete randomised design (CRD). The morphological changes of sweet peppers exposed to light and the control were investigated. The contents of chlorophylls and carotenoids pigments were also investigated. There was no significant difference in morphological changes, flowering, and fruit mass between the treated fruit and the control. Significant differences were observed in the total chlorophyll, with aluminium treated sweet peppers having less total chlorophyll when compared to the control. The aluminium treated sweet peppers had significantly high levels of total carotenoids compared to the control. It is, therefore, recommended that sweet pepper growers use aluminium foil in a controlled environment to harvest extra/ more light which ultimately result to enhancing total carotenoids concentration thereby increasing the nutritive value of sweet peppers.

Keywords: *Capsicum annuum*, carotenoids, eco-friendly, light intensity, quality

SAEES-F-6

INVESTIGATION OF HEAVY METAL POLLUTION IN GROUNDWATERS OF THE DURBAN REGION, KWAZULU-NATAL PROVINCE, SOUTH AFRICA

Nazneen Ebrahim

218015486@ukzn.ac.za

Student Number: 218015486

School of Agricultural, Earth and Environmental Sciences

Supervised by Mr Minenhle Siphesihle Ndlovu and Professor Molla Demlie

This study investigated the extent of heavy metal contamination by analysing eleven heavy metals (Mn, Al, As, Ni, Zn, Pb, Cr, Cu, Hg, Co, and B) in 55 groundwater samples collected across the greater Durban region. Water quality index (WQI), Heavy metal pollution (HPI), Heavy metal evaluation (HEI), and Synthetic pollution (SPI) indices were used as part of the data analyses. Among the analysed parameters, the concentrations of Mn and Al exceeded the South African drinking water quality standards in 40% and 5% of the samples, respectively. The WQI and HPI indicated that 12.5% and 7.5% of samples were of poor to very poor quality and high extent pollution, respectively. SPI indicated that 17.5% of samples were slightly polluted and unsuitable for drinking. The Hazard Quotient (HQ) and Hazard Index (HI) were used to evaluate the potential health risks from the ingestion of heavy metal-polluted groundwater in children and adults. HQ mean values were in the decreasing order of Mn > As > Co > B > Hg > Cr > Pb > Ni > Zn > Cu > Al for both adults and children. The HI showed that 25% and 12.5% of samples may pose a medium chronic health risk to children and adults, respectively. The study further revealed that samples of poor water quality are located around landfill sites indicating groundwater resources pollution around these sites rendering it unfit for human consumption.

Keywords: Heavy Metal Pollution, Water Quality Indices, Health Risks, South Africa.

SAEES-F-7

AN ANALYSIS OF THE PREVALENCE AND FACTORS INFLUENCING FOOD INSECURITY AMONG STUDENTS PARTICIPATING IN ALCOHOL CONSUMPTION IN THE KWAZULU NATAL PROVINCE

Senelisiwe Penelope Jilajila

215080033@stu.ukzn.ac.za

Student Number: 215080033

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Mjabuliseni Ngidi

Food insecurity among the student population is a prominent issue in South African university institutions. However, personal experiences and the myriad of underlying factors contributing to the issue remain poorly documented. Among other factors, these universities are characterized by the admission of a majority of their student population from poor backgrounds with limited financial capabilities, and this affects their food security status. The purpose of this study was to view the patterns of food insecurity among students, with a focus on alcohol consumption as one of the various factors influencing student food security status. Data were collected from 156 student respondents from the University of KwaZulu-Natal, Durban University of Technology, Mangosuthu University of Technology, and the University of Zululand.

The Household Food Insecurity Access Scale revealed that from the total sample, only 21.79% reported themselves as food secure, whilst the remainder reported varying levels of food insecurity with 17.31% of students being food insecure, 16.03% mildly food insecure, and 44.87% severely food insecure. On the other hand, a prevalence of 73.08% (n = 114) of alcohol consumption was found among the sampled students. Ordered probit models results suggested that students' alcohol consumption prevalence was determined by gender, level of study, exercise/playing sport, marital status, and distance to campus, which all had statistically significant effects on students' alcohol consumption. Most crucially, gender, institution and campus positively affected students' food security status, while the income variable made a negative significant contribution towards student food security status.

Therefore, a link between students' finances and food insecurity was evident. However, further research is required to delve into the link between the level and impact of students' alcohol consumption and its implications on their financial status, and thus food security status. This is crucial information which will help policymakers understand these underlying factors and experiences and thus find solutions for issues related with food insecurity.

SAEES-F-8

PHOSPHATE SOLUBILISING BACTERIA AND ROCK PHOSPHATE FROM ZIMBABWE FOR COWPEA PRODUCTIVITY IMPROVEMENT

Grace Kanonge

219085122@stu.ukzn.ac.za

Student Number: 219085122

School of Agricultural, Earth and Environmental Sciences

Supervised by Professor Pardon Muchaonyerwa

Despite the existence of a diverse population of P solubilizing bacteria (coded PSM) in Zimbabwean soils, their potential to improve P release from raw Dorowa rock phosphate (DRP) and their effect on cowpea productivity has not yet been evaluated. Twenty-eight phosphate solubilizing bacteria isolates were screened in pH specific DRP-PVK (Pikovskaya) liquid broth and under glasshouse conditions using cowpea (*Vigna unguiculata*. L) as a test crop. The objective was to determine the optimum pH for each species and evaluate the effect of applying DRP and the different PSMs on cowpea shoot productivity, nutrient uptake and biological nitrogen fixation capacity. The majority of the PSMs belonged to the *Bacillus* genera (19), while some were *Enterobacter spp* (3), *Kocuria spp* (2), *Klebsiella spp* (1), *Nocardioides spp* (1) and a *Microbacterium spp* (1). The PSMs were taken from the SPRL Microbial Culture Bank, including a standard *Rhizobium japonicum* nitrogen fixer (PSM1510)., which was also used as a sole source of nitrogen for all treatments.

The PSMs were inoculated into DRP-PVK broth (pH 6) bottles which were then incubated at 28 +/_2ºC for 5 days, in duplicate, arranged in a completely randomised design. The amount of P solubilized was measured by colorimetry, and pH changes were recorded. The PSBs were inoculated onto cowpea seed and planted onto pots filled with autoclaved limed field soil, fertilized with DRP powder as a sole source of P. Pots were watered using an N-P free solution except the positive control supplied with all nutrients and the negative control (distilled water). Cowpea shoots and roots were collected by destructive sampling at 6 weeks.

The studied PSM isolates solubilized P from rock phosphate in broth, showing almost similar potential at pH 6. Only the PSM 9, a *Kocuria spp* consistently dominated across all pH levels showing that it has some acid tolerance together with three *Bacillus* candidates (PSM1-*B. thuringiensis*, PSM 14- *B. amyloliquefaciens* and PSM 15- *B. megaterium*), while PSM 3, a *Paenibacillus spp* exhibited the highest P solubilization at pH 7 reaching up to 14.10 ppm. Overall, cowpeas shoot productivity and nutrient uptake was improved by PSM inoculation and rock phosphate as the only source of P. More than 50% of the PSMs contributed to higher cowpea' P (up to 56.8 kg ha^{-1}) and N (up to 165.5 kg ha^{-1}) uptake and biological nitrogen fixation capacity (up to 92.1 kg N ha^{-1}) than the uninoculated DRP fertilized crop, with the top six leading candidates related to *Bacillus thuringiensis* (PSM1), *Bacillus cereus* (PSM2), *Bacillus megaterium* (PSM 29), *Enterobacter spp* (PSM11), *Kocuria spp* (PSM8 and PSM 9) and a *Nocardioides spp* (PSM6). We concluded that cowpea productivity and response to rhizobia (N-fixer) inoculation could be enhanced by PSM co-inoculation, with the majority of PSMs studied except four *Bacillus spp* (PSM13, PSM22, PSM 30 and PSM33). This study is the first to present ability of an isolate identified as *Norcadioides spp*, as a P solubilising bacteria, which also proved to be the best in N-fixation capacity enhancement, although further validation tests are needed in different soil types.

Keywords: P-Biofertilizer, nutrient uptake, biological N-fixation, pH specific broth

SAEES-F-11

Near-infrared reflectance spectroscopy for nursery *Eucalyptus* seedlings and cutting production

Nkosikhona Trywell Mkhize

211531141@stu.ukzn.ac.za

Student Number: 211531141

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Nokwazi Mbili

Seedling production is a critical part of commercial forestry for companies like NCT, who funded this research at the ICFR. The ICFR engages in applied research to implement solutions to problems faced by the

South African forestry industry. One such challenge is sustainable seedling production, in terms of time and cost. The aim of the work was to develop and test the feasibility of using Near-infrared Reflectance Spectroscopy (NIRS) equipment and models as rapid and inexpensive analytical tools at the ICFR Analytical Laboratory Services laboratory in Pietermaritzburg, for forestry seedling production at local commercial nurseries. This technology was applied in three areas which formed the objectives of the work.

The first area was in seed germination testing where the objective was to investigate whether NIRS was able to predict seed germination properties for the major seed varieties that are used in South African forestry. Models were developed based on conventional seed germination testing methods at the ICFR, as well as some work exploring the ability to predict properties based on ISTA methods. The second objective was the development of low-cost seedling foliar nutrient analysis method using NIRS. The rising cost of fertilizer due to the global macro-economic climate means that close monitoring of seedling nutritional status can help ensure the most efficient use of such fertilizer while maintaining optimal seedling growth and health. The third objective was to be able to monitor or screen nursery hedges for varietal purity, as any errors during seedling production relating to seedling identity can have profound downstream effects on seedling sales and timber production. Current methods of clonal purity monitoring by DNA analysis are prohibitively expensive at the large scale required and cannot provide rapid results. A high-throughput NIRS approach can enable the screening of high sample numbers as a low-cost quality control measure in nurseries. In all their objectives, NIRS models were successfully developed and tested using independent test samples. Results showed that in many cases adequate results were able to be produced for screening purposes. Therefore, the use of rapid, non-destructive, and low-cost NIRS screening methods, already widely used in agricultural and pharmaceutical industries, has great potential to provide reliable results quickly to seedling producers which can save the industry significant amounts of money in terms of production and labour costs, and help ensure that seedlings are being produced on time and to the right specification for sustainable commercial forestry in South Africa.

SAEES-F-12

Spatio-temporal monitoring of soil moisture as an indicator of drought patterns in the Tyume catchment using remote sensing techniques.

Anela Mkhwenkwana

224193498@stu.ukzn.ac.za

Student Number: 224193498

School of Agricultural, Earth and Environmental Sciences

Professor Onisimo Mutanga

Droughts are extended periods of low precipitation that result in water scarcity and severe effects on various environmental, social, and economic factors. The Tyume catchment is no exception in experiencing droughts. The recurring drought events harm local communities, natural resources, and the hydrology of this area. This study aimed to assess hydrological drought severity patterns based on soil moisture content. For this study, Landsat 5 and Landsat 8 data were employed to monitor soil moisture for the years 1999, 2009, 2016, and 2023. The first objective of the study was to determine the relationship between soil moisture and precipitation patterns. Linear regression was performed to model the relationship between the precipitation and Normalized Difference Moisture Index (NDMI) which is used to estimate soil moisture content since it can monitor soil moisture and identify areas that can potentially be affected by droughts, the r^2 value was noted to be 0.20 and this shows a weak relationship. The second objective of the study was to assess the extent to which soil moisture content has changed over the years. The study used the Tasselled Cap

Transformation (TCT) to calculate the wetness index which is the indicator of vegetation density and soil moisture and the brightness index which is used to calculate the organic matter and soil moisture. The linear regression analysis revealed a significant relationship between the wetness index and brightness index in the Tyume catchment with an $r^2 > 0.7$. The year 2023 was observed to be the year with high moisture content and the year 1999 was the year with low moisture content. The study presented a novel strategy for monitoring soil moisture using satellite data, taking advantage of all multi-temporal satellite observations and proposing a new concept beyond the traditional method of estimating soil moisture content.

Keywords: Drought, Soil Moisture, NDMI, Precipitation

SAEES-F-13

Bush Encroachment: modelling transformation using Intensity Analysis and Cellular Automata Model

Ntuthuko Mncwabe

218003689@stu.ukzn.ac.za

218003689

School of Agricultural, Earth & Environmental Sciences

Supervised by Prof Onisimo Mutanga

Grassland intrusion by woody species is a globally recognised phenomenon associated with adverse impacts that include degradation and loss in biodiversity, thereby challenging the conservation of keystone and flagship species, landscapes' recreational value and people's livelihoods. Hence, a comprehensive analysis of bush encroachment is necessary to provide insights on the past, present and future encroachment and the severity of transitions. As a result, using the RapidEye and PlanetScope satellite imagery, this study adopted the intensity analysis and the Cellular Automata (CA) models to understand past, current, and future (2009 – 2033) bush encroachment trends in a protected area. The results demonstrated a steady increase in woody encroachment on other land cover types. Analysis of land cover intensities shows an intensive change in the research area's land cover in the first period (2009-2014) compared to the other periods. During the first two periods (2009-2014 and 2014-2019), woody vegetation gains were at the expense of grassland but partially avoided gaining from grassland during the period 2019-2023. Moreover, during the study period, the majority of grassland gains were from the class bare areas and its losses were mainly from woody vegetation. The prediction of future encroachment outlooks demonstrated an increasing trend of woody vegetation in the next decade. The results also, show that bush encroachment will expand by 5.50% and 6.67% during 2028 and 2033, respectively. The outcomes of this study demonstrated that there is a pressing need for evaluation and improvement of management schemes in the study area, and indeed similar landscapes threatened by woody encroachment. Critical insights on bush encroachment progression trends and intensities of transitions contribute to prioritizing landscape management and aid decision-making for the restoration of grasses.

Keywords: Bush encroachment, Intensity analysis, Prediction, Cellular Automata model, Nature reserve.

SAEES-F-15

Title: Low-Cost Portable Near-Infrared Spectroscopy Screening for Clonal Varietal Purity Identification of *Eucalyptus sp.* during Nursery Clonal Propagation

Melusi Mthethwa

218000324@stu.ukzn.ac.za

Student Number: 218000324

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Nokwazi Mbili, Dr Danvir Ramesar (ICFR), Dr Richard Burgdorf (Frequai) and Prof Mark Laing

Eucalyptus species are widely cultivated in South Africa for the pulp and paper industries due to their rapid growth and environmental adaptability. Species planted are site/climate specific and specific for their industrial purposes. The challenge faced in nurseries are keeping hedges clonal-specific and screening for clonal purity, which has significant consequences for establishing plantations if there are significant levels of contamination. Traditional methods for clonal discrimination, such as visual evaluation and DNA fingerprinting, are either subjective or costly. This study explores the efficacy of a handheld portable Near-Infrared spectroscopy (NIRS) device (NIR-S-G-1, Inno-Spectra, Taiwan, 900–1700 nm), 50 times cheaper or affordable than a standard benchtop device, to identify 10 *Eucalyptus* clonal varieties commonly used in South African forestry, from TWK Sunshine Seedlings, Pietermaritzburg, Kwa-Zulu Natal. Clonal hedges were scanned across Spring/early Summer (August 2023) to Autumn/early Winter (February 2024) months, whereby a total of 300 samples and 1800 spectra was captured. The spectra were correlated with their hybrid ID using Random Forest in R. Models from fresh scans had accuracies values of 74.72%. Accuracy from spectra of dried and milled samples improved significantly, yielding accuracy of 96.37%. Independent modelling of the dried samples using Frequai cloud-based machine learning pipeline produced models with accuracies of up to 88%. This study showed that portable NIRS can be used to differentiate *Eucalypt* varieties from scans of fresh material, allowing for close to real-time screening of hedges. Furthermore, using dried material offers greater resolution to screen hedges. Models require further development to improve resolution by capturing more spectral variation of these varieties and the impact of seasons or months to it. This study motivates the importance of portable NIRS as a rapid, cost effective and broadly non-destructive tool that can revolutionize nursery practices, thus promoting high quality control and precision forestry.

Keywords: *Eucalyptus sp*., Clones, NIRS, Varieties and Models.

SAEES-F-16

Quantifying the influence of woody encroachment on soil organic carbon across Bisley Nature Reserve using PlanetScope data

Sfundo Mthiyane

218030355@stu.ukzn.ac.za

Student Number: 218030355

School of Agricultural, Earth and Environmental Sciences

Supervised by Professor Onisimo Mutanga

Globally, grasslands are one of the largest terrestrial ecosystems storing significant amounts of Soil Organic Carbon (SOC) essential for providing various ecological services such as regulating the climate, improving water quality, and

supporting biodiversity. Woody encroachment has pronounced impacts on grassland ecosystems, exerting substantial influence on their structure, ecological dynamics, and SOC distribution. To our knowledge, there are still uncertainties on the influence of woody proliferation on SOC within protected grasslands. Remote sensing has emerged as a useful tool offering cost-effective, time-efficient, and environmentally friendly means to quantify SOC distribution and variability in grasslands. Therefore, this study sought to quantify the spatial variability of SOC across a pristine and woody encroached grassland using PlanetScope image data. Employing a stratified sampling technique, 254 samples were collected. The Loss-on-Ignition procedure was used to determine SOC. The PlanetScope spectral bands and derived vegetation indices were used to map SOC. The Deep Neural Network (DNN) model was trained based on 10-fold cross-validation with SOC values and 20 predictors. To improve the prediction accuracy of the model, hyper-parameter tuning was employed. The findings indicate a higher concentration of SOC in woody encroached vegetated areas compared to pristine grasslands. The DNN model yielded acceptable accuracies with Root Mean Square Error (RMSE) of 1.90 t/ha and R2 value of 0.64. The study provides a framework for continuous monitoring of SOC stocks in protected grasslands.

Keywords: Grassland, Woody Encroachment, Soil Organic Carbon, PlanetScope, Deep Neural Network

SAEES-F-18

The use of unmanned aerial vehicle-derived multi-spectral data for the early detection of multi-temporal maize leaf equivalent water thickness and fuel moisture content for the improved resilience of smallholder maize farming

Helen Snethemba Ndlovu

216016417@stu.ukzn.ac.za

Student Number: 216016417

School of Agricultural, Earth and Environmental Sciences

Supervised by Prof John Odindi, Prof Onisimo Mutanga and Dr Mbulisi Sibanda

Maize water stress from rainfall variability is a key challenge in producing rain-fed maize farming, especially in water-scarce regions such as southern Africa. Hence, quantifying maize foliar water content variations throughout the phenological stages is valuable in detecting smallholder maize moisture stress and supporting agricultural decision-making. The emergence of unmanned aerial vehicles (UAVs) equipped with multispectral sensors offers a unique opportunity for robust and rapid monitoring of maize foliar water content and stress. The combination of near-real-time spatially explicit information acquired using UAV imagery with physiological indicators such as equivalent water thickness (EWT), and fuel moisture content (FMC) provide viable options for detecting and quantifying maize foliar water content and moisture stress in smallholder farming systems. Therefore, this study evaluated the utility of UAV-based multispectral datasets and random forest regression in quantifying maize EWT and FMC throughout the maize phenological growth cycle. Results showed that EWT and FMC could be determined using the near-infrared and red-edge wavelengths to a relative root mean square error of 2.27 % and 1%, respectively. Specifically, the spectra acquired during the early reproductive growth stages between silking and milk stages demonstrated a high sensitivity to the variation in maize moisture content. These findings serve as a fundamental step toward creating an early maize moisture stress detection and warning system and contribute to climate change adaptation and resilience of smallholder maize farming. Furthermore, this study is critical for developing a robust and spatially explicit monitoring framework of maize water status and serves as a proxy of crop health and the overall productivity of smallholder maize farms.

Keywords: maize moisture, phenology, growing season, spatio-temporal variability, precision farming.

SAEES-F-19

INVESTIGATING THE EFFECTS OF CO-COMPOSTING HETEROGENOUS MIXTURES OF LOCAL ORGANIC AMENDMENTS ON NITROGEN MINERALIZATION

Samukelisiwe Ndlovu

218023946@stu.ukzn.ac.za

Student Number:218023946

School of Agricultural, Earth, and Environmental Sciences

Supervised by Dr Nkosinomusa Nomfundo Dube

Smallholder farming systems in Southern Africa are facing widespread problem of declining soil fertility and low crop yields, mainly due to continued cultivation of crops with minimal nutrient inputs. Co-composting of locally available organic amendments has the potential to positively impact compost composition and nutrient dynamics. This study investigated the mineralization of nitrogen (N) from the co-composting of crop residues (maize, dry beans, and taro) and manure sourced from Umbumbulu village in KwaZulu-Natal. Thermophilic composting method was employed to prepare four compost types: (a) Manure only, (b) Manure + Maize + Taro, (c) Maize + Dry Beans + Taro, and (d) Manure + Maize + Dry Beans + Taro. During the composting process, parameters such as pH, volatile solids, and ash content, were monitored. Gemination test was used to evaluate the maturity of the compost. A laboratory incubation was conducted to assess N mineralization, In a Hutton (Oxisol) at triple the recommended rate (771 kg N/ha) at field capacity moisture and a temperature of 25 °C for 84 days. Volatile solids decreased while ash content increased during composting. Final pH values across all composts ranged from 6.62 to 8.21. The total germination percentage exceeded 93% for all composts, indicating composts maturity and stability. During incubation, mineral nitrogen was significantly higher in all compost treatments compared to the control. At day 56 of incubation, the nitrogen concentrations were 2.449 mg/kg for the control (soil only), 8.626 mg/kg for Manure only compost (a), 11.012 mg/kg for Manure + Maize + Taro (b), 11.166 mg/kg for Maize + Dry Beans + Taro compost (c), and 10.206 mg/kg for Manure + Maize + Dry Beans + Taro compost (d). Among these, the Manure + Dry Beans + Taro compost had the highest N mineralization. This study suggests that compost application can enhance readily available nitrogen in the soil, contributing to improved soil fertility.

Keywords: Co-composting, Manure, N mineralisation, soil fertility.

SAEES-F-21

CHARACTERISATION OF BIOCHAR FROM VENTILATED PIT LATRINES: TOWARDS CIRCULAR HUMAN WASTE VALORISATION

Nqobile Nkomo

211543730@stu.ukzn.ac.za

Student Number: 211543730

School of Agricultural, Earth and Environmental Sciences

Supervised by Professor Alfred Oduor Odindo

A large amount of human wastes is being produced and the disposal of such is increasingly becoming a challenge due to lack of space for landfilling, environment pollution and health risk hazards. Currently there

are filled up VIP toilets in South Africa and communities are struggling to dispose the faecal sludge. Treatment of such waste can result in valorisation to products with fertiliser value to address both challenges of faecal sludge disposal and soil degradation. Faecal sludge can be pyrolysed to produce biochar that can be directly applied to soils, or enhanced with external N nutrient sources for increased fertiliser value. Ventilated improved pit latrine faecal sludge was collected from the Julukandoda community with the assistance of from Partners in Development, a private company that empties filled up pit latrines. The collected VIP FS was mixed with wood chips (WC) at four different mixing ratios, (100% FS: 0% WC; 75% FS:25% WC; 50% FS; 50%WC; 25%FS; 75%WC). Pyrolysis was carried out in a muffle furnace using a stainless steel container inserted in a ceramic crucible. The biochars were pyrolysed at four temperatures (350, 450, 550 and 700°C). The results on biochar yield showed that increasing pyrolysis temperature resulted in a decrease in biochar yield. Furthermore, addition of wood chips decreased the yield even more linked to the lower ash content of the faecal sludge and wood chips feedstock. The biochar had liming potential confirmed by $CaCO_3$ equivalence results. The presence of heavy metals was detected by EDX, however quantification to determine if standards are met will be confirmed after ICP quantification. The SEM images showed an increasing pore size and number with both increasing pyrolysis temperature and wood chips mixing ratio until 550°C. Hence faecal sludge can be mixed with wood chips to reduce heavy metal concentration. The resulting biochar has lower P concentration, however optimum temperatures of 550°C allow pore development for potential adsorption of N from urine. P can be increased by adding MgO to follow a struvite pathway.

Keywords: biochar; characterisation; circular nutrient economy; faecal sludge; valorisation

SAEES-F-22

CROP RESIDUES DIFFER IN THEIR DECOMPOSITION AND CARBON SEQUESTRATION POTENTIAL: A GLOBAL META-ANALYSIS OF DIFFERENT CROPS

Sipho Ntonta

213509983@stu.ukzn.ac.za

Student Number: 213509983

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Rebecca Zengeni

Decomposition of crop residues may affect soil organic carbon (C) stocks, which are key for soil fertility improvement and mitigation of climate change. Numerous independent studies across the world point to contradictory results but their existence provides an opportunity to conduct a comprehensive analysis of the impact of crop type on residue decomposition. In the present study, data from 394 trials from across the world were used to assess cumulative CO_2 emissions from residues of 17 crops during 0–30, 0–90, and 0–120 days (i.e. CR30, CR90 and CR120; 1-[CR30/CR120] ratio as a stability index of C emissions) and to relate the results with residue quality (C, N and lignin concentrations) and selected soil properties (texture, pH, soil organic carbon concentration). At all durations, legumes exhibited the highest CO_2 emissions per gram of C added (1003 mg CO_2-C g^{-1}C after 120 days) followed by grasses (947), oilseed crops (944), and cereals (846), with legumes and grasses showing the lowest temporal stability of C emission as pointed out by a 1-[CR30/CR120] of 0.78 and 0.79, respectively, versus 0.82 and 0.83 for cereals and oilseed crops. At all durations, maize residues emitted the least C-CO_2 (86, 275, and 495 mg CO_2-C g^{-1}C), followed by two other lignin-rich crops (cotton and sunflower), while the highest emissions were from Alfalfa residues that produced about 4 times more CO_2 (e.g. 359 at CR30 and 1319 at CR120) than maize. Overall, CO_2 emissions were positively correlated with soil clay concentration ($r > 0.22$), and residue C concentration (e.g. $r = 0.46$

at CR90 and r = 0.37 with emission stability, P <0.05) but negatively to residue N concentration (r = -0.26 at CR120, P < 0.05). The global trend pointed to decreased CO_2 emissions with increasing residue lignin. Contrary to what is generally believed, providing the soil with high lignin and high N concentration may foster C stabilization in soils by soil microbes.

SAEES-F-23

SPATIAL ASSESSMENT OF LAND USE DYNAMICS IN THE DOLPHIN COAST, KWAZULU-NATAL, USING PLANETSCOPE IMAGERY

Nzuzo Nxumalo

224045115@stu.ukzn.ac.za

Student Number: 224045115

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Ntombifuthi Nzimande and Dr Sifiso Xulu

Over recent decades, human activities have profoundly transformed significant portions of the Earth's land surface at an unprecedented rate, magnitude, and extent. Among these transformations, land use and cover changes are particularly important. On a global scale, such changes profoundly impact critical components of Earth System functioning, significantly affect global biodiversity, and contribute to local and regional climates. Moreover, urbanisation, a crucial factor in land use change, reduces vegetation cover and converts open and agricultural spaces into built environments. This study aims to quantify land use and land cover changes and identify their significant implications over 15 years (2009–2024) in the Dolphin Coast, KwaZulu-Natal. To assess these changes, we utilised satellite imagery from RapidEye (2009 and 2014) and PlanetScope (2019 and 2024) and a supervised image classification methodology using support vector machines. Understanding land use and land cover change is essential for comprehending the complex relationship between human activities and natural systems. Various sensors with different resolutions have been employed extensively, mainly using Sentinel and Landsat datasets in conjunction with GIS tools. In this study, we monitored land use changes using RapidEye and PlanetScope imageries as the only commercial satellite products available with global coverage at fine ground and temporal resolutions. The results revealed that the study area had experienced extensive land cover changes over the past decade, notably a shift from vegetation to built-up and forest regions. Between 2009 and 2024, urban areas have expanded significantly, with built-up land increasing by more than 4.7 km². These findings are crucial for ensuring sustainable resource utilisation, effective land use planning, and informed decision-making by relevant government authorities. By informing policy and practice, this study ensures that land use decisions are evidence-based, sustainable, and beneficial to human communities and the environment.

Keywords: land use change; land cover change; remote sensing; supervised classification; PlanetScope; RapidEye; support vector machines; Dolphin Coast.

SAEES-F-24

NEEDS ASSESSMENT FOR SUSTAINABLE WATER MANAGEMENT IN AFRICA: A FOCUS ON SOLAR-POWERED DESALINATION TECHNOLOGIES

Nwosu Obinnaya Chikezie Victor

224192957@stu.ukzn.ac.za

Student Number: 224192957

School of Agricultural, Earth and Environmental Sciences

Supervised by Professor Seifu Kebede Gurmessa

Water scarcity is a significant challenge in Africa, exacerbated by rapid population growth, urbanization, and climate change. This study investigates the potential of solar-powered desalination technologies to address this issue. The research explores various desalination methods, including thermal and membrane-based approaches, focusing on their applicability in Africa (Saghafi, M., 1994). The study also examines the socio-economic and environmental factors influencing water management in the region (Pappis, I. et al., 2022). This research aims to identify the key challenges and opportunities for implementing solar-powered desalination in Africa by analysing case studies and conducting a comprehensive literature review(Wydra, K., Becker, M, P. and Aulich, H., 2019). The findings of this study will provide valuable insights for policymakers, water resource managers, and stakeholders involved in promoting sustainable water management practices in Africa (Maftouh, A. et al., 2023).

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SAEES-F-25

CHARACTERISATION AND *IN VITRO* DRUG RELEASE PROFILES OF OLEANOLIC AND ASIATIC ACIDS-LOADED SOLID LIPID NANOPARTICLES

Michael Oboh

220113325@stu.ukzn.ac.za

Student Number: 220113325

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Blessing Mkhwanazi

Oleanolic and asiatic acids are plant-derived compounds with anti-diabetic properties but are poorly soluble in water. This study evaluates the *in vitro* drug release properties of oleanolic and asiatic acids-loaded solid lipid nanoparticles (SLNs). The SLNs of both compounds were prepared using the emulsion solvent evaporation method. The formulations were characterised by determining the particle size, zeta potential (ZP) and polydispersity index (PDI) using the Zetasizer and TEM. *In vitro* drug release of the optimised formulations was examined with a simulated intestinal fluid (pH 6.8 PBS). A 1:1 (drug: lipid) ratio was selected as the oleanolic acid-SLNs optimised formulation, with particle size, PDI, ZP and EE% of 312.9±3.617 nm, 0.157±0.014, -17.0±0.513 mV and 86.54±1.818%, respectively. A 1:2 (drug: lipid) ratio was selected as the AA-SLNs optimised formulation with a particle size of 115.5±0.458 nm, PDI of 0.255±0.007, ZP of -11.9±0.321 mV and EE% of 76.22±0.436%. The nanoparticles of both compounds remained significantly stable for 60 days for each storage condition (4^{O}C and room temperature) ($P<0.05$) with no observable phase separation. OA-loaded SLNs and the free drug solution showed 34.04% and 15.88% drug release within 300 min, respectively ($P<0.05$). AA-SLNs and the free drug showed 39.46% and 16.13%, respectively ($P<0.05$). The SLNs of both compounds showed a higher and sustained drug release compared to their free drugs. The findings indicate that the nanoformulations can potentially improve the solubility, bioavailability, and therapeutic efficacy of these lipophilic compounds.

SAEES-F-27

Morphometric evaluation of cattle oocytes pre and post cryopreservation

Maleke Dimpho Sebopela

223152616@stu.ukzn.ac.za

Student Number: 223152616

School of Agricultural, Earth, and Environmental Sciences

Supervised by Dr Ntuthuko Raphael Mkhize

The morphometric evaluation of cattle oocytes pre and post-cryopreservation can be positioned as a key component in advancing energy sustainability within the agricultural sector. Successfully cryopreserving both immature and mature cattle oocytes would facilitate the management of the timing of *in vitro* maturation (IVM), fertilization, and culture. To date, oocyte cryopreservation is the most promising and cost-effective option for the storage of female germplasm. However, cryopreservation can alter oocyte morphology, potentially impacting viability and developmental competence. The aim of the study was to evaluate the morphometric parameters and morphology of immature, mature cryopreserved and fresh (non-cryopreserved) oocytes. The heterogeneous cattle ovaries of unknown reproductive status were collected at the local abattoir. The aspiration method for oocytes retrieval from ovaries was carried out using 10 mL disposable syringes and an 18-gauge sterile hypodermic needle. The collected oocytes were washed in modified Dulbecco's PBS and modified M199 and then matured in 500 µL of TCM 199 medium supplemented with 10% fetal bovine serum, follicle stimulating hormone, luteinizing hormone, and oestradiol hormone before being covered with 250 µL of mineral oil. The oocyte maturation rate was determined by expansion of cumulus-oocytes complexes (COCs) after 22 h of IVM pre-cryopreservation.

The retrieved oocytes were either non-cryopreserved (fresh oocytes) or cryopreserved (immature and mature oocytes) using the conventional straw vitrification method, where they were exposed to equilibration and vitrification solutions. The vitrified oocytes straws were loaded on the aluminium cryocane, then stored inside the liquid nitrogen tank (-196°C) until thawing. The vitrified oocytes straws were removed from liquid nitrogen tank and exposed inside warm (37°C) water for 1 minute during thawing. The oocytes straws were cut at the both ends and emptied into thawing solutions to remove the intracellular cryoprotectants. Following thawing oocytes were fixed in Formaldehyde with 4% of PBS for morphometric analysis. The diameter (µM) of the oocyte ooplasm (OPS), oocyte zona pellucida (OCT ZP), zona pellucida width (ZPW) granulosa cells

width (GRSW), and zona pellucida granulosa cells width (ZP GRSW) were measured with the aid of a microscope connected to computer assisted sperm analysis (Sperm Class Analyzer®) system at 10x magnification for both vitrified and fresh oocytes. The data were analysed using analysis of variance statistical programme of GenStat® programme. A significant level of $P < 0.05$ were used. Treatment means were separated using Fisher's protected t-test. The data were presented as mean ± standard deviation. In this current study, the cytoskeletal structure of the oocytes was observed pre and post cryopreservation. The results showed no significant differences in oocyte ZP and thickness of ZPW between vitrified (immature and mature) and fresh oocytes. However, a significant difference was observed in oocyte GRS (vitrified mature oocytes= 67.56±32.61, vitrified immature oocytes= 78.46±33.51, and fresh oocytes=104.23±27.21 µM) and ZP GRSW (vitrified mature oocytes= 232.39±50.34, vitrified immature oocytes 247.25±66.92 and fresh oocytes=289.30.80±42.19 µM). In conclusion, the cryopreservation process did not affect the structural integrity of ZP in fresh and vitrified oocytes. However, it affects the granulosa cells in both vitrified immature and mature oocytes, with the most significant reduction seen in mature oocytes, which could potentially affect the developmental competence and viability of the oocytes post-thawing.

SAEES-F-28

Assessment of a collaborative relationship between public libraries and extension services in disseminating agricultural information in Eastern Cape Province

Masithembe Sigigaba

221116946@ukzn.ac.za

Student Number: 221116946

School of Agricultural, Earth, and Environmental Sciences

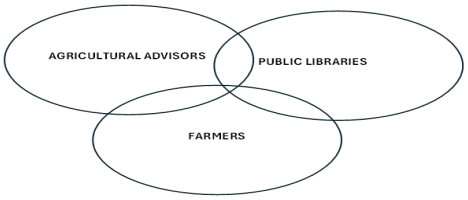
Supervised by Dr Mjabuliseni Ngidi and Dr Simphiwe Hlatshwayo

The crucial role played by smallholder farmers towards poverty reduction, food security, and improving the livelihoods of rural dwellers in developing countries cannot be overemphasized. Thus, Smallholder agriculture must be viable, productive, and sustainable to achieve the food security Sustainable Development Goals (SDGs), which call for the eradication of hunger and the reduction of poverty. Access to agricultural information to cope with various effects that impede productivity in this regard is vital.

However, information sources farmers mostly trust and rely on, which are agricultural extension services to gain such information, face numerous challenges that leave their efficacy status questionable [1]. Therefore, the study explored a complementary role that public libraries could play in improving the efficacy of extension services in delivering timely the pertinent information needed by farmers. The study was conducted in Eastern Cape Province, which was purposively selected due to the prevalence of poverty.

A qualitative approach was employed, using focus group discussions and key informants to obtain data. A sum of 315 smallholder farmers, 30 agricultural advisors with directors, and 37 librarians with directors made up 382 participants of the study. Descriptive statistics and SWOT analysis were used to analyze data.

SWOT analysis revealed a current non-existence of a working relationship between these institutions, with, however, a huge potential institutional arrangement that can be established. Such an arrangement would greatly improve farmers' access to information, especially considering the proximity and resources of public libraries that farmers could explore to access needed agricultural information. The following model was recommended, and how it can work was explained.



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SAEES-F-29

PHYSIOLOGICAL AND MORPHOLOGICAL RESPONSES OF LUCERNE (*Medicago sativa* L.) GENOTYEPES TO ACIDIC SOILS AND METAL TOXICIES

Sesethu Sokoko

223150904@stu.ukzn.ac.za

Student Number: 223150904

School of Agricultural, Earth & Environmental Sciences

Supervised by Prof Julia Sibiya and Dr Francois Müller

Soil acidity affects 50% of the world's arable land and is a serious impediment in the production and sustainability of crops in most parts of the world. Acidic soils are mostly common in areas that receive high rainfall, leading to significant land degradation. This is also common in South Africa in areas that receive high rainfall in the summer season. This is especially true for the KwaZulu-Natal province with approximately 85% of its soils being acidic. Due to soil acidity there is a decline in soil fertility and this is visible by reduced yields and poor plants. Reports have indicated that in acidic soils there is buildup of toxic heavy metals such as manganese and aluminium, with aluminium toxicity being the most widespread leading to inhibition of root growth and development on susceptible plants. Aluminium has no biological role to plants when present in optimum soils, but it solubilizes in acidic soils and becomes available for plant intake which in turn limits crop growth. Aluminium (Al) toxicity is an important abiotic stress all around the world where acidic soils are present and its toxic effect is visible in soils with pH 4.5 and 5.5. In acidic soils plants become stressed and the effect of the stress is evident in symptoms like low growth, weak tillers and crop thinning.

Many crops cannot tolerate acidic soils, Lucerne is a forage crop that has low tolerance to soils with pH less than 5.5. Various places cultivate alfalfa primarily for livestock due to its superior quality. It is also used in crop rotations and as a cover crop because of its ability to fix atmospheric nitrogen. Lucerne can adapt to a large range of different environmental and edaphic conditions and due to its large tap roots it is resistant to drought stress. However, its growth and development are restricted by acidic soils effecting its yield and nutritional quality. In most areas, farmers use soil amendments to increase pH but they are expensive and they can also cause harm to the soil when used repeatedly.

Therefore, the most promising approach is to develop acid tolerant lucerne genotypes and selecting the genotypes that shows different degrees of tolerance to acidic conditions. The purpose of this study is to evaluate the effect of soil acidity and Al toxicity on physiological and morphological traits of different lucerne lines and commercial cultivars. A net house trial was planted where lucerne plants were established

in pots filled with soils of different degree acidity (severe pH4, moderate pH5 and control pH7). The soils used were collected from the ARC Cedara research site. The plants were watered as needed and the measurements done included plant height, number of leaves, branching intensity, root length, electrolyte leakage, date to flowering, leaf diameter, fresh and dry mass of roots and shoots.

SAEES-F-30

UTILISATION OF COMPUTER ASSISTANT SPERM ANALYSER TO COMPARE SEMEN EXTENDERS ON BOAR EPIDIDYMAL SPERM MORPHOMETRY

Mamonene Angelinah Thema

223147163@stu.ukzn.ac.za

Student Number: 223147163

School of Agricultural, Earth and Environmental Science

Supervised by Dr Ntuthuko Rapheal Mkhize

Sperm morphometric analysis provides insights details of the sperm size, shape, function and structural traits, which correlate with fertility potential. The availability of sophisticated systems and tools, like computer assisted sperm analysis (CASA), has made it possible to analyze sperm morphometry more quickly and objectively. The CASA system has emerged as the preferred method due to its reduced subjectivity, increased repeatability, and reliability. Semen extenders are typically biological compounds that serve a variety of purposes, such as mitigating the effects of abrupt pH changes, enhancing the energy source, fortifying the sperm against cold shock and preventing oxidative stress and damage while the semen is being conserved. This study aimed to compare two semen extenders [Beltsville Thawing Solution (BTS) and Soya lecithin-based] on boar epididymal sperm morphometry traits using computer assistant sperm morphometry analysis. Total of 40 testes of heterogeneous boars were collected from the local abattoir and transported to the laboratory at 5°C within 30 minutes after slaughter. The testes were further stored at 5°C for additional 2 hours before being processed. Following storage, the cauda epididymides were removed from the testes, and cleaned with saline solution (NaCl 0.9%). To avoid blood contamination, superficial blood vessels were punctured so that most of the blood could be wiped off. Semen samples were retrieved from 40 cauda epididymides (20 epididymides/semen extenders) in the separate petri dishes with the use of slicing method. Sperm morphometry/semen extender treatments slides were prepared with the SpermBlue staining, allowed them to dry at a room temperature and mounted with the DPX® mounting medium. Total of 800 sperm/semen extender treatment were analysed, for sperm morphometry traits with the use of CASA.

The Chisquare were used to analyse effect of the semen extender on the sperm type, head shape, acrosome type and midpiece type. All sperm morphometric (head area, head perimeter, head length, head width, head ellipticity, head elongation, head regularity and midpiece width) traits generated were expressed as mean standard deviation and were subjected to student t-test. The semen diluted with BTS extender recorded greater than 70% normal sperm. Whereas less than 60% of normal sperm were recorded in, the semen diluted with Soya lecithin-based extender. There was a reduction in the sperm head dimensions and a change in shape of the acrosome associated with Soya lecithin-based extender ($P<0.05$). The sperm diluted with the Soya lecithin-based extender showed to have undergone an acrosome reaction, which caused the sperm head length to be shorter than usual. The sperm diluted with the Soya lecithin-based recorded less than 70% sperm with normal acrosome as compared to BTS extender. The semen diluted with BTS recorded a significant acceptable sperm head size (length: 8.9µm; perimeter: 19.57µm and area: 37.10µm^2) ($P<0.05$). Furthermore, semen diluted with BTS recorded the significant and highest average sperm elongation (0.32), ellipticity

(2.00) and regularity (0.82) ($P<0.05$). In conclusion, use of BTS is more recommendable, because of its protective effect on the boar epididymal sperm morphology.

SAEES-F-31

The Role of GW in Catchment Hydrology. Is it significant?

Mutondi Tshikororo

223152925@stu.ukzn.ac.za

Student Number: 223152925

School of Agricultural, Earth, and Environmental Sciences

Supervised by Professor Seifu Kebede Gurmessa

The role of groundwater (GW) in catchment hydrology is increasingly recognised globally. Statistics demonstrate that GW supports about 38% of the world's irrigated agricultural land, and 50% of the domestic water supply in Africa comes from GW [1, 2]. However, in South Africa, its potential is under-recognised and underutilised. This study used integrated methods such as stable water isotopes (deuterium and oxygen-18), piezometric data, baseflow separation, and in situ measurements of radioactive isotope (222-Radon) and hydrochemistry (electrical conductivity, temperature, and pH) to investigate the role of GW in catchment hydrology at nested scales (time and space).

This investigation is the first of its kind to examine the role of GW at multiple spatial and temporal scales. The study focused on three spatial scales: hillslope, catchment, and basin. For the temporal scales, it utilised hourly, daily, and monthly samples collected from five rainfall collectors located throughout the uThukela Catchment. At the hillslope scale, samples were collected from Cathedral Peak at nine catchments to understand the role of GW in runoff generation. At the catchment scale, the investigation centred on the role of intermediate GW flow in recharging mountain front aquifers. At the basin scale, the study examined the role of deep regional flow and GW discharge into the stream networks along the basin. The results revealed that GW predominates runoff generation in the investigated hills. At the foot of the mountains, GW receives recharge from losing streams. At the regional scale, the role of GW is not yet fully clear, but its presence is evident. This concludes that the role of GW is substantial and cannot be ignored in national water accounting. The objective of this abstract is to present a comprehensive conceptual model illustrating the interaction between groundwater and surface water across multiple spatial and temporal scales. This hydrological conceptual model has been meticulously developed to showcase the intricate connections between groundwater and surface water dynamics. It will be presented at the conference, highlighting the significance of these interactions.

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SAEES-F-32

Integrated knowledge systems towards flood resilience and sustainable solid waste management in South African urban informal settlements

Zwivhuya Tshivhundo

223152795@stu.ukzn.ac.za

Student Number: 223152795

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Katelyn Jonhson

This project is part of the Environmental Pollution Programme (EPP) in South Africa and Vietnam funded by the UK's Department for Environment, Food and Rural Affairs (Defra), and administered by the Joint Nature Conservation Committee (JNCC). The objective of the EPP is to manage, mitigate and prevent pollution to benefit climate, biodiversity and people and ensuring that waste management activities must become more sustainable, defined as achieving reduced net negative impacts on aquatic and terrestrial ecosystems. The aim of the research project is to generate an integrated and inclusive approach to flood risk modelling towards effective solid waste management and flood resilience in urban informal settlements in South Africa, using the case of eThekwini Municipality in KwaZulu-Natal Province. The eThekwini municipality is situated along the east coast of the province of KwaZulu-Natal. It has the largest number of informal settlements of any municipality in South Africa and currently houses over 580 urban informal settlements encompassing 314,000 households' a quarter of the city's population. Data has been acquired from numerous engagements with eThekwini Municipality and KZN Government, NGOs/, Local community members, community-based organizations, Academics, scientists, and researchers.

The findings indicate that NGOs like Trash-Boom are tackling plastic pollution on the Palmiet River by trapping it and raising awareness about illegal dumping dangers. The University of KwaZulu Natal's Community Based Flood Early Warning System (FEWS) collaborates with local governments, scientists, and communities to share flood risk warnings, rainfall, and river level data via WhatsApp. The research used HEC-RAS for flood risk assessment, relying on flood estimation techniques like Unit Hydrograph and Standard Design Flood approach. The study collected knowledge systems from residents in eThekwini flood-prone areas through questionnaires, interviews, and focus groups, including flood risk management experts and flood experience, on flood mitigation strategies. The existing initiatives require expansion, improvement, and enhancement to effectively manage sustainable waste and enhance flood resilience. Durban initiated a flood protection project following the 2022 floods, aiming to serve as a model for other African cities grappling with climate change impacts.

SAEES-F-33

ASSESSING UNMANNED AERIAL VEHICLE DATA FOR EVAPOTRANSPIRATION ESTIMATION: A CASE STUDY IN SWAYIMANE, KWAZULU-NATAL, SOUTH AFRICA

Ameera Yacoob

218023873@stu.ukzn.ac.za

Student Number: 218023873

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Shaeden Gokool and Prof Alistair Clulow

The rising global population has heightened food demand, exerting significant pressure on agricultural systems, especially in water-scarce regions like South Africa. Smallholder farmers, crucial to the farming sector, face considerable challenges due to climatic variability and resource limitations. This study explores innovative, robust methods to improve the sustainability and productivity of small-scale farms, with a focus on sugarcane cultivation. By utilising remote sensing (RS) technology, particularly unmanned aerial vehicles (UAVs), the research addresses the shortcomings of traditional evapotranspiration (ET) estimation techniques. Various vegetation indices (VIs) derived from UAV-based multispectral imagery are assessed to predict actual ET (ETa) and validated against ground-based eddy covariance (EC) measurements. The outcomes of this research encompass three ETa models derived from the Normalised Difference Vegetation Index (NDVI)—namely ET-NDVI, ET-NDVIscaled, and ET-NDVIKc—and two ETa models based on the Enhanced Vegetation Index (EVI)—specifically ET-EVI and ET-EVI2. Additionally, machine learning (ML) methods are employed to correlate ground-based crop coefficient (Kc) and NDVI values, enabling the development of Kc prediction models. Our study indicates that the Random Forest Regression (RFR) ensemble model provides sugarcane's most reliable ET estimates, with an R^2 of 0.68, RMSE of 0.11, and MAE of 0.07. The EVI2 model, combining in-situ and UAV-derived multispectral data, also performed well, achieving an R^2 of 0.63, RMSE of 0.67, and MAE of 0.52. Despite its complexity, the RFR model's exceptional prediction accuracy is promising. However, the ET-VI solution, including EVI2, is more suitable for small-scale farming due to its lower technological complexity and data requirements. This study leveraged the Swayimane GEE Data Processing App for calculating VIs, thereby enhancing the efficiency and scalability of estimating ET in sugarcane cultivation. It emphasises the need for comprehensive datasets covering complete crop cycles and varying irrigation conditions to refine ET models. However, future research should reduce reliance on in-situ data by integrating cost-effective sensors and improving the temporal resolution of remote sensing data, thereby making advanced agricultural monitoring techniques more accessible to smallholder farmers.

Keywords: Smallholder farming systems, UAV applications, evapotranspiration estimation, GEE, Kc prediction model

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FLASH ABSTRACTS

SCHOOL OF CHEMISTRY AND PHYSICS

SCP-F-2

Understanding the growth mechanisms of nanostructures in the laser ablation technique by OES study

Bala Saraswathi Amirthapandian

222124626@stu.ukzn.ac.za

Student Number: 222124626

School of Chemistry and Physics

Supervised by Prof M.K. Moodley

The primary goal in materialising the nanostructures is to achieve controlled synthesis to produce type-specific nanomaterials suitable for different practical applications. Methods employing high-power lasers have been proposed for producing high-quality nanomaterials and thin films. In that way, analysing the plasma state of the target of interest improves our understanding of the self-assembly of the nanostructures through nucleation and recombination

processes. On the other hand, characterising plasma is still challenging and unsolved because of its complex and inhomogeneous nature.

Therefore, by providing optical access to the laser-induced plasmas (LIP), we can study the evolution mechanism of the LIPs by determining the plasma physical parameters like electron density and temperature. Hence, in this work, we propose an Optical Emission Spectroscopical (OES) study of the laser-induced boron plasmas generated using combined 1064 and 532 nm laser pulses from the Nd: YAG laser source at room temperature. This work will also present the characterisation of the as collected nanomaterial samples and correlate it with the plasma evolution profiles. By improving the understanding of the atomistic processes in the plasma system through the OES study, techniques and tools for achieving controlled synthesis and production of type-specific nanostructures will be developed.

Since boron has superior properties than carbon, it opens the door for new applications in electronics, mechanical industries and the energy sectors, and it has the potential to become a more reliable source by means of its energy-saving applications as energy storage devices such as rechargeable batteries, hydrogen storage devices, supercapacitors and even in nuclear power sectors and this research will help the scientific community develop efficient, environmentally safe and economically reasonable ideas of utilising the boron nanomaterials

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SCP-F-4

Method development for quantitative analysis of Endocrine Disrupting Chemicals (ECD) in waters bodies of eThekwini Municipality

Celiwe Dlangalala

208524662@stu.ukzn.ac.za

Student Number: 208524662

School of Chemistry and Physics

Supervised by Prof Brenda Moodley

Endocrine disrupting compounds (ECDs) are chemical compounds that can alter the functioning of endocrine systems in humans and animals. They do this by affecting the communication between the glands, hormones and cellular receptors that regulates the internal body functions (Khirbet et al ., 2021). Other effects reported include a decrease in hatching rates in birds, turtles, and fish. In addition, literature has reported these EDCs also cause the onset of female features in male fish, and reproductive problems among other mammals which leads to reduction of population and loss in diversity (Forghani et al., 2018).

Recently, the South African national drinking water standard (SANS 241) draft included ECDs. Therefore, there is a need to develop reliable analytical methods to analyse and quantify these compounds in water. There are various groups of ECD's and in this study steroid hormones that are used in contraceptives are the point of focus including Bisphenol A (BPA) which is known as an xenoestrogen. The analytes of interest studied are: ethinylestradiol (EE2), estriol (E3), BPA, mestranol, levonorgestrel, medroxyprogesterone (DEPO) and progesterone. These compounds were analysed using high performance liquid chromatography (HPLC), connected to a UV detector, by gradient elution using methanol and water at 40℃. Validation parameters completed thus far include linearity which was evaluated by plotting a calibration curve of 0.63-10 mg/L standards versus peak area, the coefficient of variation was found to be between 0.997-0.9998, and the LOD/LOQ was calculated from the slope and standard error of the calibration curve.

LOD was found to be between 0.03-0.20 mg/L, and LOQ was 0.08 to 0.65 mg/L. Precision was evaluated by conducting intraday and interday analysis for a period of five days. The results were expressed in relative standard deviation which was found to be less than 15% RSD for both repeatability and reproducibility. The efficiency of separation was also evaluated with number of plates greater than 2000, resolution for all compounds was greater than 1.5 and retention factor was greater than unity.

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SCP-F-5

SYNTHESIS AND CHARACTERISATION OF NOVEL rGO-CS COMPOSITE FOR THE ELECTROCHEMICAL DETECTION OF LAMIVUDINE

Mariam Hajee

219014170@stu.ukzn.ac.za

Student Number: 219014170

School of Chemistry and Physics

Supervised by Prof Olatunde Olatunji and Prof Bice Martincigh

The high prevalence of HIV/AIDs in South Africa (SA) has resulted in the use of antiretroviral drugs (ARVDs) such as lamivudine. This results in the wide occurrence and availability of this drug in water bodies. Various analytical techniques, such as HPLC, UPLC, and GC, have been widely used for the quantification and detection of ARVDs; however, these techniques are costly and time-consuming. Therefore, an alternative rapid, accurate, simple, and in-situ measurement technique is needed for the detection and quantification of ARVDs in the environment. Electrochemical sensing is considered a cheaper and simpler technique for detecting and quantifying pharmaceuticals in the environment. In this work, a reduced graphene oxide/chitosan (rGO-CS) composite was synthesised by a simple reflux method to be used to modify a glassy carbon electrode (GCE) for the detection of the ARVD lamivudine in aqueous systems. The composite was characterised using SEM, TEM, UV-VIS, XRD, Raman spectroscopy, CV, and EIS to investigate its physiochemical and electrochemical properties. SEM revealed that the composite shows smooth edges with many corrugations, while TEM revealed a mixture of smooth and rough surfaces. The addition of CS to rGO shifts the 2θ angle of CS from 19.91° to 22.66°, implying distortion in the crystalline structure of the compositing CS while maintaining the diffraction pattern of rGO due to excess non-binding rGO. The Nyquist plot from EIS showed that the rGO-CS/GCE had a lower charge transfer resistance (R_{ct}) of 22.45 Ω than the GCE with an R_{ct} of 559.7 Ω while CV studies showed a higher electroactive surface for the modified electrode. The rGO-CS composite was used as a potential electrode modifier by drop casting on GCE and was tested for the detection of lamivudine in wastewater.

SCP-F-6

ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY. CASE OF STUDY AND SOFTWARE IMPLEMENTATION

Senzo Hlongwane

210507488@stu.ukzn.ac.za

Student Number: 210507488

School of Chemistry & Physics

Supervised by Dr Marco Mariola

The goal of applied science is to develop advanced technology for industrial, civil and define purposes. The physical property of a materials, chemical solutions, and transmission media need to be characterized before being used for a particular application. The characterisation of novel materials sometimes requires a non-standard measure approach, different methods and system need to be developed to optimise the research time. The proposed research aims to develop systems and the methods to characterise a material's and media's physical properties by hardware and software design. The design of the hardware needs to be low-cost and when it is possible, to be an open hardware.

Any substance subjected to a variable electrical signal responds like a passive electrical circuit. The electrochemical impedance spectroscopy aims to characterise the equivalent circuit of a given substance. The characterisation of the equivalent circuit is essential when the material should be used for battery or to determine any other application. In this work, the methodologies and optimisation used to characterise the electrical property of the substance are presented.

SCP-F-7

Synergy between light trapping and charge transport for improved collection of photo-current

Ncedo Jili

217041397@stu.ukzn.ac.za

Student Number: 217041397

School of Chemistry and Physics

Supervised by Professor Genene Mola

Materials for solar energy conversion are in demand owing to the abundant energy available from the sun, which is often underutilised. Organic solar cell (OSC) is one of the emerging solar cell technologies that attracted the attention of scientists, engineers as well as industries at present. OSC has brought several advantages over the inorganic ones in terms of the low cost of device production, portability, flexibility, lightweight, environmentally-friendly fabrication processes, however, semiconductor organic solar absorber exhibits poor charge transport process because of exciton short diffusion length, short lifetime, and poor carrier mobilities in the medium. Such transport properties have negatively impacted the performance of organic solar cells (OSC). In recent years, the incorporation of materials such as nanoparticles, nanorods, nanoshells, and nanowires in solar cell device structures is gaining popularity due to their unique advantages in altering optical and electrical properties. Among the most widely used metal nanoparticles, which are reported to have several applications in the fields of photovoltaics, water purification, medicine, and chemical reactions as catalysts. Nickel doped Cobalt bi-metal nano-particles (Ni/Co BMNPs) were employed in the transport buffer layer of thin film polymer solar cell to assist in the collection of photons generated current. P3HT:PCBM blend based polymer solar cells were successfully fabricated with modified hole transport layer containing BMNPs at different concentrations. The performance of the devices has generally improved compared to the reference cell by the presence of BMNPs in the transport buffer layer and shows signs of dependence on the concentration level. Significant improvements in device performance were recorded at optimum level of 0.05 % PMNPs by weight, which resulted in high current density of 15.31 mA/cm2 , and recorded 5.05 % power conversion

efficiency (PCE). This is 67.8 % growth in PCE is compared to the reference cell. Moreover, another investigation was conducted using device simulation program to check the reproducibility of the experiments. The device that was made to mimic the best performance at 0.05 % BNMP concentration produced an efficiency of 5.76 %. Such reproducibility of data is an important development towards better understanding of the charge transport process in polymer solar cell. This study further provides new evidences about factors that influences device performance due to the inclusion of the BMNPs.

Keywords: Ni/Co nano-particle; Charge transport, Photons-harvesting, Organic solar cell

SCP-F-8

COMPARATIVE ANALYSIS OF WIND SPEED PROBABILITY DISTRIBUTIONS FOR WIND ENERGY POTENTIAL IN AFRICA

Saheed Tunji Jimoh

223152536@stu.ukzn.ac.za

Student Number: 223152536

School of Chemistry and Physics

Supervised by Professor Naven Chetty

Africa is endowed with huge resources of conventional energy resources (crude oil, tar sands, natural gas, and coal) as well as a reasonable amount of renewable energy resources e.g. hydro, solar, wind, and biomass [1]. As a random phenomenon, wind speed is the most significant parameter of wind energy. Therefore, an accurate determination of the probability distribution of wind speed is essential for predicting the energy output of wind energy conversion systems (WECS). Various statistical distributions exist for describing and analyzing wind resource data. Some of these include Weibull, Normal, Lognormal, Gamma and Bimodal Mixture Weibull, and Rayleigh [2].

The study aimed to compare the performance of the conventional Weibull, normal, log-normal, and gamma probability density functions with the mixture Weibull distribution in assessing the wind energy potential across various locations in Nigeria. The analysis was conducted using 20 years (1995-2015) of wind speed data from 12 meteorological stations, two from each of the six geopolitical zones in Nigeria. The results showed that the mixture Weibull distribution provided the best fit for the wind speed data in most of the stations, outperforming the other distributions based on statistical error metrics such as Kolmogorov-Smirnov and Root Mean Square Error (RMSE). The mixture Weibull distribution captured the bimodal nature of the wind speed distribution in some locations, which the conventional Weibull function could not adequately represent. The study also revealed that the northern regions of Nigeria at some point have higher wind speeds compared to the southern regions except Lagos which showed the highest average monthly wind speed of 12.71 m/s and the lowest of 2.68 m/s in Owerri also from the Southern part of Nigeria. The mixture of Weibull parameters further highlighted the spatial variability of wind resources across the country, with the shape parameter (α) ranging from 3.98 to 15.71 and the scale parameter (β) ranging from 3.00 to 12.29 m/s. The findings of this study provide valuable insights for wind energy resource assessment and the development of appropriate wind energy technologies in Nigeria, considering the unique wind regimes across different regions. This comprehensive analysis advances the understanding of wind energy potential and informs strategic planning for sustainable energy development in Nigeria.

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SCP-F-9

SULFATE REMOVAL FROM SOUTH AFRICAN ACID MINE DRAINAGE BY ELECTROCOAGULATION

Adela Madaree

214520326@stu.ukzn.ac.za

Student Number: 214520326

School of Chemistry and Physics

Supervised by Dr Ajay Bissessur and Prof Olatunde Stephen Olatunji

Globally, the most widely reported category of water pollution associated with coal mining is acid mine drainage (AMD). In mining sites and abandoned coal dumps, the accelerated oxidative dissolution of exposed sulfide minerals, such as pyrite, FeS_2, present in high quantities in low rank coal, leads to the formation of highly acidic, metal-enriched runoff mine water. The AMD contains elevated levels of sulfate which continuously discharges into surface and ground water sources, rivers and streams. In this study, the removal of sulfate ions present in AMD contaminated river water resulting from coal dumps is evaluated by the use of electrocoagulation. In consideration of the lack of AMD treatment facilities available in South Africa, ongoing energy crisis and high cost sulfate removal technologies, a cost effective treatment of electrocoagulation using recycled aluminium was developed as an AMD treatment protocol. The controlled parameters for the optimisation of the treatment protocols were initial pH of samples (pH_0 = 2, 3, 4), current density (3, 10, 20 mA cm^{-2}) and reaction duration (0.5, 1, 3, 6 hours). The efficiency of the treatment was assessed by the sulfate removal efficiency and pH neutralisation in attaining water quality that meets the global drinking water standards. The overall feasibility of the treatment protocol was evaluated by energy consumption (EEC) and operating cost (OPEX). The preliminary optimisation experiments highlighted the influence of controlled parameters on sulfate removal efficiencies and displayed that the highest removal efficiency was obtained with pH_0 = 2 at a current density of 20 mA cm^{-2}. These optimised parameters were then subjected to AMD contaminated river water and proved successful by attaining ~ 96% sulfate removal efficiency after 3 hours of reaction time rendering a neutral pH and sulfate content well below drinking limits. Based on the EEC and OPEX, the treatment protocol was deemed feasible as the total cost of ~ 4.20 cents per litre of solution was reported in successfully removing 96% of sulfate content after 3 hours of treatment.

SCP-F-10

EFFECT OF PYROLYSIS TEMPERATURE ON PINEAPPLE PEEL BIOCHAR FOR THE ADSORPTION LEAD(II) IONS FROM AQUEOUS SOLUTION

Nomaswazi Madonsela

213539701@stu.ukzn.ac.za

Student Number:213539701

School of Chemistry and Physics

Supervised by Prof Bice Martincigh, Prof Vincent O. Nyamori, Dr Bhekumuzi Gumbi

Recently, the focus of water pollution remediation has shifted towards developing environmentally friendly adsorbents with robust stability. Pineapple peel waste has been identified as an effective and low-cost precursor for potential adsorbents for removing heavy metal ions from aqueous solutions. Lead is one of the most hazardous environmental pollutants due to its high toxicity, tendency to accumulate in the biosphere, and persistence, making it difficult to remove from effluent by traditional water treatment plants, causing ecological imbalance. Therefore, the use of

advanced materials and technologies to eliminate these pollutants from wastewater is crucial for maintaining a safer environment. This study aimed to make biochar from pineapple peel waste and to investigate its potential capacity for removing Pb2+ from water. The biochar from pineapple peels was synthesized through pyrolysis at different temperatures (400 - 800 °C). Batch adsorption experiments were performed to determine the effects of initial pH, biochar dose, adsorption time, temperature, and initial Pb2+ concentration. The results showed that increasing the pyrolysis temperature improved the adsorption efficiency and capacity. The adsorption of Pb2+ onto pineapple peel biochar (PPB) prepared at different temperatures of the biochar (PPB-400, PPB-500, PPB-600, PPB-700, and PPB-800) gave Langmuir maximum adsorption capacity ($qmax$) values of 30.12, 30.00, 29.66, 52.50 and 64.12 mg g-1 respectively. The Elovich kinetics model fitted the data best. The equilibrium data were best explained by the Sips isotherm model. In conclusion, these results illustrate the potential biochar produced from pineapple peel waste could play in environmental pollution mitigation by enhancing the removal of Pb2+ from conventional wastewater treatment effluent, thereby minimizing its potential risks to the environment.

SCP-F-11

Utilising Continuous Measurement Models to Drive an Arbitrary, Two-Level Systems into a Known Target State

Shamik Maharaj

213536178@stu.ukzn.ac.za

Student Number: 213536178

School of Chemistry and Physics

Supervised by Prof Thomas Konrad

We present here a time-continuous scheme to drive a two-level quantum system into a target state. This work is based upon the idea presented in [1], where sequential application of a specific Kraus operator forces a system to converge to a desired state. Our Kraus operators are viewed as generalized projection operators which we utilize to model unsharp measurements as a function of measurement weakness. Taking the limit as the measurement weakness approaches infinity and the time between measurements approaches zero, we derive a master equation which governs the evolution of our system. The evolution is Markovian and can be expressed as a Lindblad master equation.

Kraus operators used in the sequential measurement case take on the form of measurement and feedback operators in the continuous measurement master equation. For specific choices of parameters in the measurement and feedback operators, we can force our system to converge to any target state. This is demonstrated by simulations using the Second Order Weak Scheme [2]. We also show proof of convergence in the non-selective regime.

Lastly, we attempt to express the state evolution in terms of coherent feedback control, which has been shown for sequential interactions in [3]. The idea is that a bath system interacting with our system of interest drives our system into a desired state as if by measurement and feedback in the non-selective regime.

We also hint at the possibility to expand this formalism to include higher dimensional systems.

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SCP-F-12

Improving the security of quantum key distribution using a BB84 protocol modified to implement the Leggett-Garg test

Siphesihle Majozi

212533522@stu.ukzn.ac.za

Student Number: 212533522

School of Chemistry and Physics

Supervised by Prof Thomas Konrad

Secure communications systems based on quantum resources have been explored in past years, with the BB84 protocol being among the most relevant in terms of QKD applications. In our study, we investigate a modification of the BB84 protocol that relies on the time-based equivalent of the Bell inequality called the Leggett-Garg inequality. In this talk I describe this so called LG-BB84 protocol which increases the security of QKD for a certain kind of eavesdropping attack [1].

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SCP-F-13

PRODUCTION OF BIOFUELS FROM WASTE OILS USING TRANSESTERIFICATION DETERGENT

Aphiwe Maphalala

220026147@stu.ukzn.ac.za

Student Number: 220026147

School of Chemistry and Physics

Supervised by Dr Ajay Bissessur

Energy is a crucial factor in measuring economic development and is essential for people's livelihoods.[1] A significantly large amount of energy is generated from fossil fuels, and this has led towards the exhaustion of petroleum-derived fuel and contributed immensely to global warming and environmental contamination.[2] Biofuels are alternative fuels produced from "agricultural biomass and other organic matter".[3] One of the alternative fuels being explored is biodiesel, which is primarily made up of fatty acid alkyl mono-esters from vegetable or animal fats and oils, mainly via acidic or basic catalytic transesterification with short-chain alcohols.[4] Due to biodiesel production being more costly, and limiting its commercialisation, using waste oils could potentially cut manufacturing costs.

This project aims to develop a dual system in which an effective, and economical surfactant is used in a transesterifying detergent, that can clean surfaces of fatty acid waste, and separate the waste from biofuels. A transesterification detergent will be formulated and tested against waste oils, collected from various sources. A series of experiments and characterisations such as determining the acid value, iodine number, cetane number, etc., will be performed to assess the quality of the waste oils and optimise the transesterification conditions of the detergent. The resulting biodiesel will be characterised using GC-MS, FTIR, and physicochemical properties such as viscosity, cetane number, flash point, and calorific value. The US and EU specifications will be used to compare and ascertain the quality of the biodiesel produced.

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SCP-F-14

THERMO-RESPONSIVE CHITOSAN–AGAROSE NANOHYDROGEL FOR NANO-ENABLED PERSONAL CARE PRODUCT FORMULATION

Mandisa Mathenjwa

219004850@stu.ukzn.ac.za

Student Number: 219004850

School of Chemistry and Physics

Supervised by Dr Florence Lehutso, Dr Yolanda Tancu, Dr Mbuyi Moloi, Dr Bhekumuzi Gumbi

Silver nanoparticles (AgNPs) in nano-enabled products (NEPs) are mostly used in consumer products because of their broad range of antibacterial capabilities against pathogenic microorganisms[1]. Because of this, these NPs have been successful as preservatives in the personal care, health and fitness industries' shampoos, kinds of toothpaste, anti-acne cosmetic formulas, and other similar items[2,3,4,5]. These NPs are not permanently fixed to the NEPs matrix and have been shown to have varying degrees of environmental exposure potential, ranging from minimal to high, reliant on the type of NEP[6]. Thus, release exposure potentials of NPs from NEPs should be considered at the formulation stages. Herein, the current study aimed to produce a thermo-responsive chitosan–agarose nanohydrogel, engineered with citrate-capped AgNPs to facilitate the dynamic reabsorption of silver in aqueous environments. The thermo-responsive hydrogel, which undergoes reversible sol-to-gel transitions in response to temperature changes, is designed to optimize the retention and release of AgNPs in water-based applications. The synthesis and characterization of the chitosan–agarose nanohydrogel, highlights the hydrogel's ability to reabsorb AgNPs from aqueous solutions and release them in a controlled manner upon temperature shifts. This behavior is crucial for applications in personal care products, where precise control over silver delivery is desired. To investigate the properties of the nanohydrogel, scanning electron microscopy coupled with energy-dispersive X-ray spectrometry, Fourier transform infrared and Raman spectroscopies, X-ray diffraction, and silver loading and entrapment tests were applied. This innovative approach leverages thermo-responsive technology to enhance the functionality and sustainability of silver-enriched personal care products.

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SCP-F-15

SOLVING A QUADRATIC OPTIMISATION PROBLEM BY MEANS OF QUANTUM COMPUTING USING AMPLITUDE ENCODING

Helarie Rose Medie Fah

223153323@stu.ukzn.ac.za

Student Number: 223153323

School of Chemistry and Physics

Supervised by Prof Thomas Konrad

Quantum computers have the potential to be faster at solving certain problems, such as optimisation problems, than their conventional equivalents [1]. These speedups are made possible by the fact that quantum computers are based on quantum bits (qubits), which may use superposition or entanglement, two peculiar properties of quantum physics. In this work, we explore the quantum gradient descent method [2] and describe a modified version of it to find the minimum of a quadratic cost function. We simulate the algorithm using the so-called amplitude encoding technique, to approach the minimum of a quadratic cost function of 2 variables and of 8 variables and verify the result. We present the quantum circuit for one step and iterate it to find the optimal solution after several steps.

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SCP-F-16

HETEROARYLIC (PYRAZOLYL)IMINE Co (II) AND Fe(II) COMPLEXES AS SELECTIVE ETHYLENE OLIGOMERISATION CATALYSTS

Francis Migwi

222130491@stu.ukzn.ac.za

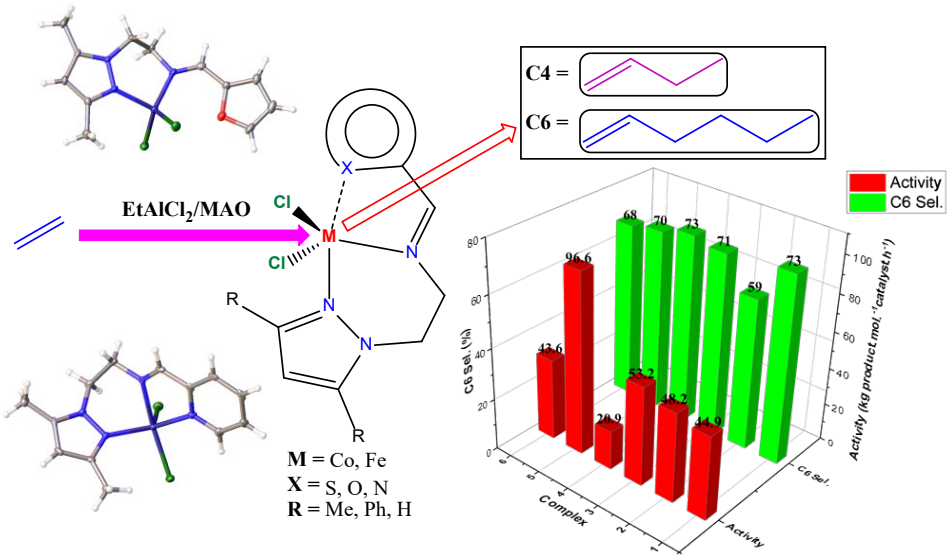
Student Number: 222130491

School of Chemistry and Physics

Supervised by Prof Stephen Ojwach

The field of ethylene oligomerisation and polymerisation has seen significant advancements due to increased demand for products like polyethylenes, lubricants, surfactants, and detergents [1]. Additionally, the design of catalytic systems that employ the readily available, cost-effective and environmentally friendly metals is equally gaining momentum [2]. Herein, the reaction of the heteroaryl (pyrazolyl)imine ligands (**L1**-**L5**) with $CoCl_2$ and $FeCl_2$ salts yielded the Co(II) (**1**-**4**) and Fe(II) (**5**-**6**) complexes reported. The complexes were characterized using IR spectroscopy, mass spectrometry, magnetic moment measurements, elemental analysis, and single crystal X-ray diffraction techniques. The molecular structures of complexes **2** and **3** confirmed the bidentate N^N and tridentate N^N^N bound monometallic complexes respectively.

Activation of these complexes with either $EtAlCl_2$ or MAO co-catalysts resulted in the selective formation of ethylene dimers (C_4) and trimers (C_6). Moreover, the effects of complex structure and reaction conditions were studied and found to influence the catalytic performance of the complexes. The tridentate systems were more active than the bidentate analogues, with activities of up to 1.46×10^5 g (product).mol.$^{-1}$catalyst.h^{-1}. On the other hand, the Fe(II) catalysts were more active than the corresponding Co(II) analogues.



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SCP-F-17

COBALT PHTHALOCYANINE-IMBEDDED ELECTROSPUN NANOFIBERS IMMOBALIZED ON A GOLD ELECTRODE FOR THE DETECTION OF Hg (II)

Danica Moodley

214503824@stu.ukzn.ac.za

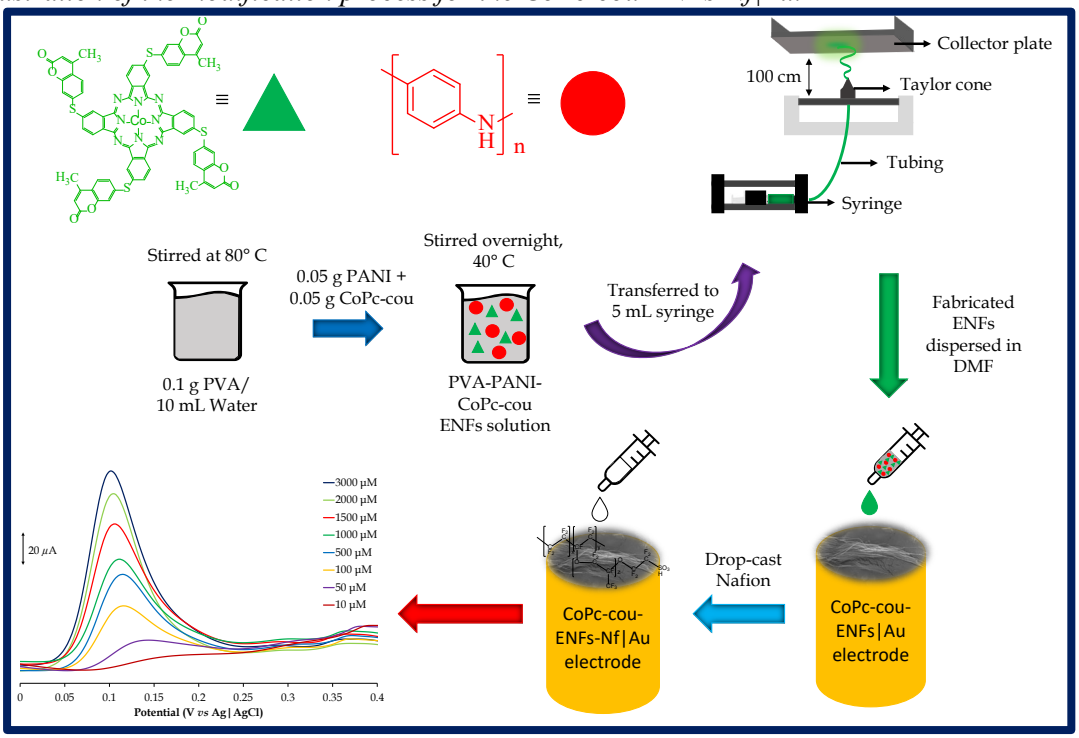
Student Number: 214503824

School of Chemistry and Physics

Supervised by Prof Irvin Noel Booysen and Co-Supervised by Dr Allen Mambanda

This research study describes the nanofabrication of electrospun nanofibers (ENFs) containing a coumarin tetra-substituted cobalt phthalocyanine (CoPc-cou), polyaniline (PANI) and polyvinyl alcohol (PVA). This nanocomposite was immobilized using a 5% Nafion (Nf) solution onto a gold substrate to afford the CoPc-cou-ENFs-Nf|Au modified electrode. Comparison of the bare and modified electrodes show that the CME under optimised conditions displayed superior detection of Hg(II) attaining a linear range of 10 – 3000 µM as well as a LOD and a LOQ of 0.14 µM and 0.46 µM, respectively. The high electrocatalytic activity of the CME was attributed to the affinity between the Hg(II) cations and the mercaptocoumarin substituent and the higher effective surface area. Furthermore, the CME exhibits selectivity and sensitivity in an interference sample containing multiple heavy metals (Pb^{2+}, Cd^{2+} and Hg^{2+}). A good percentage recovery of 96% was attained when the CoPc-cou-ENFs-Nf|Au electrode was applied to a real water sample which was comparable to a percentage recovery of 98% which was attained using the ICP-OES to analyse the same water samples.

Scheme 1: *Illustration of the modification process for the CoPc-cou-ENFs-Nf|Au.*



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SCP-F-18

CO_2 hydrogenation to methanol over Pt-promoted Cu/CeO_2 catalysts

Sbonelo Msane

220018825@stu.ukzn.ac.za

Student Number: 220018825

School of Chemistry and Physics

Supervised by Dr Abdul Samad Mahomed

Methanol is a widely used commodity chemical of great importance. Despite its extensive use in the chemical industry, there is a significant focus on the utilisation of methanol as a fuel, either through direct application in fuel cells or through dimethyl ether production. Commercially, methanol is produced from synthesis gas (syngas) which is a mixture of carbon monoxide and hydrogen with a small fraction of carbon dioxide. However, the direct hydrogenation of CO_2 rather than CO into methanol has become a particularly active subject of research in recent years due to the growing interest in reducing the perpetually increasing atmospheric CO_2 concentrations. The most commonly utilized catalysts in the production of methanol are copper-based. The extensive use of Cu is due to its relatively high activity, availability, and lower cost compared to other metals. However, the conversion tends to be poor.

Considering, the behaviour of CeO_2 and Pt in many hydrogenation catalysts, there has been substantial interest in combining them with Cu and evaluating the activity of the catalyst system for CO_2 hydrogenation to methanol. This can be accomplished by supporting copper on CeO_2 and subsequently promoting the catalyst system by the addition of Pt. One remarkable characteristic of ceria is the easy transformation of the Ce^{4+}/Ce^{3+} redox pair within its structure, resulting in the swift generation of oxygen vacancies. The reversible Ce^{4+}/Ce^{3+} ceria redox pair can intimately interact with the $Cu^{\delta+}/Cu^0$ couple thereby enhancing the reducibility and particle dispersion of materials. Ceria is responsible for stabilizing the reactive copper species [1]. One of the reasons for choosing Pt is its efficiency in promoting

hydrogen spillover, where adsorbed molecular hydrogen is dissociated to form atomic hydrogen which subsequently migrates to the metal oxide support to enhance its reducibility through the generation of more active sites [2].

Various Cu-Pt/CeO_2 catalysts were synthesised by solution combustion in conjunction with incipient wet impregnation. The catalysts were characterised by various techniques such as XRD, SEM, TEM, and H_2-TPR, amongst others, and they were tested in a high-pressure reactor system to investigate the influence of Pt loading in the combined catalytic system.

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SCP-F-19

Physicochemical Evaluation of Synthetic and Possible Green Novel Passivation of Insulating Oils in Liquid-Filled Transformers

Mhlengi Saviour Msomi

216003115@stu.ukzn.ac.za

Student Number: 216003115

School of Chemistry and Physics

Supervised by: Dr Ajay Bissessur, Dr Tishana Singh and Dr Hogantharanni Govender

Corrosive sulphur is one of the most critical issues with transformer windings three primary components: oil, paper, and copper. These include detrimental influences on the insulating qualities of oil and paper, as well as the breaking off of copper sulphide, which reduces the copper concentration on the windings and, depending on where it lodges, may cause short circuits. Dibenzyl disulphide (DBDS), an anti-wear additive, is the primary cause, however other compounds may also contribute to the development of copper sulphide. The passivating layer that forms on the metal surface is assumed to be composed of an apparently insoluble coordination complex between the metal and Benzotriazole, which produces an invisible layer on the copper surface. Studies have demonstrated that some metal-theophylline complexes have substantial anticancer action [1]. Theophylline anion is often utilized as a model ligand for studying interactions with metal ions. Thus, we were interested in the interaction of theophylline and anions with metal ions such as Co (II), Ni (II), Cu (II), Zn (II), and Cd (II). FTIR and UV-visible spectroscopy were utilized to investigate the coordination site of these ligands and metal ions. Thus, the aim of this study is to employ caffeine as a metal passivator and compare it inhibitory characteristics with that of a known benzotriazole passivator by means of physicochemical properties in fluid filled transformers [2].

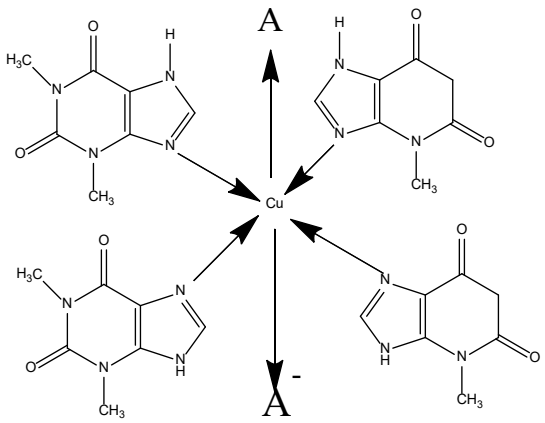

Figure 1: hypothetical caffeine-copper complexation in fluid-filled transformers [2].

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SCP-F-20

Late transition metal complexes of N-functionalised N-heterocyclic carbenes: Synthesis and application as antimicrobial agents

Lindokuhle Mthethwa

220040532@stu.ukzn.ac.za

Student Number: 220040532

School of Chemistry and Physics

Supervised by Prof Muhammad D. Bala

The continued emergence of new antimicrobial resistance (AMRs) is one of the most alarming medical concerns today. If immediate action is not taken, 10 million deaths per year might occur because of this global health concern. New drugs that might improve activity against resistant microorganisms by new modes of action compared to decades-old antibiotics are increasingly needed. Screening of organometallic compounds, which may involve coordinating well-known antimicrobial agents to a metal core, has emerged as an effective way to combat AMR.

In the past several decades, late transition metal complexes containing N-heterocyclic carbene ligands (NHCs) have been used successfully in various fields, such as homogeneous catalysis, metallodrugs, and luminous materials. Mesoionic 1,2,3-triazol-5-ylidenes have been widely employed as carbene ligand precursors in the synthesis of several transition metal complexes. For this reason, the development of metal complexes containing these ligands is crucial to the field of synthetic organometallic and organic chemistry [1].

This work aims to synthesise Ru and Os metal complexes containing pyridyl and picolyl-functionalized 1,2,3-triazol-5-ylidene ligands and investigate their antimicrobial activity. A series of C_2-symmetric and non-symmetric triazolium salts were prepared via a two-step reaction. In the first step, pyridyl and picolyl-functionalised 1,2,3-triazoles were prepared using a copper-catalyzed azide-alkyne cycloaddition reaction, which is a green chemistry approach. In the second step, the 1,2,3-triazoles were selectively methylated at the N3 position using Meerwein's salt (Me_3OBF_4). The compounds were characterized by NMR, IR and melting point determination as a quick indicator of bulk purity. Both types of triazolium salts will be complexed to Ru and Os metals via the transmetalation route using silver oxide as a metal transfer agent in tridentate NCN and CNC pincer chelating modes [2]. The obtained metal complexes, together with the corresponding ligand precursor salts, will be tested for their antimicrobial activity against Gram-positive and Gram-negative bacterial strains.

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SCP-F-21

Effect of polymer coating on the structural and magnetic properties of Mg-Zn ferrite NPs synthesized by glycol-thermal route

Sakhile Mthimkhulu

224193376@stu.ukzn.ac.za

Student Number: 224193376

School of Chemistry and Physics

Supervised by Dr Wendy Mdlalose

Magnesium-zinc ferrite ($Mg_xZn_{1-x}Fe_2O_4$, for $x = 0$, 0.5 and 1) nanoparticles (NPs) were successfully synthesised using the glycol-thermal reaction method. The NPs were then coated with a biocompatible polymer (chitosan). The materials were characterised using X-ray diffraction (XRD), Fourier Transform Infrared (FTIR), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), and Vibrating Sample Magnetometer (VSM) for their structural, morphology and magnetic properties. The XRD results of the as-prepared NPs confirmed a single cubic spinel structure with an average crystallite size of 13.5 nm. No significant changes in the XRD results were observed after coating. However, the average crystallite size slightly decreased to about 13 nm. The FTIR data confirmed the chitosan's coating and correlated with the XRD results. TEM and SEM reveal spherical shapes in all as-prepared NPs with an average diameter of approximately 15.6 nm, which decreased to about 13.8 nm. Hence, TEM and XRD agreed to each other. The magnetization hysteresis loops obtained by the VSM exhibited a superparamagnetic nature for both as prepared and coated NPs. Larger saturation magnetization and coercive field were observed in $Zn_{0.5}Mg_{0.5}Fe_2O_4$ compared to $MgFe_2O_4$ and $ZnFe_2O_4$ NPs. A similar behaviour was observed even after coating. The magnetisations of the as-prepared NPs were shielded by the coating, which enhanced the superparamagnetic behavior of the NPs. Superparamagnetism is one of the important features in the application of magnetic NPs as drug-delivery agents. Conclusively, these polymer-coated ferrites present feasible nanocarriers in magneto-targeted drug delivery.

Keywords: Ferrites, magnetic nanoparticles, superparamagnetic

SCP-F-23

SYNTHESES OF (PYRIDYL)PYRAZINE CARBOXAMIDE PALLADIUM(II) COMPLEXES, DNA/BSA BINDING INTERACTIONS AND CYTOTOXICITY STUDIES

Sabathile Thandeka Mvelase

216053719@stu.ukzn.ac.za

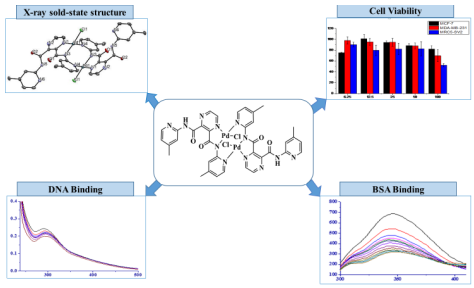
Student Number: 216053719

School of Chemistry and Physics

Supervised by: Prof Stephen Ojwach

Palladium complexes have gained interests as promising anticancer agents due to structural resemblance, and similar coordination chemistry to platinum compounds. Due to these properties, new palladium complexes have been developed and investigated for anticancer activity.[1-3] In this project, reactions of ligands [N^2, N^3-bis(pyridin-2-yl)pyrazine-2,3-dicarboxamide] (**L1**), [N^2, N^3-bis(6-methylpyridin-2-yl)pyrazine-2,3-dicarboxamide] (**L2**), [N^2,N^3-bis(4-methylpyridin-2-yl)pyrazine-2,3-dicarboxamide] (**L3**) and [N^2, N^3-bis(quinoline-8-yl)pyrazine-2,3-dicarboxamide] (**L4**) with $[PdCl_2(NC_{Me})_2]$ afforded the respective palladium(II) complexes: $[Pd_2(\mathbf{L1})_2Cl_2]$ **(Pd1)**, $[Pd_2(\mathbf{L2})_2Cl_2]$ **(Pd2)**, $[Pd_2(\mathbf{L3})_2Cl_2]$ **(Pd3)** and $[Pd(\mathbf{L4})Cl]$ **(Pd4)**. These compounds were structurally characterised by ^1H, $\{^{13}C\}$ NMR FT-IR, mass spectrometry, elemental analysis, and single crystal X-ray crystallography. Molecular structures of complexes **Pd1** and **Pd3** revealed the formation of dinuclear compounds, which contain two bridging bidentate ligand units in the metal coordination sphere. UV-visible and fluorescence competitive binding revealed that the complexes interact with calf thymus DNA through intercalative binding mode. The bovine serum albumin (BSA)

interaction monitored by fluorescence spectroscopy displayed high binding affinity and static quenching mechanism. The cytotoxic effects of the complexes **Pd1-Pd4** was probed against MCF-7, MDA-MB-231, MRC5-SV2, MRC5 cell lines. **Pd1** and **Pd4** showed significant to moderate cytotoxicity against MCF-7, whereas **Pd2** and **Pd3** were inactive. All the complexes were inactive against the MDA-MB-231 cell line, and **Pd2-Pd4** were inactive against the MRC5-SV2 cell line. Compounds **Pd1** exhibited lower cytotoxicity against the normal cell line MRC5.



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SCP-F-25

Enhanced surface characteristics and magnetic properties of PEG coated zinc- and cobalt-nano ferrites via high-energy ball milling

Nkanyiso L. Ndlovu

216006188@stu.ukzn.ac.za

Student Number: 216006188

School of Chemistry and Physics

Supervised by Dr Wendy B. Mdlalose, Prof Thomas Moyo, and Ms Bulelwa Ntsendwana

Magnetic nanoparticles (NPs) are currently being explored for use in biomedical applications, such as magnetic resonance imaging (MRI), biosensors, magnetic hyperthermia treatment for cancer, and drug delivery. In this study, we report the influence of polymer-coating on the structural and magnetic properties of zinc ($ZnFe_2O_4$) and cobalt ($CoFe_2O_4$) nanoferrites. The $ZnFe_2O_4$ and $CoFe_2O_4$ nanoparticle powders were synthesized using the glycol-thermal technique. The product nanoparticles were then coated with polyethylene glycol (PEG) ($ZnFe_2O_4$-PEG and $CoFe_2O_4$-PEG) using high-energy ball milling at different times, 10 to 60 hours. The effect of PEG coating with milling time on the structural, morphology and magnetic properties of as-prepared samples was investigated using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), scanning electron microscopy (SEM) with Energy Dispersive X-ray (EDX) and Mössbauer spectroscopy. XRD results confirmed a single cubic spinel structure in all samples. The average crystallite size in both nanoparticles was slightly reduced by an average of 0.74 nm and 0.90 nm. Therefore, the average crystallite sizes were increased between 30 to 60 hrs of milling. Similar results were observed in TEM. TEM and SEM results revealed spherical nanoparticles in a spherical shape. Reduction in lattice parameters with coating was also observed. EDX results confirmed the composition of all the elements in the materials. FTIR data confirmed the bonding of the polymer on the surface of the $ZnFe_2O_4$ and $CoFe_2O_4$ nanoparticles and confirmed features of ferrites. Spectral data from the ^{57}Fe Mössbauer effect showed an ordered magnetic spin state in $CoFe_2O_4$ nanoparticles, while paramagnetic nature was observed to dominate in $ZnFe_2O_4$. This study shows that coating significantly affects the structural and magnetic properties of Zn- and Co-ferrites.

SCP-F-26

OCCURRENCE, MONITORING, AND REMOVAL EFFICIENCY OF SELECTED ANTIBIOTICS IN A WASTEWATER TREATMENT PLANT (WWTP) IN DURBAN, SOUTH AFRICA

Ntombenhle Nompilo Ngubane

220013413@stu.ukzn.ac.za

Student Number: 220013413

School of Chemistry and Physics

Supervised by Dr Samuel Getahun, Dr Hogantharanni Govender, Prof Olatunde Olatunji and Dr Bhekumuzi Gumbi

The presence of pharmaceuticals such as antibiotics in wastewater and their detection in reclaimed water has become a major environmental concern due to their potential effects on aquatic ecosystems and public health. Due to this concern, pharmaceuticals have been identified as an emerging contaminant. This study investigates the occurrence, monitoring, and removal efficiency of selected antibiotics within a wastewater treatment plant (WWTP). A comprehensive analysis was conducted to determine the concentration levels of various antibiotics entering (influent) and exiting (effluent) the WWTP. We identified and quantified the presence of multiple antibiotics at various stages of the treatment process employing high-pressure liquid chromatography (HPLC) equipped with a diode array detector (DAD) and mass spectrometry detector. The extraction method was validated based on solid phase extraction (SPE) Oasis HLB cartridges due to observed high selectivity with respect to targeted antibiotics, which led to very good recoveries. Our findings reveal varying removal efficiencies per drug, highlighting the ineffectiveness of current processes. This work can help to identify areas for improvement in the treatment process.

SCP-F-27

Zinc-based nanoparticles rested on multi-walled carbon nanotubes for antimicrobial and catalytic application

Ndumiso Nkosi

216059338@stu.ukzn.ac.za

Student Number: 216059338

School of Chemistry and Physics

Supervised by Dr Phindile Khoza and Prof Chenia Hafizah

Herein, we report a synthesis of zinc-based nanoparticles coated with silica and rested on multiwalled carboxylic functionalised carbon nanotubes under ambient conditions. The prepared zinc nanoparticles were capped with thioglycolic acid (TGA) which allows for controlled nucleation of particles and prevents exponential growth. Thereafter the nanoparticles were coated with silica to stabilised and prevent photo corrosion. They were then allowed to rest on the multi walled nanotubes through a peptide bond in order to enhance the surface area. The formation of the nanoparticles was confirmed by FTIR, XRD, UV, BET, SEM, and TEM. The UV showed a peak at different wavelengths which were blue-shifted compared to the bulk material, the blue shift is attributed to the quantum confinement effect which is common to all nanosized materials. FT-IR confirmed the adsorption of thioglycolic acid and silica on the surface of the ZnSe and ZnS surface (Zn^{2+}) surface. The XRD pattern suggests the cubic phase crystal structure of the prepared nanoparticles, further confirming the presence of the nanostructured materials. While TEM and SEM showed spherical nanoparticles also providing visual evidence of the particles resting on the carbon nanotubes. Furthermore, increased in surface area was observed upon coating with silica and resting the nanoparticles on the nanotubes. The prepared particles displayed antimicrobial, anti-quorum sensing and photocatalytic activity.

SCP-F-28

OCCURENCE AND DISTRIBUTION OF BIOMARKER PAHs IN URBAN METROPOLIS TOPSOIL AND SURFACE WATER

Emihle Nompu

220010181@stu.ukzn.ac.za

Student Number: 220010181

School of Chemistry and Physics

Supervised by Prof Olatunde Olatunji

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous due to natural sources and human activities hence, they are found everywhere, translocating from one medium to another e.g. air, soil, and water. They are generally resistant to natural degradation process; therefore, they tend to bioaccumulate with ease, and seed into sediment in aqueous media. They also accumulate in food at different levels of the food chain due to their hydrophobicity and form, which have capacity to induce adverse effects that can affect the normal functioning and health of biota and abiotic systems. PAHs are known cause of health effects such as carcinogenic, mutagenic, immunosuppression, adverse developmental and reproductive effects, endocrine disruption, oxidative stress, cardiovascular problems, heart rate variability, lung cancer, lung function abnormality and many more. These negative consequences depend on the structure, shape and number of aromatic rings in the PAHs. Soil and sediments have high concentration of PAHs due to the organic content, particle size, surface area and hydrophobic nature. Soil, sediments, air and water can also be secondary sources of PAHs. The challenge encountered in the analysis of PAHs, is the poor resolution of its isomers and high column temperatures that commonly used columns cannot handle and cause them to bleed. This proposed study aims to separate and quantify polycyclic aromatic hydrocarbons (PAHs). To achieve this, a viable GC-MS method will be developed and validated for the detection and quantitation of PAHs in soil, surface water and sediment samples. The PAHs will be extracted by solid phase extraction technique. With the obtained results, risk assessment and statistical analysis will be performed to compare the detected and quantified PAHs in different locations.

SCP-F-29

Synthesis and characterisation of Sr doped BiOI for photocatalytic degradation of methyl orange under visible light

Sive Nosenga

218086044@stu.ukzn.ac.za

Student Number: 218086044

School of Chemistry and Physics

Supervised by Dr Phindile Khoza

Metal oxide semiconductors that respond to visible light as photocatalysts have been demonstrated to be an effective way to remove organic pollutants from wastewater. Strontium-doped Bismuth oxyiodide (Sr-BiOI) was synthesized via a simple precipitation method to improve pure BiOI photocatalytic performance. Synthesised materials were characterised by XRD, FE-SEM, BET, and UV-DRS. The photocatalytic performance of materials was evaluated using Methyl orange as a model pollutant under visible light irradiation. The photocatalytic properties were enhanced after Sr doping in comparison with pure BiOI. The difference in photocatalytic performances of synthesised materials was further investigated.

SCP-F-30

Fabrication and effects of polymer (chitosan) coating on Ni-Zn ferrite nanoparticles

Sifiso Nxumalo

223153020@stu.ukzn.ac.za

Student Number: 223153020

School of Chemistry and Physics

Supervised by Dr Wendy Mdlalose

This work compares the properties of the as-prepared $Ni_{0.5}Zn_{0.5}Fe_2O_4$ and coated with chitosan nanoparticles. The $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles were prepared using glycothermal reaction method and coated with high-energy ball milling for up to 60 hrs. The as-prepared and coated nanoparticles were characterized for structural, morphology and magnetic properties using X-Ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), Transmission electron microscopy (TEM), Scanning electronic microscope (SEM), Energy dispersive X-ray spectroscopy (EDX) and Vibrating sample magnetometer (VSM). XRD results revealed the formation of a single cubic spinel phase structure of the as-prepared and coated sample, having an average crystallite size of (11.80 ± 4) nm and (11.33 ± 4) nm, respectively. TEM images showed nearly spherical particles with distributed particles with a crystallite size of about (11.44 ± 0.13) nm to (10.25 ± 0.07) nm for as-prepared and coated samples, respectively. Hence, TEM results correlated well to XRD results. Less aggregation of particles was observed after coating, suggesting effective chitosan coating. SEM confirmed the clustering nanoparticles for an as-prepared sample and less agglomeration on the coated sample. The EDX results confirmed the presence of elements that were carried in the samples. FTIR results confirmed the coating of chitosan on the $Ni_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles' surfaces. The S-shaped magnetization loop revealed the superparamagnetic nature of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ ferrite nanoparticles. The preliminary results from the magnetic measurements revealed that the bare NPs has a saturation magnetization of 60.29 emu/g with coercivity field of 0.701 kOe. Therefore, the results confirms that $Ni_{0.5}Zn_{0.5}Fe_2O_4$ NPs are soft ferromagnetic materials and may be used to functionalize the surface of the nanoparticles to suite desired applications.

SCP-F-32

Unveiling the Quaternary Carbodiimide Symphony: Harmonising Green Chemistry in Peptide Synthesis

Hlobisile Nzama

213549045@stu.ukzn.ac.za

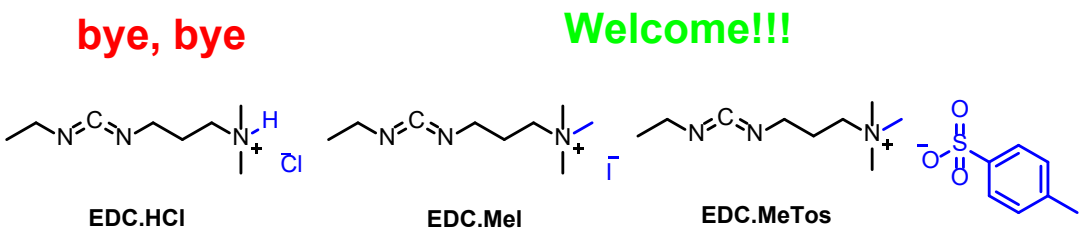
Student Number: 213549045

School of Chemistry and Physics

Supervised by Prof Fernando Albericio

Although *N*-ethyl-N'-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC.HCl) is a common reagent in peptide synthesis, it presents two drawbacks. First of all, it is in a tautomerism equilibrium with cyclic form that it is not productive. Secondly, it is hydrolysed to the corresponding urea. Furthermore, it is only soluble in water, which limits its use in solid-phase peptide synthesis (SPPS) strategy. Herein, two quaternary carbodiimides (QCD), namely 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide methiodide (EDC.MeI) and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide methotosylate (EDC.MeTos), are described. The presence of the quaternary N prevents the formation of the cyclic form but preserves its solubility in water. However, the QCDs are also soluble in other organic solvents. These QCDs are totally stable at least up to 20 days. They present a level of racemization similar or even slightly better than EDC.HCl and a better performance when used for the SPPS of different peptides. Finally, the preliminary tests indicate that its use is safer than other carbodiimides.

Graphical Abstracts



SCP-F-33

Estimation of natural radioactivity and radiological hazards in aggregate (stone dust) used as building materials in South Africa

Olusegun Yemi Omogunloye

222129717@stu.ukzn.ac.za

Student Number: 222129717

School of Chemistry and Physics

Supervised by Prof Naven Chetty

In this study, the radioactivity concentrations of natural radionuclides (Uranium-238, Thorium-232, and Potassiumi-40) in aggregate/stone dust samples used for building construction purposes have been measured with a thallium-doped sodium iodide (NaI(TI)) detector. The samples' associated radiological hazard risks were calculated using standard radiological expressions. The mean values of Uranium-238, Thorium-232, and Potassiumi-40 activity concentrations in the studied Quarries' samples were above the World mean values of 35, 30, and 400 $Bq.kg^{-1}$ for radioactivity concentrations in building materials. The lowest and highest values of all the estimated radiological hazard indices were recorded in samples Afrisam C 5 and Afrimat 3.

SCP-F-34

OPTIMAL CLONING OF SPATIAL MODES USING QUANTUM DIFFERENCE FREQUENCY GENERATION

Tanita Permaul

216044254@stu.ukzn.ac.za

Student Number: 216044254

School of Chemistry and Physics

Supervised by Prof Thomas Konrad

Due to the rise of quantum computing and communication, there is a major demand to increase the bandwidth of quantum information that can be sent. An interesting avenue is looking at nonlinear optical processes which can be developed for structured light [1] and has recently been deployed in high-dimensional teleportation with spatial modes of light [2]. Despite these exciting advances, no account as yet exists that marries a classical and quantum picture of nonlinear processes with spatially structured photons. We previously derived a quantum optical formulation of difference-frequency generation (DFG) that incorporates the spatial modes of light. It reproduces the well established result for classical light beams [3] and establishes the relation of DFG to stimulated (StimPDC) and spontaneous parametric down-conversion (SPDC).

An application of the newly derived quantum description for the output spatial modes of StimPDC is to consider optimal quantum cloning of spatial modes of light. As is well known, it is not possible to create perfect copies of an

unknown quantum state [4]. This is referred to as the *no-cloning theorem*, which is fundamental to secure quantum communication schemes. However in 1996, Bužek and Hillery [5] demonstrated that quantum cloning can be achieved partially with imperfect clones. Optimal quantum cloning produces clones with the highest fidelities allowed by quantum mechanics. We are therefore able to demonstrate that stimulated parametric down-conversion can realise $N \rightarrow M$ d-dimensional optimal quantum cloning.

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SCP-F-35

BIOMARKERS IN FUELS: ENHANCING ANALYSIS TECHNIQUES FOR RAPID, SIMPLE AND EFFICIENT RESULTS

Keleish Pillay

219001194@stu.ukzn.ac.za

Student Number: 219001194

School of Chemistry and Physics

Supervised by Dr Ajay Bissessur

A significant portion of fuel stations in South Africa are blending diesel with paraffin, impacting vehicle performance and causing lasting harm to engines. According to recent findings from the Department of Mineral Resources and Energy (DMRE), 70 out of 1000 service stations sampled were found to be diluting diesel with paraffin. This practice is driven by the desire to lower diesel costs and increase profits, as paraffin is not subject to the fuel levy, enabling stations to evade taxes. The diminishing refinery capacity and closures since 2020 have led to reduced domestic fuel production and heightened reliance on imports. It is projected that by 2025, 53% of refined fuel products will be imported into South Africa, totaling 604,000 barrels per day. This trend poses challenges to fuel supply security and inflates input costs, exacerbating unemployment due to refinery closures. Increased investment in upstream exploration and oil and gas exploration could potentially revitalize refineries and bolster fuel supplies. This research aims to identify a biomarker to be introduced into fuels from both imported and petrol station tanks to assess contamination rates and improve fuel analysis techniques. It seeks to advance biomarker chemistry, characterization, and quantification, as well as develop efficient methods for fuel identification and fingerprinting using multivariate statistical analysis. Biomarkers are crucial hydrocarbon compounds in petroleum that can be detected at low concentrations using gas chromatography/mass spectrometry (GC/MS). They are relatively resistant to environmental degradation and exhibit distinct fingerprints based on geological conditions and ages. Analyzing biomarkers provides vital information for fuel characterization, correlation, differentiation, and source identification. The outcomes of this research will have significant implications on the adulteration of fuels, prevention of exhaust emissions from vehicles which are harmful pollutants that include toxic gases as well as to inhibit the negative impact on the government taxes. Although South Africa's fuel standards permit up to 5% paraffin in diesel to prevent seizing, excessive dilution is detectable through marker tests. This study will provide crucial data to combat fuel contamination and revenue loss following the introduction of a chemical marker in illuminating paraffin sold in the country.

SCP-F-36

Adsorption of selected pharmaceuticals onto microplastics and optimisation of adsorption parameters

Vishalan Pillay

209502441@stu.ukzn.ac.za

Student Number: 209502441

School of Chemistry and Physics

Supervised by Prof Brenda Moodley

The world population continues to grow at an exponential rate and with this increase, new challenges arise each day. The frequency with which a new disease or virus enters the global stage has scientists scrambling to introduce new pharmaceutical drugs to eradicate these more advanced illnesses. These new pharmaceutical drugs may provide a short-term respite from certain ailments; however, the introduction of these new drugs brings upon new environmental challenges. As most of these drugs are not fully metabolised by the human body, they enter the environment via wastewater treatment plants or landfills and are catergorised as emerging pollutants. These contaminants are also classified as endocrine disruptors as they affect hormone levels which may result in reproductive complications in organisms. Another problematic pollutant is plastic, which has been used extensively due to its versatility but is an environmental threat due to its extremely slow degradation rate. This pollutant may be a greater threat in the form of microplastics, which could provide a platform for pharmaceutical waste to adsorb to. The aim of this study is to investigate the adsorption of selected pharmaceuticals onto microplastics. The adsorption parameters will be optimised, which will provide a better understanding of the behaviour and fate of these pollutants in the environment. Parameters to be optimised include: size and mass of plastic particle, pH, and concentration. A kinetic and thermodynamic study will also be conducted. The microplastics will be characterised using the following instrumentation: Fourier transform infrared spectroscopy (FT-IR) and Scanning electron microscope (SEM). The extracts will be analysed using liquid chromatography with a PDA detector to assess the adsorption capacity. The analytes of interest for this study are as follows: flumequine, ofloxacin, and oxolinic acid. This research could be beneficial to improving the waste management of pharmaceuticals and WWTPs to prevent the release of contaminants to the environment.

SCP-F-37

QUANTIFICATION OF SELECTED PHARMACEUTICALS IN BIOLOGICAL AND ENVIRONMENTAL MATRICES USING HPLC – PDA DETECTION

Nerissa Rajkumar
219003070@stu.ukzn.ac.za
Student Number: 219003070
School of Chemistry and Physics
Supervised by Professor Olatunde Olatunji

The increasing occurrence of pharmaceuticals in biological matrices and wastewater poses significant environmental and public health challenges. These compounds, which originate from various sources, can persist in the environment, leading to adverse effects on exposed ecosystems and humans. This research aims to develop and validate a high-performance liquid chromatography method coupled to a photodiode array detector (HPLC-PDA) for the quantification of selected pharmaceuticals, including 17-beta-estradiol, acetaminophen, acetylsalicylic acid, albendazole, ciprofloxacin, diclofenac, efavirenz, lamivudine, metformin, and sulfamethoxazole, in biological matrices (e.g., blood, urine) and wastewater samples. This method involves the optimisation of sample preparation techniques, such as solid-phase extraction (SPE), to effectively isolate and concentrate the target pharmaceuticals from complex matrices. The HPLC-PDA system will be operated over a Shimadzu SHIM-PACK GIST C18; 5 µm, 4.6 x 150 mm column to achieve good separation, and tuned for maximum sensitivity and selectivity for accurate detection of the pharmaceuticals. The developed method will be rigorously validated according to standard analytical procedures, including assessments of linearity, limit of detection (LOD), limit of quantification (LOQ), precision, and accuracy. Preliminary results suggest that the method provides high sensitivity with LODs and LOQs suitable for trace-level detection. The recovery rates

from spiked samples are also to be evaluated to ensure method reliability across different sample types. The validated HPLC-PDA method will be applied to analyse pharmaceutical residues in real biological and wastewater samples, respectively. This study will not only provide essential data on the occurrence and concentrations of pharmaceuticals in various environments but will also contribute to the development of strategies for monitoring and mitigating pharmaceutical contamination. The outcomes of this research will have significant implications for environmental management and public health, offering a robust analytical tool for ongoing surveillance and risk assessment of pharmaceutical residues in the environment.

SCP-F-38

APPLICATIONS OF 1,3,5-TRIAZINE AS A BRANCHING UNIT FOR THE SYNTHESES OF BIOLOGICAL ACTIVE BRANCHED ANTIMICROBIAL PEPTIDES

Sheyi Rotimi

218079250@stu.ukzn.ac.za

Student Number: 218079250

School of Chemistry and Physics

Supervised by Prof Fernando Albericio and Prof Beatriz G. de la Torre

In this work, we report the stepwise Solid-Phase Peptide Synthesis (SPPS) of branching peptides using 1,3,5-triazine (TCT) as ramification unit. TCT is able to react with nucleophiles in a chemoselective and sequential mode, allowing the incorporation of three different units [1-4]. SPPS is carried out using Fmoc/tBu protecting strategy with the concourse of DIC/OxymaPure as the coupling reagents. After the synthesis, the peptides were analysed and characterised by HPLC and LCMS, their activity as antibacterial peptide were investigated, and their structure studied by Circular Dichroism (CD).

Starting from a small hexapeptide containing three Lys and Leu with not antimicrobial activity, the final branching peptides have showed good anti-bacterial activity against a panel of both Gram-positive and Gram-negative bacterial strains. From the results, it has been found that the use of triazine as the branching unit has an important contribution to the antimicrobial activity of the peptides. For comparison, the same peptide using Lys as branching unit and the linear peptide containing three repetitions of the hexapeptide were synthesized and its antibacterial activity tested.

Peptides containing triazine branching unit showed improved antibacterial activity compared with both peptide references. Taking into consideration that peptides (two branched and one linear) have the same number of amino acids and positive charges, CD studies are carrying out to study the impact of the spatial arrangements into the activity.

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SCP-F-39

TITANIA NANOTUBES FOR DYE-SENSITISED SOLAR CELLS

Shruti Saroj

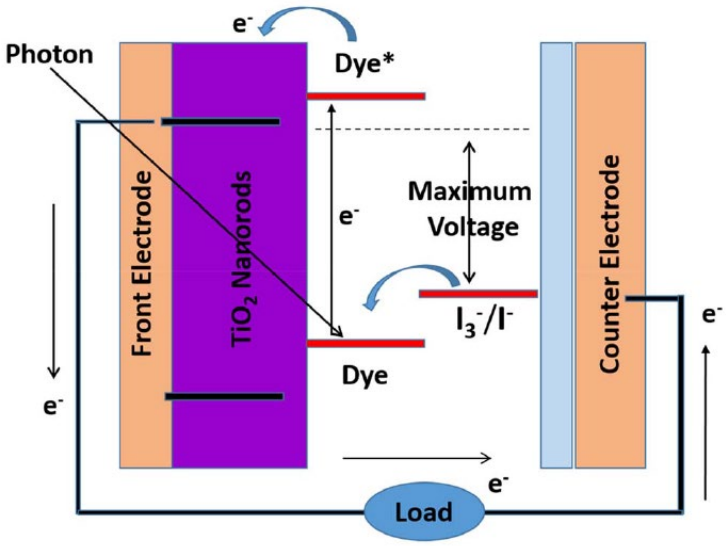
223153383@stu.ukzn.ac.za

Student Number: 223153383

School of Chemistry and Physics

Supervised by Prof Vincent O. Nyamori and Prof Bice S. Martincigh

Developing cost-efficient and stable materials for fabricating the photoanode in dye-sensitised solar cells is necessary. Titania has been the most widely used photoanode material since it has a wide bandgap and is commercially available [1]. This work aims to maximize dye-sensitised solar cell efficiency by advancing the photoanode materials to enhance dye absorption, charge transfer, photon absorption, and electron injection into the semiconductor conduction band. Towards this end, pristine titania nanotubes were prepared by a hydrothermal method and characterized by powder-XRD, FTIR, SEM, TEM, and UV-Vis DRS. The powder-XRD results confirmed the crystalline nature of titania nanotubes and the presence of mainly the anatase phase of titania. The SEM and TEM results confirmed the tubular morphology of the nanotubes of different lengths (average 227.80 nm) and different widths (average 38.71 nm). The band gap of the synthesised titania nanotubes was 2.84 eV while that of pristine titania was 3.03 eV indicating that the titania nanotubes are better photosensitizers since they absorb more readily in the abundant visible range of the electromagnetic spectrum. These results pave the way for the further study and development of nanomaterials for dye-sensitised solar cells.



Working principle of dye-sensitised solar cells [2]

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SCP-F-40

α-Glucosidase and α-Amylase Inhibitory Potentials of Thiazolidinone-Schiff base conjugates with Antioxidant Activity, Kinetic Studies, and Computational Validation

Pule Seboletswe

220112769@stu.ukzn.ac.za

Student Number:220112769

School of Chemistry and Physics

Supervised by Prof Parvesh Singh

Diabetes mellitus (DM) has become a growing concern to global public health, being at the forefront of acute disorders and causes of mortality across the globe. Clinically approved drugs that are currently being used are faced with severe side effects, consequently necessitating the development of new drugs with no/fewer side effects and improved pharmacological potency. Herein, we report a rapid and efficient synthesis of thiazolidinone Schiff bases (**2a**-**2t)** from benzylidenehydrazines and thioglycolic acid under neat conditions through ultra-sonication. All the synthesized compounds were obtained in exceptional yields (89–95%) and confirmed by 1D and 2D nuclear magnetic resonance (NMR) spectroscopy, as well as High-resolution mass spectrometry (HRMS). The synthesized compounds were then evaluated for their antidiabetic activity through *α*-glucosidase and *α*-amylase inhibitory potentials and their antioxidant activity through Nitric Oxide (NO), 2,2′-diphenyl-1-picrylhydrazyl **(**DPPH), and Ferric reducing antioxidant power (FRAP) assays. Among them, **2q** (IC_{50} = 96.63 μM) and **2h** (IC_{50} = 125.27 μM) emerged as the most potent derivatives against α-amylase relative to reference drug acarbose (IC_{50} = 131.63 μM), respectively. Antioxidant evaluation further revealed that the synthesized derivatives were excellent NO scavengers disclosing **2n** (IC_{50} = 44.95 μM) as the most potent derivative. Moreover, in silico ADME calculations predicted these compounds to have excellent drug-like properties. Kinetic studies disclosed the mode of α-amylase inhibition as competitive while molecular docking studies of the most active derivatives performed into the binding active site of human pancreatic α-amylase enzyme deciphered their ligand-protein interactions that explicated their observed experimental potencies.

SCP-F-41

THE DESIGN OF THE TIME TO DIGITAL CONVERTER BASED ON DIGITAL COUNTER AND A DELAY LINE

Lizwi Shabalala

210527007@stu.ukzn.ac.za

Student Number: 210527007

School of Chemistry and Physics

Supervised by Dr Marco Mariola

Time to Digital Converter (TDC) is a device that converts the time interval between two events and convert that time interval into digital output. There are many TDC architectures already present, the resolution varies with each TDC architecture. The goal of all architectures is to achieve the greatest possible resolution. The resolution of a TDC is a smallest time interval a TDC can measure.

The better resolution time to digital converter (TDC) is being studied and designed and the parameters to evaluate TDC (Time to Digital Converter) performance are discussed in this research. Of all the methods for time to digital conversion, the three of them are studied in few details, the ones studied are counter based time to digital conversion, delay line time to digital conversion which includes vernier, buffer and inverter-based delay lines time to digital conversion.

The research focuses on the implementation of a buffer delay line time to digital conversion and the inverters connected using ideally zero delay wires are used as buffers and the counter TDC is used for coarse measurement and buffer delay line for fine measurement. By fine measurement it is meant the detection of the smaller time interval that cannot be detected by a counter. The TDC can then be implemented in an FPGA (Field Programmable Gate Array). It can also be implemented on ASICs (Application Specific Integrated Circuit) and CPLDs (Complex Programmable Logic Devices) after being designed using combinational and sequential circuits.

The research shows that the resolution of the studied TDC can be improved by using delay elements with small time delay. The building blocks of the designed TDC circuit are simulated using a Verilog HDL (Hardware Description Language) and the whole TDC block diagram is shown. The simulations of both parts of a TDC are yielding the desired results according to the operation principle of a TDC.

SCP-F-42

A Tandem Aerobic Photocatalytic Synthesis of Quinoxaline Derivatives by Cu/Pd-N-TiO_2 Nanoparticles under Visible light

Berlinda Sikakane

215013545@stu.ukzn.ac.za

Student Number: 215013545

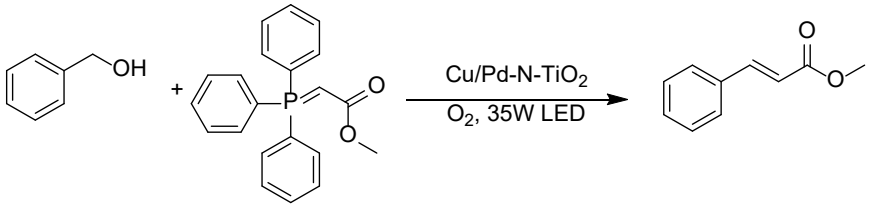
School of Chemistry and Physics

Supervised by Prof Ross Robinson

Photocatalysis by metal oxide semiconductors has advanced significantly over the years [1]. Titanium dioxide (TiO_2) has emerged as one of the most promising photocatalysts due to its low cost and stability [2]. However, its efficiency in utilizing visible light is limited, which can be addressed through functionalization [3]. The functionalized titanium dioxide has found applications in mediating photocatalytic organic transformations and one of these is the *in situ* oxidation transformation of alcohols, followed by the *in situ* trapping of the resulting aldehyde by a nucleophile in a one-pot procedure [4].

We report the Cu/Pd-N-TiO_2 photocatalyzed oxidative coupling of 1,2-diaminobenzene with α-hydroxy ketones for the synthesis of quinoxalines. The Cu/Pd-N-TiO_2 photocatalyst was prepared by a sol-gel method and then calcined at 350 °C. Multiple techniques including p-XRD, BET, HRTEM, and SEM-EDX characterized the structural properties of photocatalyst. The powder-diffused reflectance UV visible spectra of Cu/Pd-N-TiO_2 revealed a red shift absorption edge when compared with TiO_2. A decrease in the band gap energy from 2.92 eV of TiO_2 to 2.42 eV of Cu/Pd-N-TiO_2 was calculated. This suggested that doping introduced new electronic levels, resulting in higher photocatalytic efficiency.

The photocatalyst was then employed to mediate tandem oxidation reactions for the synthesis of quinoxaline derivatives. At optimal conditions, it was found to be an efficient, selective, and recyclable system for the synthesis of quinoxaline derivatives, with good to excellent conversions (84 to 99%). The successful synthesis of quinoxalines with Cu/Pd-N-TiO_2 sparks interest in further understanding how it can selectively synthesize quinoxalines, which in turn can enable us to conduct a broader range of organic coupling reactions.



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SCP-F-43

ENGINEERED TRANSPARENT WOOD WITH ENHANCED SUSTAINABILITY FOR GLASS APPLICATIONS

Nontobeko Simelane

223146765@stu.ukzn.ac.za

Student Number: 223146765

School of Chemistry and Physics

Supervised by Prof Olatunde Olatunji, Dr Maya Jacob John, Dr Jerome Andrew

Glass, a material that is used in most applications including construction, packaging, transportation etc, poses a threat to the environment. This is because when the raw material used to make glass degrade in the furnaces, they emit huge amounts of gasses such as carbon dioxide and nitrogen oxides [1]. These greenhouse gases increase global temperatures and can also form acid rain The glass-making process is also energy-intensive. In recent years, there has therefore been a demand for sustainable materials which has fueled research into innovative alternatives. Engineered transparent wood (ETW) has been found to have a potential to replace glass due to its properties which include sustainability, renewability, and low thermal conductivity [2]. ETW combines the natural beauty and structural integrity of wood with the optical clarity of glass.

This study explores the development of ETW as a sustainable alternative for glass applications. The feasibility of transforming wood into a transparent material was done through wood processing techniques called delignification and polymer infiltration. The benefits of ETW over traditional glass—such as improved thermal insulation, reduced environmental impact, and enhanced aesthetics—are demonstrated through a thorough analysis of the optical, mechanical, and thermal properties. The findings underscore the potential of ETW as a sustainable alternative for glass applications, offering a promising avenue for reducing reliance on energy-intensive materials while enhancing aesthetic appeal, functionality, and eco-friendliness.

Keywords— Engineered transparent wood, Polymer infiltration, Sustainability, Thermal insulation.

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SCP-F-44

Optimising the synthesis of ONO ligands and their Cu complexes as potential catalysts for the oxidation of *n*-octane

Nijal K. Singh

211501491@stu.ukzn.ac.za

Student Number: 211501491

School of Chemistry and Physics

Supervised by Prof Holger B. Friedrich

One of the most challenging areas of catalytic research in both academia and industry is the direct functionalization of C-H σ bonds of chemically inert linear alkanes [1-2]. The selective oxidations of linear alkanes are at the forefront of research to catalytically convert linear alkanes to value-added products. Biocatalytic systems, such as the heme-based cytochrome P_{450}, exhibit substrate specificity, regio and stereo selectivity and operate under mild conditions [3]. These systems have served as biomimetic inspiration for homogeneous catalytic selective oxidation of alkanes. In this study ONO ligands were synthesised using several methods and coordinated to Cu, these complexes will be employed as potential catalysts in the oxidation of alkanes. ONO ligands are tridentate ligands that bind to the metal centre via N and O donor atoms with the deprotonation of the O atom. This ligand imparts strong donor properties that can stabilize high oxidation states of metals and prevent ligand decomposition. These ligands can withstand harsh oxidizing conditions because they are tertiary alcohols [4-6]. The ligand can be synthesized by either lithinating 2,6-dibromopyridine or reacting it with Mg to form a Grignard reagent. The lithium salt or organomagnesium compound then reacts with the corresponding ketone to form the ONO ligands as shown in figure 1.

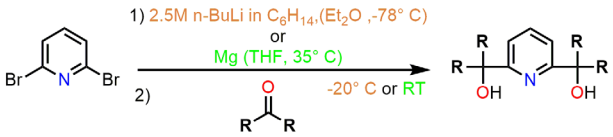

Figure 1: Synthesis of ONO Ligands

The combination of a solution of the respective ONO ligands, in methanol with a solution of a copper chloride salt in a mixture of methanol and acetone resulted in the formation of neutral complexes. The synthesised complexes were characterised.

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SCP-F-45

Schiff Base-derived Heteroleptic Copper(II) Chemotherapeutic

Saniksha Somaru

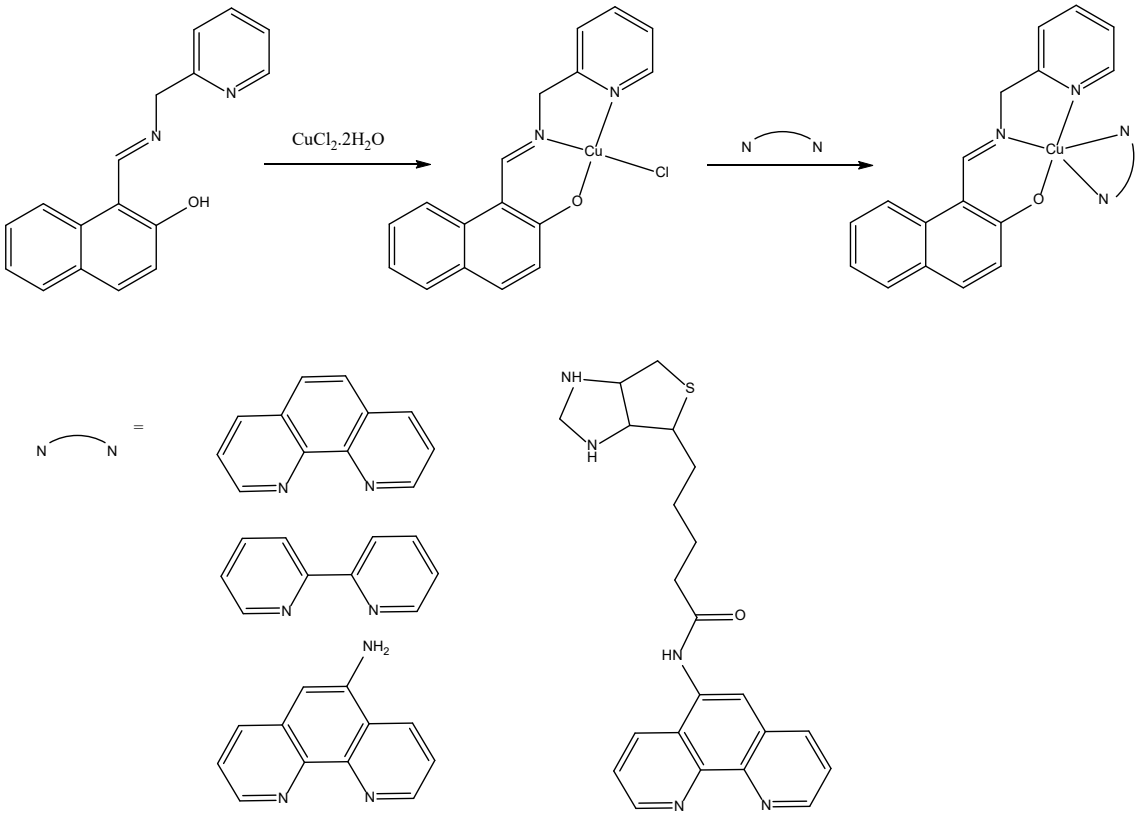
217012659@stu.ukzn.ac.za

Student Number: 217012659

School of Chemistry and Physics

Supervised by Professor Matthew Akerman

One Schiff base ligand (L1) and four copper(II) complexes were successfully synthesized (Figure 1). L1 was synthesized via an environmentally friendly solid-state reaction of 2-hydroxy-1-naphthaldehyde and 2-picolylamine, and recrystallized via a solvent diffusion system of dichloromethane and hexane, resulting in yellow crystals of 82% yield. Reaction of L1 with $CuCl_2.2H_2O$ gave a dark green microcrystalline powder, [Cu(L1)Cl], in 62% yield. Upon reacting [Cu(L1)Cl] with co-ligands, 2,2-bipyridine, 1,10-phenanthroline and 1,10-phenanthroline-5-amine (via solid state reactions), green powders of complexes [Cu(L1)bipy]Cl, [Cu(L1)phen]Cl and [Cu(L1)phen-amine]Cl were obtained with yields of 89%, 87% and 84% respectively. ^{1}H NMR, IR spectroscopy amd X-ray crystallography confirmed the successful synthesis of L1. The identity of [Cu(L1)Cl] was confirmed by X-ray crystallography and IR spectroscopy, confirming the square planar geometry. Mass spectrometry confirmed the identity of $[Cu(L1)bipy]^+$, $[Cu(L1)phen]^+$ and $[Cu(L1)phen\text{-}amine]^+$, with the structure of [Cu(L1)phen]Cl being confirmed by X-Ray crystallography.



SCP-F-46

DEVELOPMENT OF KOH-ACTIVATED CARBON DERIVED FROM SAWDUST AND ITS APPLICATION TO TEETH WHITENING

Sinenhlahla Thethwayo

218005079@stu.ukzn.ac.za

Student No: 218005079

School of Chemistry and Physics

Supervised by Dr Yolanda Tancu, Dr Fluronce Lehutso, Dr Mbuyi Moloi and Dr Bhekumuzi Gumbi

Sawdust, a prevalent byproduct of wood processing, poses serious environmental and health risks when improperly managed[1]. Unregulated storage can lead to significant pollution, and exposure to wood dust is associated with adverse health effects, including an elevated risk of respiratory diseases and cancers. Conventional disposal methods, such as combustion, release hazardous pollutants, underscoring the urgent need for sustainable waste management strategies[2]. One innovative solution is the conversion of sawdust into activated carbon, which is characterized by a high specific surface area and porosity. The production of activated carbon can be achieved through both physical and chemical activation processes. Notably, the chemical activation using potassium hydroxide (KOH) has been shown to yield highly microporous activated carbons with a specific surface area reaching up to 1876.16 m^2/g^3. The resulting activated carbon exhibits significant potential in various applications, including oral care, particularly in teeth whitening. As consumer demand shifts towards natural alternatives from traditional whitening products, activated charcoal has gained popularity due to its efficacy in adsorbing stains and discolorations from dental surfaces. This capability is attributed to its extensive surface area and porosity, which facilitate the adsorption of pigments and chromophores[4]. The study will elucidate the dual potential of biomass-derived activated carbon as a sustainable energy source and a safe, effective agent for enhancing dental aesthetics. By addressing the environmental challenges associated with waste management and offering a natural alternative for teeth whitening, this research highlights the innovative utilization of biomass resources for both energy production and health benefits.

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FLASH ABSTRACTS

SCHOOL OF ENGINEERING *AND* SCHOOL OF MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

SMSCSENG-F-2

Robustness, Timeliness, and Feedback Quality: A Comparative Evaluation of ChatGPT and VPL for Automatic Grading of Programming Assignments

Sbonile Buthelezi

209521173@stu.ukzn.ac.za

Student Number: 209521173

School of Mathematics, Statistics and Computer Science

Supervised by Mr Luke Vorster and Mrs and Rosanne Els

Automatic grading of programming assessments is a challenging field in the formative teaching of computer science. This is because traditional methods rely on unit testing, which, in turn, relies on code that compiles and runs—a rare case in undergraduate programming assignments. This research evaluates the effectiveness of two automated grading mechanisms—Virtual Programming Lab (VPL) and ChatGPT—within the Moodle LMS plugin architecture, focusing on their impact on first-year computer science programming exercises.

The study compares these mechanisms across several dimensions:

- **Robustness:** ChatGPT handles code that does not compile.
- **Feedback Quality:** ChatGPT provides consistent, informative feedback, while VPL typically offers only a grade or a compiler error message with a zero mark.
- **Timeliness:** Both VPL and ChatGPT offer instant feedback if the code compiles, but only ChatGPT gives the detailed feedback students need when it doesn't.

This research involves implementing the ChatGPT plugin in Moodle alongside the VPL plugin.

Results show ChatGPT superiority in all three areas of performance.

The study concludes with recommendations for advancements in educational technology, with proposed future work exploring broader educational applications of generative AI assessments.

SMSCSENG-F-3

On the Lower Vietoris Topology: Cellularity and Separation Axioms

Shimon Corcos

218035334@stu.ukzn.ac.za

Student Number: 218035334

School of Mathematics, Statistics and Computer Science

Supervised by Prof Dharmanand Baboolal, Dr Cerene Rathilal

Given a set $\mathfrak{S}$ of non-empty subsets of a topological space X, we can define the *lower Vietoris topology* [3] on $\mathfrak{S}$. We then say that $\mathfrak{S}$ is a *hyperspace* of X. One such hyperspace is the *Hoare powerspace*, which is closely related to the study of nondeterministic algorithms in theoretical computer science [8]. This topology has been used in the study of lower semi-continuity in multi-valued functions [2],[3], category theory [5] and order theory [4]. It has been used to study the well-known and related *Vietoris topology* [9], which has numerous applications [6].

Many topological properties, such as compactness and the countability axioms have been considered for arbitrary hyperspaces (mainly those containing all singletons of the base space) [2].

In this presentation, we discuss new results which determine the *cellularity* [1] of the hyperspace $F_n(X)$ of all n-element subsets of X, as well as characterise the *sober*, T_0, *pre-regular* and *Hausdorff* properties [7] for this hyperspace. Additionally, we characterise the T_D axiom [7] in arbitrary hyperspaces.

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SMSCSENG-F-5

Causal modelling of COVID-19 relative vaccine effectiveness of Ad26.COV2.S and mRNA-1273 boosters

Nqobile Sthembele Dlamini

218025480@stu.ukzn.ac.za

Student Number: 218025480

School of Mathematics, Statistics and Computer Science

Supervised by Dr N Yende-Zuma, Dr JM Batidzirai, Prof H Mwambi

Causal inference modeling is a statistical concept developed for estimating treatment effects with nonrandomised data, and for drawing causal inferences from observational data. In the context of COVID-19 vaccine effectiveness, making probabilistic statements about the likely similarities between (i) those who received boosters and those who chose not to, (i) those who chose certain types of booster vaccines over others, concerning the outcome(s) and drawing causal inferences becomes challenging. In this research project, we aim to use causal inference methodology to evaluate the effectiveness of boosting the mRNA-1273 vaccine against (i) SARS-CoV-2 infection and (ii) COVID-19 related hospital admissions.

We used data from SHERPA (Sisonke Heterologous mRNA-1273 boost after Prime with Ad26.COV2.S) trial in which healthcare workers in South Africa had received one or two doses of Ad26.COV2.S and later received a dose of mRNA-1273 booster. We plan to use causal inference models suitable for cross-sectional and time-varying exposure (i.e., time-varying booster vaccination status).

Cross-sectional comparisons among boosted and un-boosted individuals:

This analysis will classify participants into two groups (boosted vs. not boosted) and use propensity score weighting or matching to estimate the causal effect of boosting on outcomes.

Time-varying comparisons among various vaccine booster types:

This analysis will use marginal structural models to estimate the causal effects of dynamic vaccine strategies.

A total of 424 409 were included in the analyses; 43.7% didn't receive a booster and 56.3% received either mRNA-1273 or Ad26.COV2.S booster. The baseline analyses showed that higher proportion of females received mRNA-1273 booster. Additionally, the prevalence of HIV was higher in this group, at 18%, compared to 8% in the group that did not receive the mRNA-1273 booster.

Baseline results indicate that the vaccine groups differ in some confounders, justifying the use of causal inference methods proposed in this project.

SMSCSENG-F-6

INVESTIGATION OF CO-LOCATED GROUND DISPLACEMENTS OBSERVED WITH THE TRIGNET NETWORK AND THE SEISMOLOGICAL NETWORK

Mkhululi Gumede

218001900@stu.ukzn.ac.za

Student Number: 218001900

School of Engineering

Supervised by Dr Mulemwa Akombelwa

This research outlines a comprehensive investigation into collocated ground displacement observations obtained from two distinct monitoring networks: the Trignet and academic seismological networks. The primary objective of this study is to discern any potential disparities between the displacement measurements recorded by these networks, ultimately enhancing our understanding of their respective methodologies and contributing to the broader field of geophysical monitoring. By employing advanced analytical techniques and comparative assessments, this research aims to shed light on the reliability, accuracy, and consistency of the ground displacement data acquired from these sources.

The research will employ quantitative and qualitative methods to achieve its objectives. A thorough literature review will be conducted to gather insights into the methodologies, instrumentation, and calibration procedures utilized by the Trignet and academic seismological networks. Subsequently, a dataset of collocated ground displacement measurements from these networks will be compiled, spanning a substantial timeframe to ensure robust statistical significance.

The collected data will undergo a series of analyses to discern potential disparities. First, a statistical comparison will be performed to evaluate the degree of agreement between the measurements of the two networks. Various statistical measures, such as mean, standard deviation, and correlation coefficients, will be utilized to quantify the level of concurrence. Additionally, time series analysis techniques, including waveform cross-correlation, spectral analysis, and phase coherence analysis, will be employed to examine the displacement signals' temporal variations and dynamic behaviour.

Furthermore, a comprehensive assessment of instrumental characteristics, environmental factors, and data processing techniques will be conducted to address potential sources of discrepancy. This will involve inspecting both networks'

sensor specifications, deployment conditions, and calibration methodologies. Any observed differences in these aspects will be investigated to elucidate their potential impact on the recorded displacement measurements.

Through this research, valuable insights are expected to emerge regarding the consistency and reliability of ground displacement observations obtained from the Trignet and academic seismological networks. The comparative analysis will offer a comprehensive perspective on the inherent differences in instrumentation, data processing, and environmental conditions that may influence the collected data. By discerning the degree of agreement or disparity between the two networks, this study will contribute to the advancement of seismic and geophysical monitoring practices.

The anticipated outcomes of this research are threefold. Firstly, it will provide a deeper understanding of the strengths and limitations of the measurement techniques employed by the Trignet and academic seismological networks. Secondly, any identified discrepancies will serve as a basis for refining data acquisition and processing methods, potentially improving ground displacement measurements' accuracy and reliability. Lastly, the research findings will contribute to the broader scientific community's understanding of collocated monitoring networks, facilitating better cross-validation and interpretation of geophysical phenomena.

In conclusion, this research proposal outlines a systematic investigation into collocated ground displacement observations from the Trignet and academic seismological networks. By employing rigorous comparative analyses and comprehensive assessments, this study aims to enhance our comprehension of the reliability and consistency of displacement data obtained from these networks, thereby advancing the field of geophysical monitoring.

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SMSCSENG-F-7

A BI-LEVEL PROGRAMMING APPROACH FOR REDUCING CARBON EMISSIONS IN ELECTRICITY PRODUCTION

Ali Haroon

219090351@stu.ukzn.ac.za

Student Number: 219090351

School of Mathematics, Statistics and Computer Science

Supervised by Dr Jean Medard Ngnotchouye and Prof Surafel Tilahun

In this work, we propose a mathematical model for the reduction of carbon emissions in an electricity company in South Africa. Our model is formulated as a Bi-Level Programming Optimisation Problem (BLPPs). To solve our model, we first apply the Karush–Kuhn–Tucker optimality condition to the lower level problem, then apply a penalty method to the resulting standard constrained optimization problem to obtain an unconstrained optimization problem. We then apply the Genetic Algorithm (GA), a heuristic method suitable to solve optimization problems. The case study of the Eskom area serves as an example of the effectiveness and efficiency of the GA technique in handling difficult situations up until carbon emissions reach their maximum allowed capacity, which means lowering emissions and obtaining electricity equivalent to the maximum capacity allowed.

SMSCSENG-F-9

DESIGN, FABRICATION, AND CHARACTERISATION OF MULTI-BAND DOUBLE-NEGATIVE METAMATERIAL FOR UWB ANTENNA APPLICATION

Elijah Joseph

222037450@stu.ukzn.ac.za

Student Number: 222037450

School of Engineering

Supervised by Prof Pradeep Kumar and Prof Thomas J.O Afullo

Metamaterials are engineered materials with unique electromagnetic properties that arise from their structural design rather than their composition. Double Negative (DNG) metamaterials, which simultaneously exhibit negative permittivity and permeability, provide effective solutions to key challenges in Ultra-Wideband (UWB) antenna design, such as reduction of mutual coupling, enhancement of bandwidth, and enabling miniaturisation.

This research presents the design, fabrication, and characterisation of a DNG metamaterial specifically tailored for improving the performance of UWB antenna. The novel unit cell structure integrates a triple T-shaped resonator within square split-ring resonators (SRR) to achieve negative permittivity and permeability, necessary for advanced electromagnetic wave manipulation within the UWB spectrum. Through iterative optimization and full-wave electromagnetic simulations using CST Microwave Studio, the metamaterial's geometric parameters are tuned to achieve multi-band electromagnetic response.

Parametric analysis examined the influence of geometric modifications, substrate properties, and inter-element spacing on scattering parameters (S11 and S21), resulting in an optimised design with superior performance. The fabricated metamaterial array's effective medium ratio (EMR) of 6.38 validates its suitability for practical UWB antenna applications.

Extracted effective electromagnetic parameters confirmed DNG behaviour over a broad frequency range. This metamaterial array demonstrates its potential to revolutionise UWB antenna systems by enabling miniaturisation, reducing mutual coupling between antenna elements, and enhancing overall radiation characteristics.

SMSCSENG-F-10

PROCESS DEVELOPMENT FOR RECOVERY OF XYLOSE AND PURIFICATION OF BIOMASS HYDROLYSATE USING BIOCHAR FOR XYLITOL PRODUCTION

Mandlenkosi Robert Khumalo

213535708@stu.ukzn.ac.za

Student Number: 213535708

School of Engineering

Supervised by Prof Bruce Sithole and Mr Jonas Johakimu

The process was developed for the purification of biomass (corncob, sugarcane bagasse, and *Eucalyptus* sawdust) waste hydrolysate for the removal of lignin and recovery of xylose. Biochar was used as an adsorbent to remove lignin obtained during dilute acid hydrolysis of biomass prior to hydrogenation of xylose into xylitol. Response Surface Methodology (RMS) approach was employed to optimize the process for purification of hydrolysate and recovery of xylose. Both biochar loading and temperature were significant parameters in xylose recovery, whereas temperature was the significant parameter in lignin removal. Increasing the biochar loading and temperature led to a drastic loss of xylose, whereas lignin removal was favored by increased temperature at low biochar loading. The experimental data of the fitted quadratic models for xylose recovery offered a determination coefficient (R^2) of 0.9726 and 0.6839 for lignin removal. The optimum process conditions obtained were biochar loading at 2.0% (w/v), and temperature at 326K, which offered a maximum xylitol yield of 63.41%. The spent biochar was effectively regenerated and used for three successive cycles of operation. The removal efficiency of lignin achieved was 97.4% with 75.9% xylose recovery.

Keywords: Biomass, Xylitol, Biochar, Process optimization

SMSCSENG-F-11

Deep Reinforcement Learning for Automated Stock Trading using Different Reward Functions: An Ensemble Strategy

Sahil Lawton

215007249@stu.ukzn.ac.za

Student Number: 215007249

School of Mathematics, Statistics, and Computer Science

Supervised by Mr Asad Jeewa

In this study, we propose a method for deep reinforcement learning method for asset portfolio optimization. Previous work trained three actor-critic-based algorithms (PPO, A2C and DDPG) to generate portfolio weightings for the 30 stocks found in the Dow Jones Industrial Average and trained the networks to optimize for a maximization of the portfolio value. Our study extends this work by running the strategy separately using two new reward functions: the Sharpe ratio and the portfolio variance. Additionally, we performed experiments using different timeframes of prior data, for a deeper analysis into the strengths and weaknesses of our approach.

SMSCSENG-F-12

STATISTICS-BASED SELF-SUSTAINING FINANCIAL MODEL FOR THE NSFAS: A DECADE LONG DATA MODELLING STUDY

Ben Magabashele Malope

224193342@stu.ukzn.ac.za

Student Number: 224193342

School of Mathematics, Statistics and Computer Science

Supervised by Dr Mantepu MaseTshaba

Repayment of student loans to National Student Financial Aid Scheme (NSFAS) by graduates occur at exceedingly low rates. The study considered the potential growth of the NSFAS investment by using HEI's time series data.

The data consisted of all students who were registered in twenty-six South African public universities and were financially assisted through by NSFAS for the period 2006 to 2016 (last year were NSFAS ceased to be study loan) calendar years, tax and non-tax collection data by South African Revenue Service for period 2004/05 to 2015/16 South African government financial years were also used. NSFAS data was naturalised by taking logs.

The data analysis was done following Knowledge Discovery in Database (KDD) process, while bound testing was used to fit the model. Autoregression distributed lag (ARDL) model was used to determine the cointegration of debt, payments and loan amount variables.

The study was proved to have serial correlation on all three variables used, the variables also were moving together in long run relationship at slow speed.

The study recommended that policy makers should look at possibilities of using South African Revenue Service (SARS) to collect debt on behalf of NSFAS.

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SMSCSENG-F-13

A PREDICTIVE MODEL FOR PHISHING ATTACKS ON MOBILE INTELLIGENT AGENT SYSTEMS

Mashako David Manyama

224190636@stu.ukzn.ac.za

Student Number: 224190636

School of Mathematics, Statistics, and Computer Science

Supervised by Professor Okuthe Paul Kogeda

Phishing attacks continue to evolve with time and the attackers are always ahead of the existing mitigation plans. The more technology advances, the more sophisticated phishing attacks become. As more people rely on technology to conduct their online businesses, the need for secure Mobile Intelligent Agents (MIAs) systems becomes higher. MIAs are software that execute functions or duties such as managing electronic mail, gathering, and sending out information on behalf of an online user. MIAs play a vital role in carrying out electronic commerce activities whether from business-to- customer, customer-to-customer, or business-to-business. In this paper, we use Decision Tree (DT) to accurately predict the status of a Uniform Resource Locator (URL) and flag those predicted to be phishing. The DT algorithm extract URL features such as the domain name, URL length, host name, page ranking, etc., and feeds them into the model which then makes status prediction. The extracted features are then filtered into the model to improve its future predictions. The proposed model has a prediction accuracy of 91.3% and it is also cost effective as well as easy to use. The other benefit of the proposed solution is its capability to flag phishing URL and prevent a user from launching the web browser thereby protecting their personal information from being stolen by criminals.

Keywords: Agent, Algorithm, Artificial intelligence, Cyber-security, Decision Tree, e-commerce, m-commerce, Mobile intelligent agent, Predictive, Prevention, Phishing.

SMSCSENG-F-14

Lovelock Theories of Gravity

Snothile Manyathi

220019006@stu.ukzn.ac.za

Student Number: 220019006

School of Mathematics, Statistics and Computer Science

Supervisor: Prof Sunil Maharaj and Prof Keshlan Govinder

We explore Lovelock theories of gravity, particularly focusing on the Einstein-Gauss-Bonnet (EGB) gravity as an extension to general relativity. We consider a spacetime that is static and spherically symmetric. We generate field equations for charged gravitating perfect fluid leading to the charged condition of pressure isotropy that is an Abel differential equation of the second kind. Through this framework we showed how existing solutions are obtained, and

find new solutions that contain these existing ones, thereby extending their applicability within general relativity. This work will not only provide new insights into behaviour of highly dense stars but also establish a basis for future observational tests of these extended gravitational theories.

SMSCSENG-F-16

Barotropic equations of state in 4*D* Einstein-Maxwell-Gauss-Bonnet stellar distributions

Siyamthanda Remember Mngadi

219010652@stu.ukzn.ac.za

Student Number: 219010652

School of Mathematics, Statistics and Computer Science

Supervised by Prof Sudan Hansraj

Although initially beset by several controversies the Glavan-Lin [1] dimensionally regularised proposal to incorporate higher curvature effects through the Gauss-Bonnet invariants in four spacetime dimensions continues to attract attention as it is known to be viable in spherically symmetric spacetimes applicable to the study of stellar structures. In our present work, we investigate for the first time, the consequences of imposing a linear barotropic equation of state $p= \gamma\rho$ on a charged compact isotropic perfect fluid in 4*D* scalar Einstein-Gauss-Bonnet theory. Even though mathematically one more choice is available after invoking the equation of state to close the system, finding exact models is nontrivial. The case of constant gravitational potentials corresponding to the defective Einstein universe as well as the isothermal fluid distribution is studied. Neither of these lead to physically interesting cases. Two proposals for the temporal potential, motivated on mathematical grounds, yield physically viable charged star models. Assuming the existence of a one-parameter group of conformal motions in the spacetime geometry, we obtain a governing equation that is solvable exactly in implicit form and explicit solutions are found for the case of a stiff fluid $p= \rho$. On the other hand, if the potential is assumed to vary linearly with the radius, an exact incoherent radiation model $p= 1/3 \rho$ emerges. The physical properties of both these solutions is analysed comprehensively with the aid of graphical plots in conjunction with suitably defined parameter spaces.

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SMSCSENG-F-17

Maximising Malaria Elimination: A Mathematical Model for Optimising IRS, LLINs, and ATSB Interventions

Siyamthanda Gift Mnisi

220087226@stu.ukzn.ac.za

Student Number: 220087226

School of Mathematics, Statistics and Computer Science

Supervised by Dr Hloniphile Sithole Mthethwa

Malaria is a public health problem for more than 2 billion people globally. About 219 million cases of malaria occur worldwide and 660,000 people die, mostly 91% in the African Region despite decades of efforts to control the disease. Although the disease is preventable, it is life-threatening and parasitically transmitted by the bite of the female Anopheles mosquito. A deterministic mathematical model with intervention strategies is developed in order to investigate the effectiveness and optimal control strategies of indoor residual spraying (IRS), long lasting insecticide nets (LLINs) and attractive toxic sugar bait (ATSB).

This model executed two equilibrium points, namely the disease-free and epidemic equilibrium points. The DFE was proved to be stable when $R_0<1$ and the EE was proved to be stable when $R_0>1$. The sensitivity analysis was computed using the PRCC technique. MATLAB ode45 solver is used to compute a numerical analysis of the population dynamics. Optimal control analysis was introduced and solved using Portraying's maximum principle. The dynamics of the optimal control showed that the infections decrease with an increase in the control to reduce the disease.

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SMSCSENG-F-18

INTEGRATIVE APPROACHES COMBINING MULTIVARIATE CNN WITH THE DCC MODEL FOR FORECASTING STOCK MARKET VOLATILITIES

Anas Mohammed

220032438@stu.ukzn.ac.za

Student Number: 220032438

School of Mathematics, Statistics, and Computer Science

Supervised by Prof Henry Mwambi and Prof Bernard Omolo

Machine learning and deep learning approaches have been extensively studied across various fields, significantly contributing to the successful resolution of numerous problems. For instance, image classification, computer vision applications, and natural language processing. Due to their powerful capabilities, they have not only made significant contributions in the aforementioned fields but have also increasingly been applied to time series analysis and particularly, in analyzing financial time series to forecast the volatility and correlation among stock markets. To enhance time series analysis and forecasting, researchers propose hybrid models in various combinations of machine learning and deep learning approaches with statistical and econometric models. In this work, the dynamic conditional correlation (DCC) model as an econometric model and multivariate convolutional neural networks (MCNN) as a deep learning model are employed to construct hybrid models in attempting to enhance the forecast of dynamic volatility and correlation among stock markets. Two methods for combining the DCC model with the CNN model are presented. The results show that the best way to combine the DCC model and the CNN model is to use the outputs of the CNN model as inputs to the DCC model. The hybrid DCC-MCNN model demonstrates stronger performance across both in-sample and out-of-sample accuracy measures such as root mean square error (RMSE) and mean absolute error (MAE). Specifically, the hybrid DCC-MCNN model emerges as the top performer among the evaluated models, surpassing both the single model approaches and the hybrid MCNN-DCC model in forecasting time-varying volatility and correlation among stock markets.

SMSCSENG-F-21

EXTRUSION-INJECTION FABRICATION FOR THE DEVELOPMENT OF SAWDUST-REINFORCED POLYPROPYLENE COMPOSITES

Ipoteng Justice Mphahlele

223146965@stu.ukzn.ac.za

Student Number: 223146965

School of Engineering

Prof Annegret Stark, Dr Viren Chunilall, and Dr Vincent Ojijo

This study presents sawdust-reinforced polypropylene composites with various sawdust particle sizes and concentrations fabricated using extrusion-injection molding. Before wood composite fabrication, sawdust was treated with 6 % NaOH to enhance the interfacial adhesion with polypropylene (PP). The mechanical properties of fabricated composites such as tensile, flexural, and impact properties were investigated. The thermal stability and temperature-dependence mechanical properties, morphological analysis, and water absorption of sawdust-reinforced polypropylene wood composites were investigated. The highest tensile strength of 42.4 MPa 20 wt.% sawdust/PP composite was observed using 101-150 µm particle size, whilst 1-50 µm exhibited the lowest tensile strength of 39.6 MPa. The composite 20 wt.% sawdust/PP exhibited the highest flexural strength of 101.2 MPa using 51-100 µm particle size. This performance was attributed to good mechanical interlocking between the reinforcement and matrix resulting in satisfactory stress transfer from PP to the sawdust [1]. The impact strength of the composite depicted the highest strength at 11.5 kJ/m^3 using 5wt.% sawdust/PP composite with 1-50 µm particle size. The incorporation of sawdust at 51-100 µm particle size showed good thermal stability as depicted by TGA/DSC measurements. The temperature-dependent mechanical properties of sawdust-reinforced polypropylene wood composites were investigated using dynamic mechanical analyses (DMA). The composite 20 wt.% sawdust/PP showed highest storage modulus (**E'**) and loss modulus (**E''**). Moreover, loss factor tan δ exhibited good interface adhesion. Scanning electron microscopy (SEM) micrographs showed that low sawdust content shows a fractured surface with various numbers of cracks and voids which impairs the mechanical properties of the composites [2]. Sawdust/PP composites depicted improved water absorption as compared to neat wood. Based on the properties exhibited by sawdust/PP composites, the material has the potential to be used in building applications.

Keywords: Sawdust-reinforced composites, mechanical properties, dynamic mechanical properties, particle size, sawdust content

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SMSCSENG-F-22

Evaluating the potential of woody and non-woody invasive alien plant species grown in Kwa-Zulu Natal for biogas and bio-oil production

Bongiwe Mtshali

218002421@stu.ukzn.ac.za

Student Number: 218002421

School of Engineering

Supervised by Dr Alakia Kassim

The depletion and negative impact of fossil fuels has prompted significant interest in renewable energy sources such as bio-oil. The objective of this research study is to evaluate the quantity and quality of bio-oil derived from non-woody and woody IAPs as a potential sustainable energy source. Non-woody and woody IAPs were proximate, elementary, structurally, and thermally assessed as potential substrates for bio-oil production. The IAPs were further pyrolysed in a fixed bed reactor at a temperature (450 °C), and heating rate (5 °C. min^{-1}), particle size (1 mm), reaction period (90 min), gas flow rate (50 ml. m^{-1}), and vapor residence time (2 s). The bio-oil from IAPs was chemically analysed with Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography-Mass Spectrometry (GC-

MS) methods to assess the quality for heat and power generation. The results demonstrated a bio-oil yield ranging from 18.77 to 20.45 %, and 22.93 to 27.55 % for non-woody and woody IAPs respectively. Functional groups such as 1˚, and 2˚ amines, amides, aliphatic amines, alkanes, alkyl halides, alkyne, aromatic, and aldehydes suggest improved stability, better energy density, better ignition quality, and superior combustion properties, indicating possible applications for heat, power production, and transportation fuel. The findings answer the research question that IAPs can produce good quality bio-oil but further recommend adequate consideration of operating conditions, reactor design, and upgrading methods for higher efficiency bio-oil. This study contributes toward the development of sustainable energy sources and environmental conservation.

SMSCSENG-F-24

Investigating the Use of UAVs for Cadastral Surveying in South Africa

Samkelo Patrick Ncama

219028270@stu.ukzn.ac.za

Student Number: 219028270

School of Engineering

Supervised by Dr Mwitwa Chilufya, Mr Thando Nqasha and Dr Mayshree Singh

Efficient land management and administration requires the documentation of information relating to the ownership of land. This information includes the individual who holds the right to the land, the form of right the individual holds, and the dimensions of the land the individual has the right to. The need to document this information is met by the cadastral system. The South African cadastral system uses a fixed boundary system to determine the dimensions of the land for documentation. This system involves the ascertaining of existing land rights, the emplacement of beacons on the ground to delineate land parcel boundaries, a cadastral survey to measure the coordinates of the emplaced beacons, and the recording of the land right and land parcel dimensions. A title deed can be issued only after the completion of the described stages, providing the holder with security of tenure guaranteed by the state.

Land management and administration is a lengthy and complicated process with many challenges. It often requires comprehensive reforms, capacity building, investment in technology, and efforts to improve transparency and accountability in land administration processes. Its lengthy nature has created a backlog in the issuance of title deeds in South Africa. One of the challenges in fast-tracking this process are the speed and cost of undertaking the boundary determination process using total stations and GPS equipment. In the early 2000s, aerial photogrammetry using aircrafts was critiqued for being too costly and not meeting the accuracy requirements for cadastral surveying. The emergence of Unmanned Aerial Vehicles (UAVs) which are cheaper than aircrafts and provide better accuracy since they can fly at lower altitudes presents an opportunity to fast track the rate of boundary determination to meet the needs of the South African cadastral system.

This study will review the cadastral surveying standards regarding boundary determination set out by the South African Geomatics Council (SAGC) and other relevant legislation. It will explore the technological and methodological considerations for UAV mapping for boundary delineation in a cadastral system that uses fixed boundaries. This will be demonstrated by capturing images using a camera mounted on a UAV. The captured images will then be used to create an orthophoto which in turn will serve as a backdrop for delineating land parcel boundaries based on location of boundary beacons placed on the ground prior to imagery capture. The study will also review the South African Civil Aviation Authority (SACAA) regulations for compliance with UAV mapping and compare the regulatory framework with international standards to identify gaps and make recommendations.

SMSCSENG-F-25

On Completeness and Paracompactness of Localic Groups

Onesipho Ntombela

217020822@stu.ukzn.ac.za

Student Number: 217020822

School of Mathematics, Statistics and Computer Science

Supervised by Dr Simo Mthethwa

A frame is paracompact if and only if it admits a complete uniformity. A localic group is a group structure in the point-free topology context. In this dissertation, we study the completeness and paracompactness of localic groups. We give two descriptions of the completion of uniform frames: first, as a quotient of the frame of uniformly regular ideals of the frame at hand, and via generators and relations. We use the latter technique to exhibit the completeness (and paracompactness) of localic groups in their two-sided uniformity.

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SMSCSENG-F-26

APPLICATION OF MACHINE AND DEEP LEARNING TECHNIQUES IN THE CLASSIFICATION OF TERRESTRIAL AND SUB-AQUATIC 3D POINT CLOUD DATA

Simiso Ntuli

215017855@stu.ukzn.ac.za

Student Number: 215017855

School of Engineering

Supervised by Dr Mayshree Singh and Mr Angus Forbes

Machine and Deep Learning (ML and DL) methods are increasingly applied to classify 3D point cloud data from terrestrial and sub-aquatic environments, focusing on enhancing the efficiency and accuracy of spatial data interpretation. This study highlights the significance of 3D point cloud classification in various practical applications such as urban planning, environmental monitoring, cultural heritage mapping, and underwater search and rescue operations. In the terrestrial domain, the study classifies 3D point clouds generated from aerial imagery captured by a drone equipped with a CCD camera using Unmanned Aerial System-Structure-from-Motion Photogrammetry (UAS-SfM). The classification aimed to differentiate between land-cover categories such as open ground, trees, and buildings. Using supervised classification techniques with Random Forest (RF) and Support Vector Machine (SVM) algorithms, the study achieved an overall accuracy of 81.3% and a Kappa coefficient of 0.70. These results underscore the potential for using open-source tools and UAS-SfM photogrammetry for efficient landscape mapping and monitoring, offering significant advantages over traditional manual methods [1]. In the sub-aquatic environment, the study extends the

application of point cloud classification to underwater search and rescue operations. It employs acoustic (Sonar) and laser-based (Lidar) remote sensing technologies to identify submerged objects. The BlueView BV5000 mechanical scanning sonar (MSS) and Faro Focus 3D 120 laser scanner were used to acquire and evaluate 3D point clouds of submerged objects such as tyres and chairs. The classification, using CANUPO-SVM [2] and RandLA-Net algorithms [3], achieved overall accuracies of 79.81% and 80.72%, respectively, indicating the effectiveness of these methods in sub-aquatic environments. The overall research provides a comprehensive framework for applying ML and DL techniques to 3D point cloud classification, offering promising insights for future work in natural aquatic environments, infrastructure monitoring, and underwater heritage preservation. The findings demonstrate the potential of these technologies in enhancing decision-making processes across various environments.

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SMSCSENG-F-27

CYTOKINE PROFILES AS PREDICTORS OF HIV INCIDENCE USING MACHINE LEARNING SURVIVAL MODELS AND STATISTICAL INTERPRETABLE TECHNIQUES

Sarah Ogutu

220041740@stu.ukzn.ac.za

Student Number:220041740

School of Mathematics, Statistics & Computer Science

Supervised by Prof Henry Mwambi and Dr Mohanad Mohammed

Cytokine profiles are increasingly recognised as potential predictors of HIV incidence due to their role in immune regulation and inflammatory responses. Traditional statistical methods for time-to-event data, such as the Cox proportional hazards (PH) model, may have limitations in handling high-dimensional data and non-linear relationships between predictors. Machine learning (ML) survival models may address these issues, including violating the PH model assumption. Survival support vector machine (SSVM) and random survival forest (RSF) models using the change or mean in cytokine values as predictors were used to investigate the association of HIV incidence and cytokine profiles, evaluate variable importance, and assess predictive accuracy using the concordance index (C-index) and integrated Brier score (IBS). We interpreted the model's predictions using Shapley additive explanations (SHAP) values. The RSF models exhibited superior performance over the SSVM models, and the difference covariate model outperformed the mean covariate model. The best C-index for the SSVM model was 0.7180 under the difference covariate model. For the RSF, it was 0.8801 under the difference covariate model using the log-rank split rule. Key cytokines identified as positive predictors of HIV incidence included TNF-A, BASIC-FGF, IL-5, MCP-3, and EOTAXIN, while a broader set of 29 cytokines were negative predictors. Baseline variables like frequency of condom use, treatment, number of partners, and sexual activity were also strong predictors. This study underscored the potential of cytokine profiles in predicting HIV incidence and demonstrated the competitiveness of RSF models for analysing high-dimensional, time-varying data over SSVM.

SMSCSENG-F-28

Performance Evaluation of Pavement's Seal Courses Using Nanomaterial and Sasobit® REDUX

Eche Samuel Okem

221121916@stu.ukzn.ac.za

Student Number: 221121916

School of Engineering

Supervised by Prof Mohamed Mostafa and Prof Gerrit Jordaan

Chip and cape seals are commonly used as surface treatment due to their cost-effectiveness as a pavement maintenance strategy. In cold regions, the performance of these surface treatments is undermined by the low-temperature effect. These surface treatments should prevent water ingress into the pavement and resist damage from freeze-thaw cycles. However, failures such as bleeding, aggregate stripping, brittleness caused by the stiffening effect in bituminous binders and loss in microtexture due to aggregate embedment are common with seals constructed during freezing periods. Conventional materials such as lime and cement used as adhesion promoters in slurries for cape seals have been reported to propagate cracks within the seal. These cracks become fault lines for pavement deterioration in winter; hence, there is a need to seek alternative innovative materials for surface treatments.

This review investigates the potential of incorporating innovative Sasobit® Redux and nanomaterial as alternatives to conventional materials in constructing chip and Cape seals in cold weather. Sasobit® Redux is widely used as an additive in warm mix asphalt to extend the paving window. It provides better coating over aggregates and ensures better compaction at lower temperatures; however, its benefits in surface treatment have been underexplored. On the other hand, using nanomaterial significantly improves the binder-aggregate adhesion and reduces temperature susceptibility and the likelihood of cracking. This review analyses the selection procedure for binder, aggregate, and modifiers to ensure a more durable seal in cold regions. The findings indicated that both Sasobit® Redux and nanomaterial offer cost-effective approaches to enhance the performance of pavement seals in cold weather; therefore, future studies should explore the practical application of these materials in the field.

Keywords: Surface Treatments, cold regions, nanomaterial, chip seal, microtexture, Cape seal.

SMSCSENG-F-29

ASSESSING THE IMPACT OF IMMUNOTHERAPY ON ONCOLYTIC VIROTHERAPY IN THE TREATMENT OF CANCER

Salaheldin Omer

219096191@stu.ukzn.ac.za

Student Number: 219096191

School of Mathematics, Statistics, and Computer Science

Supervised by Dr Hermane Mambili-Mamboundou

Combined oncolytic virotherapy and immunotherapy are novel treatment protocols that represent a promising and advantageous strategy for various cancers, surpassing conventional anti-cancer treatments. This is due to the reduced toxicity associated with traditional cancer therapies. We present a mathematical model that describes the interactions between tumour cells, the immune response, and the combined application of virotherapy and interleukin-2 (IL-2). A stability analysis of the model for both the tumour and tumour-free states is discussed. To gain insight into the impact of model parameters on tumour cell growth and inhibition, we perform a sensitivity analysis using Latin hypercube sampling to compute partial rank correlation coefficient values and their associated p-values. Furthermore, we perform optimal control techniques using the Pontryagin maximum principle to minimise tumour burden and determine the

most effective protocol for the administered treatment. We numerically demonstrate the ability of combined virotherapy and IL-2 to eliminate tumours.

SMSCSENG-F-31

RECYCLING OF WASTE POLYSTYRENE (WPS) INTO ADSORBENTS FOR WASTEWATER TREATMENT

Emerald Celestine Reddy

212504185@stu.ukzn.ac.za

Student Number: 212504185

School of Engineering

Supervised by Prof Prathieka Naidoo and Dr Kuveneshan Moodley

Polystyrene (PS) is the most widely used aromatic thermoplastic polymer (food contact packaging, insulation and electronics [1]) but has the lowest recycle rate in South Africa [2]. The vast consumption and limited life cycle design of PS products result in annual generation of waste PS (WPS) being greater than 10^6 tons. WPS can be handled in three ways: landfill, incineration, or material recycling. Non-biodegradability, low shrinkability and leaching of toxins into the soil causing contamination of surface and groundwater limit landfilling [3]. Incineration is limited by low energy reclamation and the generation of potentially hazardous emissions which have a harmful impact on the environment and to humans through their contribution to both air pollution and the greenhouse effect. Material recycling is the preferred option to address conservation, sustainability and environmental pollution prevention [4]. However, since the recycling of WPS into its original products or other low-graded products is neither cost-effective nor economically sustainable, it is consequently not a common practice [4,5]. Hence the intention of this work is to develop and test strategies to recycle WPS to higher value-added products. WPS can be used as a precursor for the synthesis of hyper crosslinked conjugated microporous polymers which possess porosity and conjugation-based properties making them useful as adsorbents for liquids. Water treatment applications include methylene blue [6] and Congo red [3]. The crosslinking procedure for WPS was performed following a 3^2 factorial design approach, varying the weight of WPS and the reaction time to optimize the reaction and determine the combination that produced the best performing adsorbent. The structural/physical properties of the adsorbent were determined. The effectiveness of the adsorbents was tested on water samples contaminated methylene blue and Congo red.

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SMSCSENG-F-33

Novel application of biochar to improve hydrophilicity and the permeability of aramid nanofiber hybrid membrane

Kitenge Sumbu

223150644@stu.ukzn.ac.za

Student Number: 223150644

School of Engineering

Supervised by Prof David Lokhat

Mixed matrix membranes have received more attention due to their high separation performance, taking advantage of both porous fillers and polymer backbones. This study involves synthesising and characterising the Kevlar-biochar nanofiltration membrane. The hybrid membrane was synthesized by thermo-assisted phase inversion, and biochar was synthesised from invasive wood species (eucalyptus) by pyrolysis.

The morphologies of hybrid membranes were inspected using a scanning electron microscope. The functional groups were recorded by Fourier transform infrared spectroscopy. The Brunauer-Emmett-Teller method was used to quantify specific surface area and pore volume of the membrane. The contact angles were assessed using a KSV CA meter for a hydrophilicity test.

Biochar yield decreased as temperature and time increased (32.9-27.9 % at 500 °C, 24,9-19.3 % at 600 °C, and 18.5-16.1 % at 700 °C). Maximum carbonisation was realized in between 500-600 °C. Scanning Electron Microscope images of biochar showed a mesoporous structure at 500 °C for 2 hours and a macroporous structure at 700 °C for 1 hour both suitable for membrane synthesis. Fourier transform infrared spectroscopy of biochar revealed the presence of hydroxyl; carboxyl; alkynes and nitrile groups, as pollutant adsorption sites. Fourier transform infrared spectroscopy results of pristine membrane revealed the presence of N-H, C=O; C=C, C-N amide II; phenyl-N; carboxylate groups. With the addition of biochar, the N-H and C=O peaks increased in the hybrid membrane as the C-H, alkynes, and nitrile peaks disappeared on the biochar. This confirmed biochar's dispersion in the Kevlar matrix and improvement in the membrane's hydrophilicity. Scanning electron microscope images of pristine membranes showed a dense and smooth surface. However, a rougher surface with more peaks and valleys was observed on the hybrid membrane. The obtained membrane with biochar as additives provided extra channels for molecular transfer.

SMSCSENG-F-34

MATHEMATICAL ALGORITHMS APPLIED TO OPTIMAL CONTROL PROBLEMS

Victor Uzor

221116281@stu.ukzn.ac.za

Student Number: 221116281

School of Mathematics, Statistics and Computer Science

Supervised by Professor Oluwatosin Mewomo and Dr Aviv Gibali

Mathematical algorithms form the bedrock and underlying framework of several real-life problems. One of such problems is the optimal control problem which is known to be very important due to its wide application and relevance across diverse fields such as space science, engineering, communications as well as building energy-efficient and artificial intelligent systems.

In this work, we design robust and efficient mathematical algorithm based on the fixed-point approach for solving variational inequalities. We further apply our algorithm to solve some practical optimal control problems. In addition, we compare our algorithm with some state-of-the-art algorithms via numerical experiments on the MATLAB R2022(b)

software. Computational results clearly indicate that our algorithm out-performs other existing methods in the literature.

SMSCSENG-F-35

Nonlinear Equations in Compact Stars in EGB Gravity

Ntandoyenkosi Zama Xulu

217014084@stu.ukzn.ac.za

Student Number: 217014084

School of Mathematics, Statistics and Computer Science

Supervised by Prof Sunil Maharaj

In this thesis, we investigate spherically symmetric spacetimes in relation to the Einstein field equations, focusing on scenarios involving neutral matter and isotropic pressures. Our goal is to model relativistic stellar systems. We reformulate the Einstein field equations and the pressure isotropy condition using both Schwarzschild and isotropic coordinates. For Schwarzschild coordinates, we examine transformations introduced by Durgapal and Bannerji (1983).

In isotropic coordinates, the pressure isotropy condition can be framed as either a Riccati equation or a linear equation. We have found one solution by transforming the governing equation to a Riccati equation. This will be used to perform a physical analysis in future work.

SMSCSENG-F-36

One-Step Optimised Second-Derivative Hybrid Block Method for Solving First-Order IVPs

Saidu Daudu Yakubu

219052722@stu.ukzn.ac.za

Student Number: 219052722

School of Mathematics, Statistics and Computer Science

Supervised by Prof Precious Sibanda

This research presents a novel approach for solving first-order stiff initial value problems through the development of a one-step optimised second derivative hybrid block method with three optimal points. The optimisation process was integrated into the derivation of the method to achieve maximal accuracy. Through a rigorous analysis, the properties of the method are found to be zero-stable, consistent, convergent, and A-stable. The numerical results obtained from the proposed method are better than some existing methods investigated in the study. The method even converged at a larger step number and found to be computationally efficient.

SMSCSENG-F-37

ANALYSING LONGITUDINAL ANTHROPOMETRIC MEASUREMENTS AMONG HIV-EXPOSED, UNINFECTED CHILDREN

Mthobisi Zondi

213532968@stu.ukzn.ac.za

Student Number: 213532968

School of Mathematics, Statistics, and Computer Science

Supervised by Prof Henry Godwell Mwambi, Dr Fortunate Nonhlanhla Yende-Zuma, Prof Sileshi Fanta Melesse

Advanced statistical and geographical analyses are needed to fully comprehend the complex interplay between biological, psychological, and social factors impacting growth trajectories as revealed by anthropometric measures in HIV-exposed uninfected children. The chronological, geographical, and social features of anthropometric data from a longitudinal cohort study are explored in this work using advanced statistical tools and spatial models. Our project intends to investigate the effects of maternal and environmental factors on child growth patterns and overcome the difficulties caused by data loss in follow-up studies.

This work will utilise Latent Class Growth Models (LCGM) to identify discrete growth trajectories and examine the influence of various factors on these trajectories. By including survival analysis, we will address potential biases brought about by loss to follow-up, enhancing the reliability of our findings. Furthermore, covariates are included in spatial analysis to investigate the influence of the geographic setting on growth patterns.

Our objective is to provide a comprehensive knowledge of how different factors interact to influence growth trajectories by a thorough analysis of these data. Such knowledge will serve as a basis for focused interventions and inform global health efforts.

Keywords: Anthropometric measures, Growth trajectories, Latent class growth models (LCGM), HIV-exposed uninfected children, Survival analysis.

FLASH ABSTRACTS

SCHOOL OF LIFE SCIENCES

SLS-F-1

CODIUM EXTRICATUM AS A POTENTIAL OXIDATIVE STRESS THERAPUTIC AGENT TOWARDS OBESITY AND TYPE 2 DIABETES

Vunene Nkateko Chabalala

222045806@stu.ukzn.ac.za

Student Number: 222045806

School of Life Sciences

Supervised by Prof. Shahidul Islam

Obesity is associated with excessive amount of body fat, which may have detrimental effects on one's health. Whilst type 2 diabetes mellitus (T2DM) is the most prevalent type of diabetes and is defined as a chronic disorder that alters how the body processes blood sugar, obesity and T2DM are two common closely associated global public health problems, when oxidative stress is one of the major risk factors in this regard. There are pharmacological therapies for both diseases that need to be used in conjunction with a healthy diet as well as physical activity. None of these pharmacological therapies are without side effects. Additionally, these medicines are not affordable for people in developing countries. Hence, there has been a growing interest in the development of alternative medicines from medicinal plants for the treatment of obesity and T2DM. It has been suggested that seaweeds contain bioactive compounds with positive health benefits. The study aimed to investigate the potentials of *Codium extricatum* extracts (hot, cold, and ethanol) to ameliorate oxidative stress as a possible source of antioxidant agents, by using *in vitro* experimental models. The seaweed extracts were screened for antioxidant activity using 1,1-diphenyl-2-picrylhydrazyl (DPPH), Nitric oxide (NO), and non-site-specific hydroxyl radical ($HO^{\bullet}$) scavenging activity. The extracts were also

evaluated for α-amylase, α-glucosidase, pancreatic lipase inhibitory activities, as well as on glucose uptake using yeast cells. The extracts' antioxidant potentials were further assessed through the investigation of oxidative stress biomarkers including, GSH levels, catalase and SOD enzymatic activities after the induction of glucotoxicity in hemoglobin. Furthermore, the extracts were subjected to Liquid Chromatography-Mass Spectrometry (LC-MS) analysis to elucidate their possible bioactive compounds. The ethanol extract displayed the highest level of total flavonoid content. The hot-water extract exhibited the highest total antioxidant capacity, total phenolic content, and $OH^{\bullet}$ scavenging ability (IC_{50}= 44.25 µg/mL). The cold-water extract revealed antioxidant activity through DPPH and NO scavenging assays (IC_{50} = 65 µg/mL and 82.45 µg/mL, respectively). Moreover, the ethanol extract significantly inhibited the lipid digestive enzymes (IC_{50} = 50.77 µg/mL). The hot-water extract revealed carbohydrate digestive enzyme inhibition (IC_{50} = 53.09 µg/mL, α-amylase, and IC_{50} = 50.77 µg/mL, α-glucosidase) as well as better ability to uptake glucose by yeast cells (IC_{50} value of 65.06 µg/mL) than the cold-water and ethanol extracts. Following the induction of glucotoxicity in hemoglobin, the seaweed extracts were able to correct the interruption caused by glucotoxicity. The ethanol extract showed better ability to increase GSH levels and SOD enzymatic activity, when hot-water extract revealed the better ability to increase catalase enzyme activity than other extracts. Furthermore, the LC-MS analysis revealed the presence of Myricetin, Kaempferol, Quercetin, and Hydroxycinnamic acids. The results from this study suggest the potentials of *Codium extricatum* as a source of antidiabetic and anti-obese agents. Further studies using animal model is needed to ascertain the results of this study.

SLS-F-2

Biogenic Nanoparticle Synthesis and their associated Biotechnological Applications

Shreya Dayanand

220054589@stu.ukzn.ac.za

Student Number: 220054589

School of Life Sciences

Supervised by Dr K. Pillay, Dr A. Govindsamy and Mrs V. Reddy

Nanoparticles (NPs) have acquired an abundance of interest for various biotechnological applications. Biological NP synthesis, falling under bottom-up synthesis, accounts for the most environmentally friendly strategy for NP synthesis in comparison to the top-down and other bottom-up approaches which involve high energy consumption and the use of toxic chemicals for physical and chemical synthesis respectively. Therefore, the biological method applies less strain on the environment and potentially increases the biocompatibility of the NPs.

In this study, metallic nanoparticles are synthesized from plant extracts and from bacteria. African Wild Ginger is a traditional medicinal plant that exhibits antimicrobial and antioxidant activities; therefore, leaf and tuberous root extracts can be compared for deducing the relative activities. *Magnetospirillum magnetotacticum* is a gram-negative bacterium containing magnetosomes that allow the bacterial cells to navigate with the magnetic field of the Earth and this unique feature involves the bacteria naturally synthesizing NPs. In the age of antibiotic resistance, it is crucial that alternative antibiotics are explored for potential activity. The development and testing of NPs can prove to be a suitable option and aid in lifting the burden placed upon the healthcare system by multidrug-resistant bacteria.

The tuberous root extract of the African Wild Ginger produced silver (Ag) and gold (Au) NPs with a mean size of 12 nm and 9 nm respectively while the leaf extract produced AgNPs and AuNPs of 30 nm and 32 nm respectively. AgNPs and AuNPs synthesized from *M. magnetotacticum* averaged with a size of 20 nm and 18 nm respectively; additionally, all NPs synthesized displayed uniform spherical shapes. Preliminary results suggest that some NPs portray antioxidant and antibacterial activities, however, more data is required to confirm this.

SLS-F-3

The Use of Traditional Medicine in Neonates and Infants in KwaZulu-Natal

Anele Dlamini

220021891@stu.ukzn.ac.za

Student Number: 220021891

School of Life Sciences

Supervised by Dr Fikisiwe Gebashe

African Traditional Medicine (ATM) is a type of traditional medicine that is native to African cultures. Despite ATM being accessible, diverse, affordable, and utilized by approximately 80% of Africans and 27 million people in South Africa, it is not sufficiently documented. Information on the use of ATM to treat neonates and infants is inadequate, even though neonate and infant primary healthcare is essential given the high neonate and infant morbidity and mortality rates in Africa. In South Africa particularly, as of 2024, the neonate and infant mortality rate is 23.13 deaths per 1000 births, and KwaZulu-Natal (KZN) has been reported to be amongst the top 3 provinces with many neonate and infant deaths. The lack of substantial research and documentation on the use of ATM on neonates and infants results in a lack of safety and efficacy data on ATM and implements a risk of "muti" intoxication. This is unfortunate as ATM could be a good alternative healthcare to consider, thus integrating traditional knowledge and practices, science, human health, and environmental conservation and sustainability. Therefore, this study is necessary to document and spread awareness about the use and medicinal properties of ATM on neonates and infants, specifically in KwaZulu-Natal, for informed and safe use. The aim of this study is to document commonly used medicinal plants to treat neonates and infants in KwaZulu-Natal and determine their medicinal properties. This will be done by documenting medicinal plants used to treat neonates and infants in KZN by employing an ethnobotanical survey of new mothers, herbalists, and traditional healers in KZN. Followed by determining the ethnobotanical parameters (Frequency Citation, Fidelity Level, and Use Value) and the biological activities (anti-inflammatory and antimicrobial) of all the mentioned and documented medicinal plant species. A statistical parameter, Informed Consensus Factor, will be used to determine the common illnesses and/or diseases being treated according to the ethnobotanical survey. Commonly used medicinal plants exhibiting biological activities will then be evaluated for their phytochemical properties (total phenolics, flavonoids, and quantification of secondary metabolites using UPHLC/MS-MS), antioxidant activities (Beta carotene, DPPH, Orac, Frap), and pharmacological activities [anti-inflammatory, antimicrobial, and cytotoxicity], followed by computational modelling of compounds identified within the selected medicinal plants against important proteins that confer illnesses or diseases highlighted in the survey.

SLS-F-4

Green Synthesis Of Nanoparticles Using the Medicinal Plant *Kedrostis nana* Lam. (Cogn.) and Their Antibacterial Efficacy

Kareshma Doolabh

210504977@stu.ukzn.ac.za

Student Number: 210504977

School of Life Sciences

Supervised by Professor Yougasphree Naidoo and Dr Karen Pillay

Traditional healing has been rooted firmly into South African history, which stems from the vast biodiversity of flowering plant species present [1]. However, the pharmacological activity of most of South Africa's plant biodiversity has not been thoroughly explored. Green nanoparticle synthesis has become popular as it is more advantageous than traditional physiochemical methods, with regard to the non-toxic reagents, inexpensive instruments, and economical and sustainable nature [2]. *Kedrostis nana* Lam. (Cogn.) is a traditional medicinal plant hailing from the Western to

Eastern Cape of Southern Africa. This species has traditionally been used as a diuretic, to treat hypertension, ulcers, cancers and malaria [3]. There have been no scientific investigations into the bioactivity of this plant species. Therefore, the aim is to investigate the antibacterial efficacy of silver nanoparticles (SNP) synthesized from *K. nana* extracts.

This was accomplished by extracting the leaves, stems and tuber using distilled water (dH_2O). Synthesis of SNP was achieved using a water bath. The resultant SNP solution was centrifuged, and the pellets were dried and resuspended in 10%DMSO to make a stock solution. The stock solution was serially diluted in 96-well plates to varying concentrations. Different bacterial strains were added to these wells, namely *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Enterococcus faecalis and Klebsiella pneumonia*. The plates were incubated for 18 hours and then treated with a solubilization solution. The optical densities were measured, and the percentage toxicities were calculated.

The results revealed that *K. nana* extracts could synthesize SNP, evident by the solution colour change, with SNP sizes ranging from 106.2 d.nm to 323.0 d.nm and TEM imaging. All extracts revealed moderate antibacterial activity; however, the tuber SNP extract proved superior in its antibacterial capabilities against all bacterial strains compared to the leaves and stems SNPs. The results highlight the importance of investigating medicinal plant extract's antibacterial potential, to aid in controlling resistant bacterial strains that have become an alarming threat to human health.

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SLS-F-5

Advancing Bioethanol Production from Sugarcane Molasses: A Genetic Algorithm Approach Using *Saccharomyces cerevisiae*

Caitlyn Gobey

216011733@stu.ukzn.ac.za

Student Number: 216011733

School of Life Sciences

Supervised by Professor Gueguim Kana and Dr Lorika Beukes

The efficient conversion of sugarcane molasses into bioethanol is a key focus in pursuing sustainable energy solutions. This study investigates the enhancement of bioethanol production by applying a genetic algorithm, leveraging the fermentative capabilities of *Saccharomyces cerevisiae*. With the molasses concentration held constant at a substrate loading of 20% (w/v) following autoclave-assisted acid pre-treatment, this research aims to optimise the bioprocess technology to maximise bioethanol yield.

The ability of *S. cerevisiae* to grow and ferment under various environmental conditions—ranging from aerobic to anaerobic—enhances its utility as a fermentation agent. This yeast can shift to a mixed respiro-fermentative metabolism, producing ethanol when glucose is abundant, and its performance is influenced by factors such as glucose concentration and oxygen availability [1][2][3]. This adaptability underscores the potential of using *S. cerevisiae* in conjunction with genetic algorithms to optimise bioethanol production processes efficiently. The use of *S. cerevisiae* as a fermentation agent, coupled with the adaptive capabilities of a genetic algorithm, presents a novel approach to improving bioethanol production efficiency. Additionally, the application of artificial intelligence (AI) in modelling bioethanol production processes, including genetic algorithms, has enhanced efficiency and predicted outcomes, addressing the complexities inherent in biomass conversion [4]. In this study, the key parameters to be optimised

include temperature (27-35°C), pH (4-6), nanoparticle inclusion of Fe_3O_4 (0-0.05 wt%), and ammonium phosphate concentration (0.5-5 g/L).

The outcomes of this study will provide valuable insights into the application of evolutionary algorithms in bioprocess optimisation and their potential to advance the industrial production of bioethanol. This research contributes to the ongoing development of renewable energy technologies, highlighting the significance of innovative computational methods in bioprocess engineering.

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SLS-F-7

SPIDER DIVERSITY ALONG THE RIPARIAN ZONES OF THE UMGENI RIVER IN THE NATAL MIDLANDS

Asande Hadebe

218017851@stu.ukzn.ac.za

Student Number: 218017851

School of Life Sciences

Supervised by Dr Caswell Munyai, Prof. Rob Slotow and Dr Sindiso Nkuna

Despite riparian zones covering a small area, they support significantly higher biodiversity than the surrounding areas. Spiders are among the dominant animal groups in the riparian zones. They are highly diverse and facilitate connectivity between riparian zones, river ecosystems, and neighbouring uplands.

The current state of knowledge focuses on selected species, neglecting terrestrial arthropods, and the physical boundary of the riparian zones can vary depending on the type of organism and its specific habitat needs. Therefore, to clearly understand these dynamics, the study investigates how distance from the river margins to the uplands influences spider diversity. The study was conducted in the upper section of the Umgeni River. Sampling included setting up pitfall traps in 40 m plots, covering a range of 0 to 2200m along the river margins. Additionally, sampling extended away from the river margins to uplands, ranging from 0 to 300m. The pitfall traps are left open for seven days and retrieved after for sorting and identification.

The preliminary results indicated that 1,987 spiders, representing 116 species, were collected. Spider abundance differed significantly at 0m and 100m, while species richness varied at each distance. Seasonality had no significant influence on spider richness but did affect abundance. The Lycosidae family (wolf spiders) was the most abundant, with *Pardosa crassipalpis* identified as the indicator species at 0m. This could be explained by the fluctuation of food resources across both longitudinal and lateral gradients of riparian zones. With a notable abundance of emergent aquatic insects, making up a significant portion, ranging from 40% to 80% of the diets of riparian spiders.

Understanding the influence of distance from the river margins to uplands on spider diversity is crucial for effectively conserving and managing riparian zones and their biodiversity.

SLS-F-8

Xylitol has a better antioxidative, antidiabetic, and anti-obesity effect than erythritol: A comparative study

Nothando Philile Hlongwane

220012197@stu.ukzn.ac.za

Student Number: 220012197

School of Life Sciences

Prof Shahidul Islam

Diabetes is an escalating public health epidemic that demands urgent medical attention. Therefore, this study aimed to investigate and compare the antioxidant, anti-hyperglycaemic, and anti-hyperlipidaemic properties of erythritol and xylitol, two widely used sugar replacers. The antioxidant potential of xylitol and erythritol was measured by their ability to scavenge 2,2-Diphenyl-β-picrylhydrazyl radical (DPPH), nitric oxide (NO), and Hydroxyl radical (OH) radicals. Furthermore, the effects of xylitol and erythritol on carbohydrate and lipid digestive enzymes were assessed by measuring their inhibitory activity on α-amylase, α-glucosidase, and pancreatic lipase, respectively. Anti-hyperglycaemic effects were further evaluated using glucose uptake in yeast cells. Moreover, oxidative stress biomarkers including glutathione (GSH), superoxide dismutase (SOD), catalase (CAT), and nitric oxide (NO) enzymes were measured further to evaluate the antioxidative effect of xylitol and erythritol. The binding affinities of xylitol and erythritol to the aforementioned digestive enzymes were also assessed using molecular docking. Xylitol and erythritol exhibited a dose-dependent antioxidant activity on DPPH, NO, and OH radicals, and inhibitory activity on lipid and carbohydrate digestive enzymes. Both sugars promoted the absorption of glucose into the yeast cells. Inducing oxidative stress on the liver resulted in increased NO, and a decrease in GSH, CAT, and SOD levels. However, the addition of sugar alcohols reversed these effects as shown by an increase in GSH level, and CAT and SOD enzymes activity with a decrease in NO level. Overall, xylitol showed better activity than erythritol in terms of all parameters mentioned above including highest binding affinity to α-amylase, α-glucosidase and pancreatic lipase compared to erythritol. The findings of this study suggest that xylitol has better efficacy in terms of antioxidative, anti-hyperglycaemic, and anti-hyperlipidaemic effects than erythritol. Further studies on experimental animal models and humans are required to ascertain the results of this study and to understand the possible mechanisms of action.

SLS-F-9

COFFEE IMPROVES THE ANTIDIABETIC AND AMELIORATE EFFECT OF METFORMIN IN OXIDATIVE HEPATIC INJURY

Almahi M. Idris

219094524@stu.ukz.ac.za

Student Number: 219094524

School of Life Sciences

Supervised by Prof. Shahidul Islam

Diabetic complications are one of the most common phenomena in people with diabetes and at least 50% of people with diabetes suffer from one or more diabetic complications. Numerous liver diseases associated with type 2 diabetes (T2D) are considered as a major contributor to mortality in T2D, when oxidative stress plays a critical role in this regard. On the other hand, metformin is the most widely used medicine for T2D and coffee consumption is associated with a significant reduction of hyperglycemia as well as T2D. The present study evaluated the inhibitory effects of

Brazilian coffee beans (*Coffea arabica*) or Metformin, and their combination on carbohydrate digestive enzymes and their protective effects against iron-induced hepatic injury, using in *vitro, ex vivo* and in *silico* experimental models. Oxidative injury was induced by incubating liver tissue collected from normal male Sprague-Dawley rats with iron and treated with the different concentrations of Brazilian coffee beans, Metformin, and their combination for 30 mins at 37ºC. Induction of iron-induced oxidative injury led to the significant depletion of GSH, SOD, and total glycogen levels; while elevated the MDA, NO, glycogen phosphorylase, fructose-1,6-bisphosphatase, ATPase, and acetylcholinesterase levels. Treatment with different concentrations of coffee beans, Metformin, and their combination significantly restored the levels and activities of the above-mentioned biomarkers. Among all extractions, Metformin-coffee strongly inhibited the α-glucosidase and α-amylase enzymes activity, with former showing the better activity. Furthermore, LC-MS analysis indicates the presence of chlorogenic acid, caffeic acid, theacrine, 3,4-dicaffeoylquinic acid, trigonelline, caffeine, quinic acid, ferulic acid, trigonelline, and styrene in the coffee bean extracts. *In silico* analysis revealed a strong molecular interaction of chlorogenic acid with α-glucosidase, α-amylase, and acetylcholinesterase enzymes. The data of this study suggest that that bioactive compounds from Coffee arabica may attribute to the higher activity of Metformin-Coffee combination, which may lead to strong hepatoprotective effect. Hence, consumption of coffee while taking metformin may be beneficial for the prevention and delay of hepatic diseases related to oxidative stress and T2D. However, further investigations in animal models and human subjects are warranted to ascertain the results of this study.

SLS-F-11

ALOE FEROX LEAF GEL EXTRACTS ATTENUATE REDOX IMBALANCE IN OXIDATIVE RENAL INJURY AND STIMULATES GLUCOSE UPTAKE, WHILST INHIBITING KEY ENZYMES LINKED TO DIABETES AND OBESITY

Huda Ismail

220010558@stu.ukzn.ac.za

Student Number: 220010558

School of Life Sciences

Prof Shahidul Islam

Aloe ferox, a member of the *Aloe* genus, is indigenous to South Africa and has a long history of traditional medicinal use. The worldwide prevalence of diabetes and obesity is growing rapidly. Both of these metabolic disorders are linked to chronic adverse complications, impairment, and potential organ failure, which includes kidney dysfunction. The present study was conducted to determine the antioxidative, anti-obesogenic, and antidiabetic effects of *A. ferox* leaf gel extracts using *in vitro*, *ex vivo*, and *in silico* experimental models. Oxidative renal damage was induced using ferrous sulfate ($FeSO_4$). Subsequent treatment with *A. ferox* leaf gel extracts, both aqueous and ethanolic, improved this condition, in which the aqueous extract demonstrated better efficacy, leading to higher reduced glutathione (GSH) level, and superoxide dismutase (SOD) and catalase enzymes activity, along with a concurrent reduction of nitric oxide (NO) and malondialdehyde (MDA) levels. Likewise, both extracts showed potent *in vitro* DPPH, NO, and OH• radical scavenging activity, when aqueous extract was shown to be more potent. The extracts also inhibited the enzymes α-amylase, α-glucosidase, and pancreatic lipase significantly ($p<0.05$) compared to the respective controls. Incubation of the extracts with yeast cells stimulated glucose uptake dose dependently, when ethanolic extract showed the better activity compared to the aqueous extract. Furthermore, LC-MS analysis led to the identification of many compounds, when chlorogenic acid demonstrated a stronger molecular interaction with the active site amino acids of α-amylase and catalase compared to other compounds. However, Aloin B showed the highest affinity with α-glucosidase and 5-Hydroxyaloin A showed the lowest binding energy with lipase, and SOD enzyme. These results suggest the reno-protective effects of A. *ferox* leaf gel extracts against $FeSO_4$-induced oxidative stress along with its anti-hyperglycaemic activity. The observed antioxidative, reno-protective, antidiabetic and anti-obesogenic effects of *A. ferox* leaf gel extracts corroborate its traditional medicinal use. Further studies in animal model are needed to ascertain the results of this study.

SLS-F-12

Mucuna pruriens as a cover crop reduces soil acidity and promotes beneficial plant growth promoting bacteria in KwaZulu-Natal small-scale sugarcane growers (SSGs)

Sikhanyiso Khwela

217079525@stu.ukzn.ac.za

Student Number: 217079525

School of Life Sciences

Supervised by Dr Anathi Magadlela

KwaZulu-Natal (KZN) small-scale sugarcane growers face declining soil fertility due to monoculture and excessive use of environmentally harmful chemical fertilizers, resulting in reduced productivity and yield. Therefore, this study investigated the use of *Mucuna pruriens* as a cover crop/green manure to improve soil conditions in acidic and nutrient-poor sugarcane plantations. Post-*M. pruriens* harvest, the soil pH increased across all five plantations soils while nitrogen (N) and phosphorus (P) concentrations decreased. *Mucuna pruriens* sanctioned for bacteria that aid in nutrient cycling and acquisition by increasing its root exudate signals for N and P cycling bacteria such as *Pseudomonas*, *Burkholderia* and *Rhizobium*. Additionally, there was noticeable increase in nitrate reductase and acid phosphatase enzyme activities, further demonstrating the capacity of *M. pruriens* to increase nutrient cycling in these acidic and nutrient poor plantation soils. Overall, findings of this study indicate that *M. pruriens* is a viable cover crop option for KZN small-scale sugarcane growers, as it positively affects soil pH and the bacterial profiles of the different plantation soils. Furthermore, nutrients assimilated by *M. pruriens* can be recycled back into the soil, promoting sustainable agricultural practices.

SLS-F-13

Effect of genetically modified sugarcane in combination with sterile insect releases to control *Eldana saccharina*: a shade house trial

Vanessa Lauchande

217012751@stu.ukzn.ac.za

Student Number: 217012751

School of Life Sciences

Supervised by Dr Caswell Munyai and Dr Lawrence Malinga

In South Africa, the lepidopteran stalk borer *Eldana saccharina* is one of the most important sugarcane pests. Because of its cryptic nature, an independent pest control method, the use of genetically modified crops with *Bacillus thuringiensis* (Bt) is steadily growing. However, insect adaptation can reduce the efficacy of Bt and result in resistance. A multi-tactic eradication programme that includes the sterile insect technique (SIT) can suppress resistance to Bt sugarcane and decrease the *E. saccharina* population. The aim of the project was to develop a proof of concept that SIT used in combination with Bt sugarcane had a synergistic effect on the control of *E. saccharina* under a controlled environment. The study included the release of *E. saccharina* moths into the treatment and control shade houses planted with Bt and non-Bt sugarcane. Sterile and non-sterile *E. saccharina* moths were released in the treatment shade house, while only non-sterile moths were released in the control shade house. A survey on stalk damage and *E. saccharina* abundance was conducted when the sugarcane was 12 months old. A generalised linear model was used to analyse the percentages for internode damage (IND), stalk length damage (SLD), and stalk red length (SRL), while a linear mixed model was used to analyse the stalk length (SL). These analyses were conducted using Genstat 22nd edition. There was no significant difference in the IND (P-value = 0.084), SLD (P value = 0.085) and SRL (P value = 0.050) between the shade house and sugarcane type. However, within the sugarcane types, non-Bt sugarcane had the highest significant IND of 0.158% (P value < 0.001) and SLD of 0.099% (P value < 0.001), while there was no significant SRL 0.381%

(P value = 0.076). The non-Bt sugarcane in the treatment shade house had the highest Eldana/100 stalk (14.74), which consisted of 23 *E. saccharina* larvae that survived until adulthood. There was significance in the shade house with the treatment having the highest IND of 0.078% (P value = 0.001), SLD of 0.047% (P value < 0.001) and SRL of 0.142% (P value = 0.003). By dividing the Bt sugarcane mean from the non-Bt sugarcane, the relative difference in damage was estimated. Overall, the treatment shade house had a greater reduction in stalk damage, with 11 times less internode damage, 12 times less stalk length damage and 26 times less stalk red damage. There was no significance between the shade house and sugarcane type (P value = 0.052). However there was signficance within shade houses, with the treatment having SL 76.37 (P value < 0.001) and within sugarcane types with non-Bt sugarcane having an SL 79.71 (P value < 0.001). Further experiments should be conducted using larger release numbers over an extended period to increase sample numbers, increasing the viability of the experiment. This study is a basis for developing an efficient resistance management strategy for sugarcane farmers in South Africa.

SLS-F-14

Assessment of Gobiidae species found around eThekwini district, KwaZulu-Natal using eDNA metabarcoding data

Khethiwe Nosicelo Maphosa

216001309@stu.ukzn.ac.za

Student Number: 216001309

School of Life Sciences

Supervised by Dr Tshoanelo Miya

One of the largest fish families in the Perciformes suborder is the family Gobiidae. Gobiidae has more than 2,000 different species, making it one of the largest fish families in the world They are known for their size and adaptability in a variety of habitats, including freshwater and marine environments. However, identifying Gobiidae species can be difficult despite their ecological importance. They are difficult to collect since they are relatively small, with many of them measuring less than 10 cm. They are also, prone to being misidentified because they are morphologically reduced, in other words they have simplifications and losses in certain morphological characters, and they also camouflage in their respective environments. A simple way to overcome this is by using innovative methods such as DNA barcoding or metabarcoding to enable the detection and identification of Gobiidae species. These techniques can help accurately identify Gobiidae species and distinguish between different species. Environmental DNA (eDNA) metabarcoding is a relatively new approach used to detect and identify fish species from water samples. This method uses genetic material (DNA) shed by fish into their surrounding environment to identify the presence of fish species including the Gobiidae family. The aim of this study is to assess fish species belonging to family Gobiidae found around eThekwini district, KwaZulu-Natal, using metabarcoding data. Gobiidae tissue was clipped from pectoral, dorsal, and tail fins with a sterile puncture, and DNA was extracted with DNeasy Blood and Tissue extracting kit. Tissue derived DNA extracts were then analysed by the PCR assay. Fish specific primers for COI gene were taken from Nevers et al., (2018). Where, three out of the four primer combinations (Fish F1 and GobyCOI-R5; GobyCOIF5 and Fish R2; Fish F1 and GobyCOI-R2) produced positive bands through gel electrophoresis analysis. These samples were then sent to Inqaba Bio-tech laboratory for sequencing. The resulting DNA sequences were edited using Chromas and aligned using MEGA 11.

SLS-F-15

Plant-associated bacteria and enzymes support *Canavalia rosea* growth in coastal hypersaline soils

Sithabile Mbonambi

217033680@stu.ukzn.ac.za

Student Number: 217033680

School of Life sciences

Supervised by Dr Anathi Magadlela

Canavalia rosea is an extremophilic legume that grows in hypersaline and nutrient-deficient ecosystems. The extremophilic nature of *C. rosea* may be attributed to its ability to establish symbiotic associations with nutrient mineralizing and plant growth promoting (PGP) bacteria housed in the nodules. This study examined legume-microbe symbiosis and plant nutrition of *C. rosea* growing in subtropical coastal zone in KwaZulu-Natal province, South Africa. *Canavalia rosea* adult plants of the same age from Westbrook, Scottburgh and Durban were collected for plant biomass and plant nutrition and root nodules were used for bacterial extraction and identification. Rhizosphere soils sampled from the three localities were used for bacterial extraction and identification, extracellular enzyme assays and soil characteristics (pH, nutrient concentrations, total cation, and exchange acidity). Westbrook, Scottburgh and Durban soils were nutrient-deficient with varying total cations, acid saturation and a pH range of 7.3–7.6. Soil nutrient mineralizing extracellular enzyme activities varied across study sites. The culturable bacterial strains isolated from the sampled soils belonged to the *Pseudomonas*, *Pantoea* and *Flavobacterium* genera. *Canavalia rosea* root nodules were nodulated by *Pseudomonas guariconensis*, *Pseudomonas fulva, Pseudomonas fluorescens, Pseudomonas chlororaphis* and *Pseudomonas chlororaphis subsp. aurantiaca.* Plants growing in Westbrook soils had a significantly higher total plant biomass compared to Scottburgh and Durban plants. Plant P concentration did not vary significantly between sites while plant N and C concentrations varied significantly. Plant-associated and soil bacteria with phosphorus (P) solubilising, nitrogen (N) cycling, and N fixing functions and associated enzymes seem to facilitate the mobilization of nutrients enabling *C. rosea* to thrive in hypersaline and low-nutrient environments.

SLS-F-16

DETECTION OF PARACETAMOL FROM THE INSECTS COLLECTED FROM SPIKED PIG CARCASSES: SIMULATION OF DRUG RELATED DEATH INVESTIGATION

Eden Rebekah Moodley

220015370@stu.ukzn.ac.za

Student Number: 220015370

School of Life Sciences

Supervised by Dr Danisile Tembe

The increasing prevalence of drug overdoses has necessitated the development of innovative methods for detecting pharmaceutical substances in biological samples. This study investigates the use of insect species as bioindicators for the detection of paracetamol in drug overdose cases, with a focus on analysing paracetamol concentrations using Liquid Chromatography-Mass Spectrometry (LCMS). Insects, being decomposers, often colonize human remains and can accumulate drug residues, thus providing valuable forensic evidence. This research explores the identification of specific insect species that are likely to serve as effective bioindicators, as well as the optimization of LCMS protocols for the accurate quantification of paracetamol in insect tissues.

The study commenced with the collection of insect samples from various simulated overdose scenarios, ensuring a controlled environment for assessing drug uptake. A comprehensive identification process was conducted to determine the forensically important insect species most commonly associated with decomposing remains. Subsequent LCMS analysis was employed to measure paracetamol levels within these species. The findings indicate a significant correlation between the presence of paracetamol and specific insect taxa, suggesting that these insects can be reliable indicators of drug presence in postmortem investigations.

This research contributes to the growing field of forensic entomotoxicology by highlighting the potential of insects as bioindicators in drug detection. The use of LCMS for analysing paracetamol in insect tissues offers a novel approach to forensic toxicology, providing a non-invasive and cost-effective method for detecting drug use in overdose cases. The outcomes of this study could pave the way for more accurate and efficient forensic investigations, aiding in the determination of cause and manner of death in drug-related fatalities.

SLS-F-17

Reducing inorganic nitrogen inputs in small scale sugarcane growers using legume species (*Vigna unguiculata* and *Cajanus cajan*)

Mncedisi Motaung

217006183@stu.ukzn.ac.za

Student Number: 217006183

School of Life Sciences

Supervised by Dr Anathi Magadlela

The sugar industry in South Africa faces declining sugarcane production due to the limited number of small-scale sugarcane growers (SSGs) and the challenges they face due to the declining soil fertility. To enhance soil fertility, farmers apply high amount of nitrogen (N) fertilizers to increase sugarcane yields. However, excessive application of chemical fertilizers is costly and detrimental to the environment. Incorporating legumes between sugarcane cycles is a sustainable alternative that reduces reliance on synthetic N fertilizers, increases crop diversity, and promotes bacterial diversity, thereby increasing nutrient cycling and soil health. Therefore, this study investigated the chemical and biological contributions of *Vigna unguiculata* and *Cajanus cajan* to nutrient-deficient small-scale sugarcane plantation soils in KwaZulu-Natal. Additionally, it aimed to understand the growth physiology of both species under these nutrient deficient conditions. The soils were analyzed for soil nutrients, N and phosphorus (P) cycling bacteria and their associated enzymes pre- and post- *V. unguiculata* and *C. cajan* harvesting. Post-harvest, soil pH levels increased across all plantation soils. The number of plant-growth promoting bacteria increased post-harvest and included bacterial strains in the *Pseudomonas, Paraburkholderia* and *Burkholderia* genus. Phosphate- solubilizing bacteria increased across all plantations except in Mzinto post-*C. cajan* harvest, and in Hibberdene and Mzinto post- *V. unguiculata* harvest. The number of N- cycling bacteria increased across all plantation soils, increasing nitrate reductase activities for both species. The current findings indicate that *V. unguiculata* and *C. cajan* improve the soil health of nutrient-deficient sugarcane plantations by increasing the number of nutrient cycling bacteria and enzyme activities.

SLS-F-18

Using reverse vaccinology to construct multi-epitope subunit vaccines for *Klebsiella pneumoniae*

Tehrim Motiwala

216013319@stu.ukzn.ac.za

Student Number: 216013319

School of Life Sciences

Supervised by Dr Thandeka Khoza

Klebsiella pneumoniae is a Gram-negative clinically relevant pathogen responsible for causing nosocomial infections. This bacterium is resistant to a spectrum of antibiotics and has been listed under “critical” priority for research and development of new antibiotics and alternative strategies. Reverse vaccinology was used to construct multiepitope vaccines against six K. pnuemoniae outer membrane proteins. Bioinformatic tools confirmed the antigenicity and non-allergenic nature of the sequences selected for analysis. The identification of B and T cell epitopes led to the design and in silico characterisation of six multiepitope vaccines. The interaction of the six vaccines to TLR-2 and TLR-4 were investigated using molecular docking and molecular dynamic simulations. Codon optimised multiepitope cloning strategies are proposed for each vaccine, for expression in bacterial vectors. The results confirmed that the multiepitope vaccines have potential as a vaccination strategy against K. pnuemoniae and should be further investigated.

SLS-F-19

Baseline susceptibility of laboratory-reared *Eldana saccharina* larvae to *Bacillus thuringiensis* Cry toxins and the Coragen insecticides

Kwanele Msele

218009991@stu.ukzn.ac.za

Student Number: 218009991

School of Life Sciences

Supervisors: Dr Caswell Munyai and Dr Lawrence Malinga

Sugarcane is one of the most important crops globally and is essential for global food security and development. However, lepidopteran pests, including the African sugarcane borer *Eldana saccharina*, present significant challenges to crop production. This is due to their destructive feeding habits and rapid growth of resistance to conventional management strategies. The *Bacillus thuringiensis* (Bt) protein is one of the effective control strategies for lepidopteran pests and has been used successfully in several crops. However, there is no information on the susceptibility of *E. saccharina* against Bt protein. Laboratory bioassays will be conducted at the South African Sugarcane Research Institute Insect Rearing Unit to determine the susceptibility and monitoring resistance of *E. saccharina* to Cry1 and Cry2 proteins and CORAGEN® SC insecticide. Two-day-old *E. saccharina* larvae will be inoculated separately into artificial diets with different concentrations of Cry proteins (0, 0.02, 0.03, 0.1, 0.2, 1, and 2 µg/ml) and insecticide (0, 0,25, 1, 10, 15, and 30µl /ml). Daily monitoring of larval feeding and movement behaviour on the diet will be done. The larvae will be harvested after seven days, and mortality rate and larval weight data will be determined. Mortality, larval weight and growth inhibition will be compared between Cry1, Cry2 and CORAGEN® SC insecticide. The data will be subjected to probit analysis using IBM SPSS version 27 to determine a lethal concentration where 50% (LC_{50}) of the population dies and 95% confidence intervals. The non-parametric Kruskal-Wallis will be conducted if the assumptions are not satisfied even after the transformation. The outcomes of this study will provide baseline susceptibility of *E. saccharina* against the Cry1 and Cry2 proteins in comparison with the CORAGEN® SC insecticide. This will further inform the development of a durable resistance management strategy against *E. saccharina* and enhance the global agricultural productivity of sugarcane.

SLS-F-20

GENETIC DIVERSITY AND POPULATION STRUCTURE OF *Cannabis sativa* IN SELECTED PROVINCES OF SOUTH AFRICA

Vuyisile Ndlangamandla

222129381@stu.ukzn.ac.za

Student Number: 222129381

School of Life Sciences

Supervised by Dr Fikisiwe Gebashe

Cannabis was finally decriminalised in South Africa, opening doors for the plant to be legally explored for medical, industrial and recreational purposes. *Cannabis sativa* L. is one of the oldest cultivated crops hypothesised to have originated in Central Asia and is widely grown in Afghanistan. South Africa has varieties with rich genetic reservoirs that have never been explored before and have been adapted regionally to Southern Africa. To evaluate these genetic diversity Cannabis varieties, 131 samples were collected from four South African provinces (Eastern Cape, KwaZulu-Natal, Mpumalanga and Limpopo) and sequenced for whole-genome sequencing and genotyping. Additionally, a survey was conducted using a questionnaire to understand the indigenous knowledge of the cultivation, uses and variation of Cannabis. During the collection, twenty-four colloquial names of *Cannabis* used by the traditional growers were found with *Insangu* and *Ugwayi wesizulu* being the most mentioned varieties in the study. The recognised

Cannabis varieties differed in morphological traits (flower, leaf and plant height) and scent. It was revealed by the survey that *Cannabis* can be used in various ways, most growers cultivated *Cannabis* to supply recreational users while a few mentioned that they used it personally for medicinal purposes, and burning during cultural/traditional rituals. A total of approximately 1.6 million Single Nucleotide Polymorphisms (SNPs) were obtained after quality control and filtering. The Principal Component Analysis (PCA) and phylogenetic tree grouped the *Cannabis* into two main clusters and associated the varieties according to their area of origin. The genetic structure was further investigated using ADMIXTURE which K=2 showed clustering from two ancestries, the KwaZulu-Natal and Eastern Cape were clustering from one ancestry, and Limpopo and Mpumalanga from the same ancestry. The Admixture which had the lowest cross validation error at K=5, which was the most suitable admixture-based clustering. K= 5 clustered the *Cannabis* varieties according to areas of origin and landrace names. Furthermore, this K value showed that *Cannabis* varieties are highly admixed. However, the fixation index (Fst) analysis uncovered relatively low levels of variation (ranging from 0.007 to 0.058) among the *Cannabis* populations. This probably means there is a minimal genetic variation between gene populations of *Cannabis* in South Africa and are likely not very distinct from one another in terms of genetic structure.

SLS-F-21

Histology-based health assessment and estrogenic effect on *Labeobarbus natalensis* in the uMgeni River system

Mandlenkosi Nkala

215008198@stu.ukzn.ac.za

Student Number: 215008198

School of Life Sciences

Supervised by Dr Jeffrey Lebepe, Dalene Vosloo, Wilmien Luus-Powell

The uMgeni River is home to more than 40 fish species and is highly polluted by anthropogenic activities. The study aimed to assess the overall health and oestrogenic effect on *Labeobarbus natalensis* in the uMgeni River system. The physical-chemical properties of the water were measured, and water and sediment were sampled at the Inanda and Nagle dams, uMsunduzi, uMngcweni, and eSikelekehleni rivers. Simultaneously, fish were collected and processed following standard routine and various health indices were calculated for assessment of the general health of the fish. Moreover, a histopathologic assessment was done on the liver and gills, and organ indices were calculated. The VTG concentration in the male liver was measured to assess the oestrogenic effect in fish.

Physical water parameters showed no significant difference between the two dams whereas sulphate and phosphate were significantly higher in the uMsunduzi and uMngcweni rivers, respectively. Other nutrients such as NO2, K, NO3 and NH3 showed no significant difference between the two dams. Most metals were below detection levels in the water column whereas sediment exhibited considerable concentrations. There was no definite trend of concentrations between the two dams. No difference was observed for the general health of the fish. However, a higher prevalence of alterations in gills and liver was observed for the Inanda Dam population compared to Nagle Dam. The gill histopathology such as necrosis, deposits, oedema, architectural and structural alterations, nuclear alterations, hypertrophy, and hyperplasia were the most prevalent pathologies at Inanda Dam whereas deposits, plasma alterations, architectural and structural alterations were highly prevalent at Nagle Dam. In the liver, architectural and structural alterations, necrosis, nuclear alterations, vacuolar degeneration, and hypertrophy were the most prevalent pathologies at Inanda Dam. Similarly, organ indices were relatively higher for the Inanda Dam population. However, both populations exhibited gill and liver indices >40, denoting, severe alterations. Nevertheless, the two populations exhibited considerable vitellogenin (VTG) levels with no significant difference being observed between the two ($p>0.05$). Although the general health of the fish seemed to be in an acceptable state, it is evident that these fish populations are living in stressful conditions. These findings show that there is a need for urgent attention to address the water pollution issue in this river system for the sustainability of L. natalensis and possibly other sensitive species.

SLS-F-22

PHYTOCHEMICAL COMPOSITION AND *IN-VITRO* ANTIOXIDANT ACTIVITY OF *SOLANUM MAURITIANUM* SCOP. LEAF, STEM AND FRUIT EXTRACTS

Myuri Parusnath

216004323@stu.ukzn.ac.za

Student Number: 216004323

School of Life Sciences

Supervised by Professor Yougasphree Naidoo and Professor Moganavelli Singh

Humans produce endogenous antioxidants to mitigate free-radical damage and oxidative stress from reactive oxygen species (ROS), which in excess, can damage cell structure and function, leading to the pathogenesis of several diseases. When ROS levels exceed the natural antioxidant capacity, exogenous sources are required. Since synthetic antioxidants can be toxic and mutagenic, this study has looked at the phytochemical and biological activity of a medicinal plant that has been utilised in the traditional treatment of illnesses potentially associated with oxidative stress. *Solanum mauritianum* (Scop.) has reportedly been utilised in African traditional medicinal practices for the treatment of gastrointestinal, respiratory and inflammatory conditions. This study investigated the hexane (H), chloroform (C) and methanol (M) extracts of the plant's leaves (L), stems (S) and fruit (F) for its phytochemical composition and *in-vitro* antioxidant activity. All extracts presented positive results when qualitatively screened for phytochemicals such as alkaloids, phenolic compounds, flavonoids, polyphenols and terpenoids, at varying intensities. Quantitative assays revealed significant differences ($p < 0.05$) in total phenolic content within all extracts besides HS and HF, with methanol extracts containing the greatest amounts of phenolics (ML = 73.46 ± 0.87; MS = 25.41 ± 0.44 and MF = 39.59 ± 0.25 mg GAE/g), followed by the chloroform and hexane extracts, respectively. Furthermore, similarities in total flavonoid content were revealed within HL and CF, between CL, ML, CS and MS, as well as within HS and HF ($p > 0.05$). Again, methanol extracts exhibited the highest flavonoid content (ML = 516.25 ± 13.71; MS = 519.42 ± 11.41 and MF = 425.67 ± 20.31 mg QE/g). Since phenolics and flavonoids exert antioxidant effects, these results corroborated with findings of the 2,2′-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging and ferric (Fe^{3+}) reducing antioxidant power (FRAP) assays where methanol extracts generally presented relatively lower IC_{50} values. The radical scavenging activity of ML, as presented by its IC_{50} value (8.74 ± 1.34 µg/mL), was comparable ($p > 0.05$) to that of the ascorbic acid control (1.69 ± 0.76 µg/mL), indicative of exceptional antioxidant activity, while MS and CL additionally exhibited good activity (91.87 ± 0.79 and 96.51 ± 2.95 µg/mL). The ferric reducing abilities of all extracts were significantly higher than the gallic acid control which had an IC_{50} of 0.34 ± 0.00 µg/mL. However, ML did have a relatively lower IC_{50} of 74.55 ± 1.23 µg/mL, followed by HL, CL and MS (159.52 ± 1.50, 226.20 ± 2.22 and 229.34 ± 3.50 µg/mL), respectively, suggesting adequate antioxidant activity. These findings justify further exploration of the extracts' bioactivities and its isolated phytochemicals.

SLS-F-23

Prevalence of mycoplasmas and antibiotic resistance in the Limpopo Province

Winnie Thabisa Ramaloko

221119286@stu.ukzn.ac.za

Student Number: 221119286

School of Life Sciences

Supervised by Adeleke M.A, Abbai N, Osei Sekyere J. and Maningi N.E.

Mycoplasmas refer to *Mycoplasma* and *Ureaplasma* species. These are neglected opportunistic pathogens that cause infections, particularly in immunocompromised individuals [1]. They are implicated in urogenital and sexually transmitted infections in humans [2], [3] In some cases, they may cause miscarriage or premature labor in women and

infertility in men [2]. These infections are difficult to treat due to their lack of cell walls [4], [5]. Their resistance to commonly used antibiotics poses a substantial challenge to treatment and infection management. The study aimed to estimate the prevalence of urogenital mycoplasma in the Limpopo region and characterize their antibiotic resistance profiles.

Urine samples (n = 239) from symptomatic patients were screened for mycoplasmas using Real-Time Polymerase Chain Reaction (qPCR). Positive isolates were tested for antibiotic resistance using a MycofastRevolution kit and PCR. Four urogenital mycoplasmas were identified. The prevalence of *M. genitalium, M. hominis, U. parvum,* and *U. urealyticum* was 4.2%, 46.0%, 33.0%, and 49.0%, respectively. The MycofastRevolution kit revealed that 13.6% (n = 3/22), 40.9% (n = 9/22), and 13.6% (n = 3/22), *U. urealyticum* isolates were resistant to macrolide, fluoroquinolones, and tetracyclines, respectively. Furthermore, 31.8% (n = 7/22), 40.9% (n = 9/22), and 40.9% (n = 9/22), *M. hominis* isolates were resistant to macrolide, fluoroquinolones, and tetracyclines. PCR revealed that 88% (n = 97/110) of *M. hominis* isolates carried genes associated with macrolide resistance.

The most prevalent pathogens from the Limpopo region were *U. urealyticum* and *M. hominis*. These mycoplasmas were resistant to the commonly used antibiotics such as macrolides and fluoroquinolones. With these species developing resistance to first line antibiotics globally, more studies are required to get a better understanding of the resistance mechanisms that are involved.

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SLS-F-25

Environmental DNA (eDNA) metabarcoding reveals vertical layer-specific preferences of fish communities

Raelene Sappor

220111837@stu.ukzn.ac.za

Student Number: 220111837

School of Life Sciences

Supervised by Professor Sandi Willows-Munro and Dr Ashrenee Govender

Environmental DNA (eDNA) metabarcoding is a molecular approach for analysing DNA collected from environmental samples such as water, air and soil. eDNA can identify species through genetic material released into the environment through skin cells, faeces, mucus, and blood. eDNA analysis offers many advantages over traditional monitoring methods such as visual surveys, netting, and baited remote underwater video systems (BRUVS), which can be time consuming, labour intensive, intrusive to species and requires taxonomic expertise. This study aimed to explore the utility of eDNA to provide information on habitat preferences of different fish communities by cataloguing and comparing eDNA from fish species across different vertical layers within a closed system at uShaka Marine World aquarium. Using the aquarium allowed us to compare our eDNA results to a curated fish inventory. Water samples

were collected from three different depths in the uShaka Snorkel Lagoon tank: surface, middle and bottom. To account for eDNA from other sources we also collected water from the intake pipe and any food that was fed to occupants of the tank during the day of sampling. Water samples were filtered and the eDNA was extracted. Samples were amplified using universal fish primers, and then underwent high-throughput sequencing at KRISP. A total of 54 fish species were identified from the eDNA in water samples, this included 26 species from the surface sample, 21 species from the middle sample and 15 species from the bottom sample. A total of 31 fish species were only detected in a single layer while eDNA from seven species were found at all water depths. The depth that fish eDNA was detected was linked to behaviour of certain species, with some demersal fish species such as *Scorpaenopsis diabolus* only detected in the bottom layer of the tank. We also found that most species were detected in the surface layer probably due to water currents in the tank. This study showed the importance of sampling different depths to effectively assess marine biodiversity. This finding has important consequences for future marine eDNA studies.

SLS-F-26

The effect of combination oxidative stress on yeast survivability

Savarna Singh

223115041@stu.ukzn.ac.za

Student Number: 223115041

School of Life Sciences

Supervised by Dr Ché Pillay

Pathogenic fungi represent an emerging and serious threat to human health, leading the World Health Organisation to release a fungal priority pathogen list in 2022. Significantly, many of these fungi have developed resistance to the four major classes of antifungal drugs and there is an urgent need to develop novel antifungal therapeutic and prophylactic approaches. Redox stressors, such as hypochlorous acid, have long been used as surface disinfectants, and many antifungal drugs trigger oxidative stress as part of their activity mode. This study investigates the sensitivity of the model yeast *Schizosaccharomyces pombe* to the combination stress of hydrogen peroxide and the lipid peroxide analogue tert-butyl hydroperoxide. Preliminary work from our lab has shown that this combination stress exerts a more lethal effect at lower concentrations than either hydrogen peroxide or tert-butyl hydroperoxide alone, and we will confirm this result using both growth (CFU/ml) and viability (Eosin Y) assays. We hypothesise that the combination stress disables the adaptive response in yeast by inhibiting the activation of antioxidant transcriptional programs, which we will test with RT-qPCR and western blotting. This work will also be extended to include the pathogenic *Candida albicans* species. These findings will inform the development of novel antifungal surface disinfectants and provide further insights into the stress tolerance pathways essential for fungal survival.

SLS-F-27

TARGETED MRNA DELIVERY TO BREAST CANCER CELLS USING FUNCTIONALISED GOLD NANOCLUSTERS *IN VITRO*

Nishthi Singh

216004294@stu.ukzn.ac.za

Student Number: 216004294

School of Life Sciences

Supervised by Professor Moganavelli Singh

Breast cancer is the most frequently diagnosed cancer and the leading cause of cancer-related death among women worldwide, claiming almost 1 in every 6 cancer deaths. The burden of breast cancer is increasingly experienced

globally, albeit more so in low- to middle-income countries. Conventional therapies encompass both local interventions, such as surgery and radiation, and systemic treatments, including chemotherapy and hormone therapy. Although these approaches have shown improved survival rates, they are often limited by their invasivity, non-specific toxicity, detrimental health effects, failure to prevent recurrence, and the development of resistance. The recent application of mRNA in the production of vaccines and therapeutic agents holds immense potential as a viable alternative in the prevention or treatment of various incurable diseases, including breast cancer. However, achieving successful clinical translation requires a safe and efficient gene delivery system due to mRNA's inherent instability and high susceptibility to enzymatic degradation. Gold nanoclusters (GNCs) have gained significant interest as potential delivery vectors owing to their ultrasmall size (< 2 nm), ease of synthesis, ability to be functionalized and low toxicity in biological systems. This study aimed to develop a non-toxic and efficient mRNA delivery system using functionalized GNCs targeted to overexpressed folate receptors in breast cancer. GNCs were synthesized and functionalized with chitosan (CGNCs) and folate (FCGNCs) and bound to Fluc-mRNA at varying concentrations. All GNCs and mRNA-nanocomplexes were chemically and physically characterized and evaluated for their compaction and protection abilities using gel and fluorescence-based assays. The HEK293 (embryonic kidney) and MCF-7 (breast adenocarcinoma) cell lines were used to determine the cytotoxicity and transfection efficiency of the nanocomplexes. UV-visible spectroscopy, Fourier-transform infrared spectroscopy (FTIR), nanoparticle tracking analysis (NTA), and transmission electron microscopy (TEM) confirmed favourable synthesis, functionalization, colloidal stability, ultrasmall size, and spherical shape of the GNCs. RNA binding studies indicated that Fluc-mRNA was successfully bound, compacted, and protected by the functionalized GNCs. Cytotoxicity studies revealed that functionalized GNCs and their corresponding nanocomplexes were well tolerated in both cell lines with cell proliferation observed in the HEK293 cells. In both cell lines, the FCGNCs showed higher transgene activity than the non-targeted CGNCs. However, transfection by FCGNCs was considerably greater in the MCF-7 cells than in the HEK293 cells, confirming enhanced cellular uptake by the folate-receptor-positive MCF-7 cells. Overall, these GNCs successfully complexed, protected, and delivered mRNA to breast cancer cells with low cytotoxic effects. Thus, they hold immense promise in mRNA-based therapies for breast cancer but require further investigation and development for future use *in vivo* and clinical studies.

SLS-F-28

GREEN SYNTHESIS OF METALLIC NANOPARTICLES FROM PLANT EXTRACTS FOR BIOTECHNOLOGICAL APPLICATIONS

Dineo Okuhle Tokota

220017130@stu.ukzn.ac.za

Student Number: 220017130

School of Life Sciences

Supervised by Dr Karen Pillay and Dr Anushka Govindsamy

Extensive research has been done on metallic nanoparticles. The conventional chemical and physical techniques of synthesis are disadvantageous as they promote energy consumption, discharge of pollutant chemicals, toxic intermediates and waste. A more all-round sustainable alternative has been green biogenic synthesis mediated by bacteria, fungi, algae and plants for their natural stabilising agents.

The textile industry has been identified as a majority contributor to environmental pollution, with the discharge of toxic chemicals and dyes used in manufacturing. Simultaneously, the misuse of conventional antibacterial, antifungal, and antiviral agents has led to the increased threat of antimicrobial resistance crisis.

This has necessitated a dual solution to these global public health and environmental challenges. In response, the main aim of this study has been to investigate the green synthesis of metallic nanoparticles using plant extracts from local ethnomedical species such as *Siphonochilus aethiopicus*, *Aloe africana*, and *A. ferox* for various biotechnological applications.

The methodology involves screening the different plant species for their efficiency in synthesising metallic particles. Techniques used in this study include UV-Vis spectroscopy to confirm nanoparticle synthesis; High Resolution Scanning Electron Microscopy for characterisation of the nanoparticle's surface morphology, Transmission Electron Microscopy to establish size and shape of the nanoparticles Energy Dispersive X-ray Spectroscopy for elemental composition determination; and Dynamic Light Scattering for zeta potential and hydrodynamic size determination.

The preliminary results suggest that the plant extracts exhibit high efficiency in producing stable metallic nanoparticles with monodispersed shapes. Ongoing experiments are investigating the biotechnological potential, particularly in the context of antimicrobial activity and environmental bioremediation. The anticipated results of this research have the potential to contribute green synthesised metallic nanoparticles with great capability for application in the field of biotechnology.

SLS-F-29

Nutritional composition of thin porridge and crumbed pap (Uphuthu) fortified with edible insects

Sindiswa Zondo

216027208@stu.ukzn.ac.za

Student Number: 216027208

School of Life Sciences

Supervised by Dr Zabentungwa Hlongwane, Dr Caswell Munyai, Prof Muthulisi Siwela, Prof Rob Slotow

World's population is expected to increase to at least 9 billion by the year 2025 [2]. Currently, we are facing issues such as malnutrition, food insecurity, and global warming, so the increase in population will emphasize these already existing crises [1]. Livestock farming is associated with land degradation, water and land pollution and they emit prominent levels of greenhouse gases such as methane, which contribute to global warming. Edible insects have been recommended and promoted by the food and Agriculture Organisation (FAO) as sustainable, environmentally friendly protein alternative and food sources, which can assure food security [2]. Edible insects rearing requires minimal land and produces fewer greenhouse gases compared to traditional protein sources, hence they qualify as alternative protein sources [3]. The use of edible insects as the main protein source will reduce the scale at which global warming is escalating [2].

This study is aimed to evaluate the effect of enriching common food products with edible insect meal on the nutritional composition, and consumer acceptability.

The uphuthu and thin porridge was prepared according to [4] recipes. Edible insects (Mopane worm, Gynanisa caterpillar and Termites) were incorporated at 0% (control), 5% and 10% into thin porridge and crumbed pap (Uphuthu). Two-way multivariate ANOVA was used to analyse the data and a nested design was used to test the effect of incorporation rate within edible insects.

The incorporation of edible insects into thin porridge and Uphuthu significantly increased their nutritional composition. The protein concentration increased to the increase in edible insects' incorporation of 0%,5% and 10%, the greatest increase was observed for termites incorporated food products 2.00, 20.67 and 39.67%, respectively. Gynanisa 5% (Uphuthu) had the lowest protein content 9.00%. Zinc and iron concentration increased with the incorporation of edible insects. The highest zinc concentration was reported for termites (10%) 35,33%. Where on the other hand the highest iron concentration was reported for Gynanisa (10%) 35.33%. Edible insects are the future to end malnutrition and it related diseases. Using staple food to reintroduce edible insects may increase consumer acceptability.

Keywords: edible insects, global warming, nutritional composition, protein, malnutrition, food insecurity, entomophagy, sustainability

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ABSTRACTS

INDUSTRY SESSION: UMNGENI-UTHUKELA CHAIR IN WATER RESOURCES RESEARCH AND INNOVATION

ENHANCING FLOOD RISK ASSESSMENT THROUGH MULTIVARIATE FREQUENCY ANALYSIS: A SOUTH AFRICAN PERSPECTIVE

Sandile Sifiso Dladla

215035978@stu.ukzn.ac.za

Student Number: 215035978

School of Engineering

Supervised by Prof J.C. Smithers, Prof O.J. Gericke, Prof T.R. Kjeldsen and Dr U. Maharaj

Accurate flood estimates for high return periods are crucial for designing and managing hydraulic structures like dams. Traditionally, these estimates rely on univariate flood frequency analyses, focusing on peak flows. However, floods are inherently multivariate, necessitating the consideration of multiple characteristics, such as flood peak, volume, and duration, for a comprehensive analysis. Standard bivariate distributions have been used to model the correlation between variables like peak and volume. Still, they are limited by requiring the same type of marginal distribution and assuming a linear dependence relationship. Recently, copulas have emerged as a superior method in hydrology, overcoming the limitations of traditional approaches by capturing the dependence structure of variables and facilitating the estimation of multivariate return periods and quantiles. This study addresses the need to move beyond the univariate design flood estimation commonly used in South Africa, where the focus has been almost exclusively on flood peaks. It also challenges the traditional design event approach, which does not adequately reflect real-world variability between peak flows and runoff volumes. The motivation for this research lies in updating traditional methods to develop a joint distribution function for flood variables using multivariate frequency analysis. Literature highlights the efficacy of copulas, particularly the Gumbel-Hougaard copula, in modelling the correlation between flood peaks and volumes, thus addressing the shortcomings of traditional methods. While promising, challenges remain in selecting appropriate copulas and quantile combinations for deriving Design Flood Hydrographs (DFH). This study proposes a joint distribution function to enhance the accuracy of flood risk assessments in South Africa. This approach aims to improve conditional probability and return period estimation for various flood scenarios by developing bivariate distributions for peak-volume, volume-duration, and peak-duration combinations.

DETECTING TRENDS IN RAINFALL AND FLOOD EXTREMES AND NON-STATIONARY DESIGN FLOOD ESTIMATION IN KWAZULU-NATAL

Demian Mukansi

215064982@stu.ukzn.ac.za

Student Number: 215064982

School of Engineering

Supervised by Prof J. Smithers, Dr K Johnson, Dr T. Kjeldsen, and Dr M. Mutema

The current methods and models used to estimate design rainfall and flood in South Africa assume that data and hydrological processes are stationary. However, the reported increase in the occurrence of extreme rainfalls leading to catastrophic flood events has raised the question of whether changes in the magnitude and frequency of observed extreme rainfall events are already evident in South Africa. Therefore, a method to account for non-stationary models in extreme design rainfall and flood estimates in South Africa needs to be developed.

In terms of rainfall data analyses undertaken in this study, the peak-over threshold approach was used to extract daily rainfall exceeding the 90^{th}, 95^{th}, 99^{th}, and 100^{th} percentile from 26 observational stations in KwaZulu-Natal, located along the east coast of South Africa. The existence of temporal trends in the data series were investigated using the non-parametric Man-Kendall tests. The results indicate weak evidence that the daily rainfalls have increased in magnitude and frequency over time. The trends detected in the magnitude of the extracted daily rainfall varied across the sites, with approximately 23 % of sites showing a positive trend, only one of which showed a significant increasing trend in magnitude. The results of trends in the frequency of occurrence of extreme rainfall showed that approximately 27 % of the sites showed a positive trend, of which only one station showed a significant increase in the frequency of occurrence of extreme rainfall.

Regarding flood data analyses undertaken in this study, the annual maximum streamflow from 14 stations in KwaZulu-Natal, along the East Coast of South Africa, were analysed. The Man-Kendall trends were investigated, and the results indicate that the annual maximum streamflow has decreased in magnitude in approximately 79 % of the stations. Extreme value analysis was performed using stationary and non-stationary models with time and rainfall as covariates. Where possible, streamflow stations were linked with rainfall stations to determine the impact of rainfall on annual maximum streamflow. The results indicate that the non-stationary model incorporating observed rainfall as a covariate performed better than the stationary and non-stationary models with only time as a covariate.

Modelling, assessment and optimisation of rules for selected Umgeni water distribution systems

Mnguni Khanyisile

216009423@stu.ukzn.ac.za

Student Number: 216009423

School of Engineering

Supervised by Prof M. Kumarasamy and Prof J.C. Smithers

uMngeni-uThukela Water is a water board that supplies most parts of KwaZulu Natal with bulk portable water. Currently uMngeni-uThukela Water is running their distribution system based on required reservoir levels and demands and does not consider the energy cost at different times of the day, number of pump switches and background leakages. Including these constraints can reduce operational cost, energy usage, leakages and increase performance. Optimising pump schedules can reduce energy usage and costs while adhering to hydraulic and operational constraints. Based on studies reported in the literature, introducing pump scheduling optimisation can reduce energy usage by approximately 30% without any change in infrastructure. Including tariff structures in an optimisation problem can reduce pumping costs by 15%, while including leakages decrease cost by 10% and pressure drop in the system can be up to 12 m.

The pumping scheduling optimisation problems are NP hard, making them hard problems to solve using linear optimisation algorithms. Genetical optimisation algorithms are widely used due to their ability to solve nonlinear, non-convex and mixed integer problems. Umgeni Water has installed an online hydraulic software, WaterNet Advisor, that allows running different operational scenarios prior to implementation to optimise the distribution system. This study will investigate different operating scenarios constrained by energy tariff, water levels and maximum pressure. The scenarios will be implemented using a EPANET-MATLAB and optimisation done using non-sorting genetic algorithm using MATLAB. The developed optimisation will be testes using a theoretical water distribution, Richmond Network and real-world water distribution system. The objective of the study is to reduce energy usage, operational cost, and leakages and the feasibility of optimal solution will be checked using the Waternet Advisor.

Coupling Hydrologic and Hydraulic Modelling to Enhance Predictive Accuracy of Umgeni River Flood Forecasting

Glen Mkhonta

219091736@stu.ukzn.ac.za

Student Number: 219091736

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Daniel Kibirige and Dr Shaeden Gokool

Flood forecasting is one the crucial parts of disaster management, it attempts to predict the occurrence, timing, and magnitude. It involves the coupling of hydrologic and hydraulic models for flood prediction. This paper examines the evolution of the hydrologic and hydraulic models involved in coupling for flood forecasting over three time periods; pre-2000s, 2000 – 2010, and post-2010. Again, the study aimed to provide insights to model selection based on existing combinations of models coupled for flood forecasting. The scoping literature review (SLR) was carried out through a standardised procedure known as Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The SLR was conducted using the electronic databases Scopus and Web of Science (WoS) for three time periods; pre-2000s, 2000 – 2010, and post-2010. The results of the SLR found that pre-2000s simple models such as the XSRAIN, OMEGA, ARNO, HEC-2 were used. Between 2000 and 2010, models a bit more sophisticated were used such as the TOPMODEL, MARINE, IMECH-1D, CARIMA. Post-2010, a combination of complex, physically-based models that incorporate various hydrological processes and land-use changes, and sophisticated two-dimensional capable of accurately simulating floodplain dynamics and urban flooding scenarios, were found. Additionally, the study found that the most common combination overall is HEC-HMS and HEC-RAS due to its free availability and accurate and reliable flood forecasts. The study highlighted the key advancements in technology as the major driver of the evolution of model coupling techniques, including the use of data assimilation, machine learning, and real-time forecasting systems. Moreover, it identifies challenges and gaps in current coupling practices, such as the need for high-quality input data, computational efficiency, and the integration of climate change projections. Finally, the study recommended scientists a comparative analysis of the performance of the coupled models against the stand-alone models coupled for flood forecasting be carried out to provide insights on which models are more accurate, fully coupled models or loosely coupled models.

An Assessment of Radon (222Rn) Level in Aquifers Along the Umgeni Catchment: Health And Geohydrological Significance

Thobani Ngwazi

217043646@stu.ukzn.ac.za

Student Number: 217043646

School of Agricultural, Earth and Environmental Sciences

Supervised by Prof Seifu Kebede Gurmessa

This research aims primarily to reveal the levels of Radon (222Rn) in aquifers that stretch along the Umgeni catchment, concerning health implications and environmental implications associated with groundwater. 222Rn, a gas produced by the process of uranium-238 decay that is naturally occurring and mainly found in groundwater, can inflate health risks if inhaled or ingested from water resources. This research centres around collecting well water samples from various depths and locations in the catchment area of the Umgeni River and analyzing the sample for 222Rn concentrations and hydrochemical data using liquid scintillation or gamma spectroscopy. Geohydrological significance will be carried out by correlating the 222Rn levels with groundwater flow, recharge rate, and aquifer properties. The investigation of radon movement and chemical species in groundwater systems will be conducted to address protective strategies and control its health implications. The project is arranged with a detailed plan of study that is supported by the necessary equipment and resources. Besides that, there will be precautionary measures that will be taken for the health, safety, environmental, ethical, and intellectual property issues. This study will contribute to the understanding of the presence of 222Rn in the groundwater, thereby supporting its effective management within the Umgeni Catchment.

DEVELOPING AN INDICATOR SYSTEM TO ASSESS WATER EQUITY IN SOUTH AFRICA: A DELPHI CONSENSUS

Carla Higgs

962079479@stu.ukzn.ac.za

Student Number: 962079479

School of Agricultural, Earth and Environmental Sciences

Supervised by Prof Trever Hill and Prof Richard Meissner

Equality and equity are cornerstone principles of global, and priority objectives of South African water policy. However, significant inequalities and inequities in access to water and participation in water resources management persist worldwide. Until recently, the concept of 'equity' has been ill-defined in water resources management, with a notable absence of mechanisms for monitoring it. Despite its global uptake, water equity has not been effectively operationalised in water policy. Achieving the priority goal of equity in water resources management requires a clear definition and practical means for its implementation and monitoring.

Using the Delphi Method, this research translates this complex, multifaceted concept into measurable units. The primary aim of the method was to translate the researcher's definition of 'water equity' into criteria and indicators for monitoring water equity within defined geographical space. A review of the literature resulted in the author developing a definition of the concept and broke the concept down into measurable elements. A total of 28 subject matter experts across numerous relevant disciplines comprised the Delphi panel. A two round Delphi was conducted, that yielded priority elements that could be translated into water equity criteria and indicators. The Delphi also yielded and unexpected, and rich commentary that was considered in the development of a total of 11 water equity indicators: five human rights, three procedural and three distributive equity indicators. These indicators are the first attempt to bridge the gap between theory and practice, are the first to translate the theoretical concept into measurable units.

The application of the indicators is intended to aid the South African government, who are the custodians of water governance, management, and decisions, in assessing and achieving water equity. They call attention to activities that contribute to, or hinder equity. This will, in turn, aid in decision making, facilitating decisions that promote equity. Further significance of the research is that the research method can be applied in other countries to develop context-specific water equity indicators, offering a framework for operationalising and monitoring water equity globally.

AN EVALUATION OF THE STATE OF CITIZEN SCIENCE FOR WATER QUALITY MONITORING

Tanisha Curtis

217007840@stu.ukzn.ac.za

Student Number: 217007840

School of Agricultural, Earth and Environmental Sciences

Supervised by Dr Mark Graham, Dr Simphiwe Ngcobo, and Dr Jim Taylor

South Africa is facing water security issues including threats to the conditions of water quality in river systems. River health is paramount in sustaining healthy riparian zones and aquatic biodiversity. Citizen science (CS) techniques allow for accessible and understandable methods to equip anyone to be able to monitor the condition of their local river systems. CS involves citizens from various backgrounds addressing a water quality issue through accessible techniques which are based on scientific methods to monitor, evaluate and/or address the issue. These techniques range from being completely designed and led by professionals with limited input from the broader society, to being completely designed and led by citizens with the exclusion of the scientific community. This research proposes that collaboration across sectors and experience is vital to encourage a co-ordinated and sustainable CS for water quality monitoring network.

Simplified river health assessments through the observations of macroinvertebrates through the mini–Stream Assessment Scoring System (miniSASS), the determination of the turbidity levels of a stream, and the determination of the levels of certain chemicals present in a water body, are all CS indicators of the state of a river system. These are a few techniques which are explored, applied, and evaluated in this research. Data collected through CS techniques will be collated into a report detailing the condition of rivers across South Africa in the *2024 Citizen Science State of Rivers Report*. The aim of this report is to empower water users – ranging from research and corporate businesses to local farming communities and school children – to link their actions to the environment through first-hand monitoring and impact evaluation. The intention is to develop a greater sense of agency and responsibility toward the environment, and to have the ability to instantaneously possess scientifically-sound data to justify their concerns, practices, and actions. These citizens will contribute to the state of local rivers which is being reported on and fed back to communities across the region.

Apart from the local societal benefits of CS practices, the data generated through these networks can be used to increase the spatial-temporal frequencies of national-scale reporting on the local rivers of South Africa. Biological monitoring and CS techniques are also considered Level 2 monitoring parameters for the Sustainable Development Goal (SDG) 6.3.2 which evaluates the proportion of bodies of water with good ambient water quality. This can contribute to the monitoring and reporting by the Department of Statistics of South Africa (Stats SA) in SDG country reports, detailing South Africa's progress towards achieving SDG 6.3.2.

Water governance in uMsunduzi Catchment: politics and construction of socio-economic and environmental values

Susan Risko

217081425@stu.ukzn.ac.za

Student Number: 217081425

School of Built Environment and Development Studies

Supervised by Prof C. Sutherland and Dr S. Stuart-Hill

Despite its significance, both politically and economically, the Msunduzi River which flows through the heart of Pietermaritzburg, the provincial capital of KwaZulu-Natal, South Africa, falls victim to extreme pollution levels. This poses serious health risks to society, affecting overall wellbeing, and further limiting an already stressed supply. The purpose of this research project was to study the politics of water governance for the uMsunduzi River catchment, constructing its socio-economic and environmental value. The researcher aimed to answer the question, who are the main actors (institutions, rules, laws, and organisations) involved in water governance in the uMsunduzi

Catchment? This includes determining the dominant discourses of and the relations between stakeholders. Objectives for the study include: summarise the historical background of the uMsunduzi River from a socio-economic and environmental perspective; contextualise the legislation and institutions involved in water governance that have direct and indirect impacts upon the uMsunduzi River; and review the cultural significance of the uMsunduzi River based on existing literature. Within the social constructivist and transformative paradigms stakeholders and relations were determined through the review of archival material, government documents, academic literature, and popular articles. Nvivo 11 Plus Software was utilized to perform discourse analysis, content analysis and stakeholder mapping. From a postpositivist paradigm approach, Geographic Information Software (GIS) shapefiles containing land ownership spatial data from Msunduzi Municipality were analysed. This study aims to identify gaps and potential water governance opportunities that promote equity and social justice.

Experimental validation of a settling velocity model using post-image analysis

Nkosinathi Emmanuel Madlala

212518283@stu.ukzn.ac.za

Student Number:212518283

School of Engineering

Supervised by Prof David Lokhat

Estimating the average settling velocity of sediments is imperative in both environmental and technological science. A better understanding of sedimentation processes enhances the outstanding development of numerical models. Flocs engineered during sedimentation/aggregation comprise clay, finer silt, and organic matter. Four different treatments were used originating from two categories, homogenous and heterogenous mixtures from two different leguminous seeds namely Glycine and Cicer. The kaolin powder used at a 200 NTU, yields flocs of 2 μm to 2.5 μm on average experimental from heterogenous and homogenous mixture suspension at 0.89 mPa.s average viscosity. Flocs characteristics such as floc diameter, porosity, and shape (fractal dimension) were quantified experimentally using a Charge Couple Device (CCD) camera. Physical characteristics (characterization) of flocs that determine settling velocity reveal no significant difference from CCD camera measurement in post-image analysis. The average settling velocity for Glycine, Cicer homogenous and heterogenous mixture are 0.1 m/s, 0.5 m/s and 0.3 m/s, 0.8 m/s respectively. The study seeks to validate the use of CCD in situ technique and model developed for estimating the settling velocity.

Standardised Methods for Analysing Emerging Contaminants in Wastewater to Enhance Water Quality Management

Numeerah Ally

218033284@stu.ukzn.ac.za

Student Number:218033284

School of Chemistry and Physics

Supervised by Dr. Bhekumuzi Gumbi and Dr. Samuel Getahun

Given historical water resource development and the impending scarcity, there is a shift towards a new water management paradigm due to the social, economic, and environmental impacts, as well as the risk from contaminants of emerging concern (CEC) in direct and indirect water reuse. The main hurdle in this field is the lack of standardised procedures for detecting and quantifying CECs. Therefore, implementing regulations for this sector is equally crucial as its development. Emerging contaminants (ECs), including pharmaceuticals, personal care products, endocrine-disrupting compounds, and industrial chemicals, pose significant risks to human health and the environment because of their persistent nature and resistance to conventional treatment processes. In KwaZulu-Natal, South Africa, these contaminants present a complex challenge because of the region's diverse industrial activities and socio-economic

conditions. Consequently, there is a critical need for standardised methods to analyse these contaminants and enhance water quality management in the province.

Conventional wastewater treatment methods such as activated sludge, sedimentation, and disinfection are inadequate for removing ECs because of their unique physicochemical properties. This inadequacy underscores the importance of advanced analytical techniques for EC multicomponent detection and quantification in complex media. The current research focuses on liquid chromatography-tandem mass spectrometry (LC-MS/MS), gas chromatography-mass spectrometry (GC-MS), and high-performance liquid chromatography (HPLC). These techniques are essential for identifying ECs at trace levels and offer the high sensitivity and specificity required for effective analysis.

In KwaZulu-Natal, collaboration between academic institutions, government agencies, and industry stakeholders is crucial for the analysis and management of ECs. These collaborative initiatives have led to significant progress in monitoring and managing these contaminants, enabling more targeted interventions and informed policymaking. Effective water quality management in the province relies on establishing standardised methods for analysing ECs in wastewater. Such methods provide reliable, consistent data essential for making informed decisions, implementing proactive management strategies, and ensuring sustainable use of water resources. By addressing the challenges of ECs through standardised analytical techniques, KwaZulu-Natal can better protect public health and the environment and cultivate a more sustainable future for its water resources.

Removal of sulfamethoxazole from aqueous solutions by adsorption onto biochar/graphene oxide composites

Oyeladun Rhoda Adegoke

220082237@stu.ukzn.ac.za

Student Number: 220082237

School of Chemistry and Physics

Supervised by Prof Bice S. Martincigh and Prof Vincent O. Nyamori

The presence of antibiotics as emerging pollutants is a worldwide pressing issue because it can lead to antibiotic-resistant genes, which can potentially create superbugs. Existing wastewater treatment technologies are inadequate in effectively eliminating antibiotics from sewage effluent, thereby necessitating the development of innovative and affordable technologies. Adsorptive materials have been widely employed to treat, restore, and eliminate harmful inorganic and organic substances. This work examines the effectiveness of a novel biochar/graphene oxide composite as a low-cost adsorbent for the removal of sulfamethoxazole (SMX) from aqueous solutions. The biochar was obtained from pyrolysis of pine pallets (BCH1) and exotic plant material (BCH2). These two biochars were studied together with graphene oxide (GO) and their composites (BCH1/GO and BCH2/GO). The adsorption isotherms, kinetics, and thermodynamic studies for removing SMX from aqueous solution with these BCH/GO composites were evaluated. The degree of adsorption was monitored as a function of solution pH, adsorbent mass, contact time, initial adsorbate concentration, and solution temperature. The adsorption of SMX onto the BCH/GO composites was conducted at an optimum pH of 2 under a constant temperature of 25 °C. BCH1, BCH2, GO, BCH1/GO, and BCH2/GO had maximum removal percentages for SMX of 66.82, 56.80, 57.11, 70.23, and 80.85 %, respectively. Four kinetics models, including the pseudo-first order, pseudo-second order, Elovich, and intraparticle diffusion models, were employed to evaluate the sorption kinetics of SMX onto the BCH/GO composites and to identify the possible rate-determining step. The kinetics data generated for the adsorption of SMX onto the BCH/GO composites was best described by the pseudo-second-order model, indicating that this was a bimolecular process. The equilibrium data obtained were fitted into eight isotherm models: Freundlich, Langmuir, Temkin, Redlich-Peterson, Dubinin–Radushkevick, Sips, Toth, and Khan, and the best-fit model for each adsorbent was selected based on the model with the lowest sum of squared residuals (SSR). The Freundlich isotherm best described the removal of SMX from the aqueous medium onto BCH/GO composites indicating a heterogeneous surface. It was concluded that the BCH/GO composites can be used as effective and low-cost adsorbents for removing SMX from aqueous solution, although out of all the materials studied, the composite formed with biochar from exotic plants, BCH2/GO, performs best.

EVALUATION OF BIOCHAR AND ACTIVATED CARBON PRODUCED FROM DIFFERENT FEEDSTOCK FOR USE AS AN ADSORBENT

Relebogile Morake

216005246@stu.ukzn.ac.za

Student Number:216005246

School of Engineering

Supervised by Dr Santiago Septien Stringel

Water contamination caused by compounds of emerging concern(CECs), primarily pharmaceuticals, hinders water reuse in South Africa [1]. Conventional wastewater treatment technologies are unable to completely remove these contaminates, leading to detrimental environmental impacts and posing a risk to human health and aquatic ecosystems [2]. This has led to a recent increase in the discovery and development of inexpensive materials for the removal of pharmaceuticals in wastewater treatment. This study attempts to assess several forms of biochar and activated carbon made from various feedstocks for use as an adsorbent for the removal of pharmaceuticals in wastewater treatment facilities.

The biochar was generated from three renewable feedstock (black wattle, eucalyptus and horse manure) through the process of pyrolysis at 350 °C and 700 °C. Subsequent chemical activation was performed using potassium hydroxide(KOH) and phosphoric acid(H_3PO_4). Adsorption tests using tartrazine dye as a proxy were carried out to determine the effect of initial concentration on the adsorption process. To understand the physiochemical composition of the biochar and activated carbons, the materials were characterized by Brunauer-Emmet-Teller surface area analysis (BET), scanning electron microscopy (SEM), and thermogravimetric analysis (TGA).

High surface area of 383,477 m^2/g, 400 m^2/g, 396,0873 m^2/g was observed for BW-700-KOH, E-700-KOH and HM-700-KOH respectively. A high adsorption capacity of 93 m^2/g was achieved by BW-700- H_3PO_4. Adsorption experiments indicated that biochar and activated carbon may be used as sustainable material for removing tartrazine dye from water.

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TESTING OF A PILOT SCALE SCREW CONVEYOR SOLAR SLUDGE DRIER

Akhil Ramlucken

217007409@stu.ukzn.ac.za

Student Number: 217007409

School of Engineering

Supervised by Dr Santiago Septien

The right to sanitation and clean water is one of the basic human rights which we are all entitled to, however worldwide there are in excess of two billion people who have no access to proper sanitation. The situation is dire in Southern Africa, where there are in excess of 90 million people who are living without access to proper sanitation and are forced to utilise solutions such as open defecation. A lack of sanitation can be linked to many diseases such as typhoid and cholera from the sludge contaminating either food or water sources within the community. A solution for the treatment of this faecal sludge is that of thermal drying, however this method is very costly, both in terms of the equipment, and the energy required. This is not feasible as the cost of energy will result in the device being far too expensive for rural communities to operate. For these reasons, a purely solar thermal solution is very attractive, as a solar solution could

easily reach the required high temperatures for the drying and treatment of sludge, while using a renewable and free energy source.

This project details the testing of a device which may be utilised by a faecal sludge treatment plant. This device utilizes a unique screw conveyor based drying chamber, which allows for both conveyance of the feedstock as well as agitation during the drying process. The screw conveyor drying chamber is mated to a solar collector and dehumidifier, which preheats and dries the incoming airstream prior to being fed into the drying chamber. The drying chamber includes transparent walls, for ingress of sunlight. The testing of the device has a few main objectives, namely finding the optimum conditions of operation for the device and assessing the feasibility of the dryer as a concept based on the drying performance during the tests performed. The testing took place in 4 main phases, firstly the compatibility testing, which consisted of setting up the individual subsystems, and checking how well these worked by themselves, and with each other, culminating in a dry run test, in which the whole device was assembled and run with no feedstock in the drying chamber to ascertain how well the components functioned together. Next a preliminary drying test using wetted soil, and lastly a round of final tests with synthetic faecal sludge.

The main tests utilise synthetic sludge, which starts with a moisture content of 80%. These tests are conducted to find ideal settings for the most drying performance. Tests conducted so far have been able to reduce moisture down to 50% within a 4-hour drying time, this test had sustained temperatures of ~47C, and humidity of ~30%, from ambient conditions of ~30C and ~70% humidity. This data shows an effective device, as the moisture liberated during this test is mostly bound within the synthetic sludge, and not free moisture.

The project posits the use of a novel screw conveyor based solar thermal system. The data collected is promising for a first iteration of such a device, with a large amount of moisture liberated from a synthetic sludge within a very small drying time for a solar thermal based dryer. More testing is required to determine the true drying potential, but current data shows that the device has potential to be a solution to the lack of sanitation in South Africa.

Development of a Urine Evaporator for Innovative Non-Sewered Sanitation Systems

Kirthi Rampersad

217016379@stu.ukzn.ac.za

Student Number: 217016379

School of Engineering

Supervised by Dr Santiago Septien Stringel and Dr Jonathan Pocock

Urine found in domestic wastewater contributes 80% N, 56% P, and 63%K of the total N, P, and K content in wastewater. Dehydration of urine via evaporation is a vital process to remove the water content and repurpose the concentrated urine solution as a fertiliser. The evaporation process is energy intensive due to the high latent heat of vaporization of water. A conventional evaporator for urine dehydration will impose high running costs, maintenance complexities, and extensive electricity/fuel consumption. Therefore, the characteristics of urine must be understood to design an efficient and cost-effective urine evaporator. Little research has been reported on the physical properties of dehydrated urine, particularly the properties associated with evaporation – which influence evaporator design and operation.

The aim of this research is to develop a cost-effective urine evaporator for non-sewage sanitation systems. The physical properties associated with urine during its evaporation are measured to provide the parameters needed for calculation of the energy requirements to achieve evaporation and the properties of the concentrated urine, aiding the urine evaporator design.

The objectives of this work are to firstly to measure the physical properties of urine during its evaporation via laboratory experiments to provide the parameters aiding the urine evaporator design, and secondly, to build and test a urine evaporator.

Disrupting Bound Water in Faecal Sludge to Improve Water Removal Processes

Yashlen Pather

216041338@stu.ukzn.ac.za

Student Number: 216041338.

School of Engineering

Supervised by Dr Jonathan Pocock, Dr Santiago Septien Stringel and Dr Reneiloe Seodigeng

Faecal sludge (FS) solids are a valuable resource rich in nutrients and organics which could provide circular economic opportunities for local communities as a fertiliser or fuel. The high-water content of FS matrices remains a challenge in FS management systems. Although unbound water can be removed easily, water within the sludge that is bound physically, chemically, mechanically or intracellularly to the solid phase – termed bound water (BW), is a limiting factor in FS management systems due to the additional energy required for its release. Releasing BW influences the overall dewaterability of the sludge. Sludge is easier to dewater and dry and benefits from improved flowability and reduced stickiness. Transportation and treatment costs decrease significantly due to a decrease in volume. Additionally, pathogen inactivation occurs as the water content decreases due to a decrease in water activity [1], improving the overall health and safety within the waste management process (collection, transportation, treatment and disposal). There is a need to improve BW removal processes in a sustainable, yet cost effective, manner. This project continues with lab-scale experimentation following a literature review in which a number of promising treatments were determined, and the key BW disruption mechanisms found were extracellular polymeric substance (EPS) degradation [2], and cell lysis [3]. Selected treatments include Microwave (MW) radiation, Lime treatment, Enzyme treatment, Cyclic freeze-thawing and mechanical shearing. These are benchmarked at lab-scale against key performance indicators in dewatering, drying and rheology. The experiments at the WASH R&D Centre (University of KwaZulu-Natal) are conducted with faecal sludge collected from onsite sanitation facilities, which included Ventilated Improved Pit (VIP) latrines, Urine Diverting Dry Toilets (UDDT) and Septic Tanks (ST) located in the eThekwini Municipality (Durban, South Africa), as well as fresh faeces supplied by donors at the University of KwaZulu-Natal. Initial experimentation has begun and will utilise treatments and conditions applied to other sludges from literature. Extensive testing on the most promising treatments will be conducted to determine the optimum conditions for the South African sanitation landscape.

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