Program and Book of Abstracts

RESEARCH WEEK
— 2023 —

THEME: "Harnessing Research for Resilience and Sustainability of Community"

UNIVERSITY OF NAIROBI

23-27 OCTOBER 2023

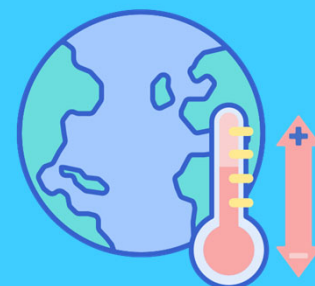University of Nairobi

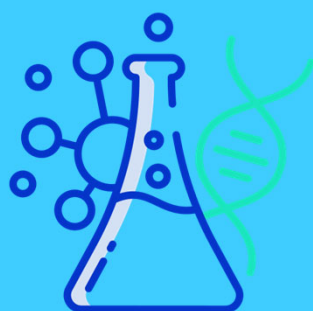www.researchweek.uonbi.ac.ke

**6th Annual Conference
of the Faculty of Science and Technology
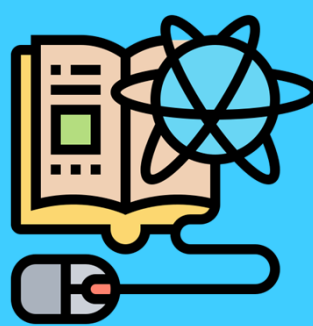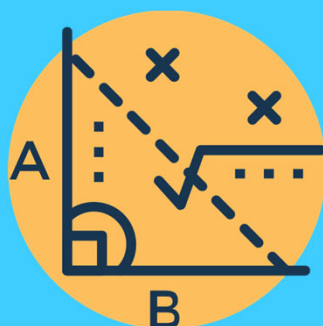University of Nairobi, Nairobi, Kenya**

25 – 27 October 2023   Virtual

"Harnessing Science and Technology for Resilience and Sustainability of Communities"

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Foreword

The national, regional and international experiences of the recent past including the pandemic and economic woes afflicting humanity necessities the need for research to urgently contribute to societal resilience and sustainability of all spheres which support welfare and ensure a brighter future. Measurable socio-economic development and attainment of SDGs remains an elusive dream until new knowledge translates into resilient socio-economic welfare support systems. We must learn how to do things much better, to thrive and increase our safety nets during good times and able to sail through difficulties of the future.

There are many recent experiences pointing to us that we must make a paradigm shift to sail through challenges. We need to appraise how our utilization science and research outputs may guide in the application of knowledge for resilience and sustainability. Are we upholding good scientific disciplines, for example scientific leadership, championing innovativeness in research, applicability and working towards legacy to the benefit of present and future generations? Addressing these issues will be the core focus of the papers during the 6th Annual Conference of the Faculty of Science and Technology. The overall theme of the conference is "Harnessing Research for Resilience and Sustainability". The presentations will focus on the following subthemes:

1. **Science, Technology and Innovation in Industry for Sustainable Socio-Economic Transformation:**
   - Start-Ups, SMEs; MSMEs and Spin-offs
   - Science, technology and innovation for value addition and job creation
   - Natural and artificial raw materials in industry
   - Biotechnology and nanotechnology
   - Statistical Quality control and acceptance sampling in industry
   - Automation for improved industry
   - Alternative sources of energy for development
   - Science- Investment Partnerships for Training and Technology Transfer
   - Climate Change Mitigation and Environmental Conservation

2. **Accelerating Sustainable Universal Health Care through Advances in Scientific Research, Technology and Innovation:**
   - Water, Sanitation and Hygiene (WASH) technologies.
   - Emerging viral, bacterial and societal diseases
   - Improved diagnostic techniques
   - Actuarial models for health insurance
   - Models for disease prediction
   - Geo-environment and health
   - Advances in management and disposal of hazardous wastes

3. **Promoting Collaborative Scientific Research, Technology and Innovation for Sustainable Utilization of Natural Products:**
   - Advances in bio-materials for construction, fuel and biochemical production
   - Green-housing technologies

- ➢ Indigenous knowledge, Traditional Health systems and natural products
- ➢ Pharmacology and bio-prospecting
- ➢ Sustainable environmental resource utilization
- ➢ Biofuels and alternative energy sources versus food security
- ➢ Renewable energy sources
- ➢ Natural products in drug discovery
- ➢ Natural product chemistry - biology
- ➢ Patenting
- ➢ Climate change and natural product

4. Scientific Research, Technology and Innovations for Sustainable Food Production

- ➢ Insects for food and feed
- ➢ Microorganisms in food production enhancement
- ➢ Advances in crop protection
- ➢ Monitoring, Early Warning Systems for Agriculture and Livestock
- ➢ Genetically Modified Foods and Crops
- ➢ Water for Food Security
- ➢ Rocks for Crops
- ➢ Smart farming
- ➢ Alternative food sources for enhanced food security
- ➢ Climate Change and Smart Agriculture

5. Management of Emerging Calamities, Diseases and Pests

- ➢ Pest control - Locust, army worm, maize virus etc.
- ➢ Predicting and managing emerging and chronic calamities such as flooding and drought.
- ➢ Models for prediction of agricultural pest invasions.
- ➢ Control /management of emerging human diseases.

6. Research Outputs and Applications from the Basic Sciences and Practices

- ➢ Mathematics (Biostatistics, Algebraic Geometry, Actuarial Sciences, among others)
- ➢ Meteorology
- ➢ Geology
- ➢ Climate Change
- ➢ Chemistry
- ➢ Biology
- ➢ Computer Science
- ➢ Physics

Members of the Organizing Committee

Prof. Leonidah Kerubo, Dean, Faculty of Science and Technology

Prof. Francis Mulaa, Associate Dean, Faculty of Science and Technology

Dr. Solomon Derese, Convener and Chair

Dr. Joseph Mutemi, Co-Chair

Prof. Robinson Musembi, Member

Prof. Agnes Wausi, Member

Dr. Elisha Abade, Membe

Dr. Zephania Birech, Member

Dr. Geoffrey Okeng'o, Member

Dr. Evans Nyaboga, Member

Dr. Rosaline Macharia, Member

Dr. Aaron Waswa, Member

Dr. Samuel Kiboi, Member

Dr. Geoffrey Kirui, Member

Dr. Vincent Madadi, Member

Dr. Immaculate Michira, Member

Dr. Idah Orowe, Member

Dr. Timothy Kamanu, Member

Ms. Dorothy Iseu, (FST Committee Secretary)

Mr. Thomas Wanambisi (ICT Support)

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Program
Day 1: Wednesday 25ᵗʰ October 2023
Opening Ceremony

Chair: Prof. Catherine Lukhoba	
Time	**Speaker**
09:00 – 09:45	Dr. Solomon Derese, Faculty of Science and Technology RSW 2023 Chair
	Prof. Francis Mulaa, Associate Dean, Faculty of Science and Technology
	Prof. Leonidah Kerubo, Dean, Faculty of Science and Technology
	Prof. Justus M. Munyoki, Director of Research, University of Nairobi
	Prof. Margaret J. Hutchinson, Deputy Vice Chancellor (RIE), University of Nairobi
	Prof. Stephen Kiama, Vice Chancellor, University of Nairobi
	Prof. Ivivi J. Mwaniki, Vote of thanks
	Prof. Joseph N. Mutemi, FST RSW Co-Chair – Program Overview

Session 1
Session chair: Prof. Alfred Opere

09:45 - 10:05   **Short Lecture 1**
Mutemi, J. N.
Bridging the Gap between researchers and Service Agencies to Provide Climate Information to Accelerate Resilience Building for Sustainability

10:05 – 10:25   **Invited Lecture I**
Terrence Ross, William Adu-Krow and Reeta Gobin
Experiences of BSc Nursing students at the University of Guyana Berbice Campus during the transition from face-to-face to online learning (1st Cohort)

10:25 – 10:45   **Short Lecture 2**
Bessy Kathambi
Socio-Cultural Tenets in Water Governance Principles in Urban Development, Case of Nairobi, Kenya

10:45 – 11:05   **Short Lecture 3**
Jane Mutune, Thuy Pham, Dibo Duba , Peter Minang and Elma Odhimbo
Coordinated Efforts in Sustainable Forest Restoration in Nandi County

11:05– 11:20   **Student Presentation 1**
Felix M Wesonga, Frankline Opijah and Bethwel K Mutai
Influence of Weather Parameters on the Air Quality of Nairobi, Kenya

11:20 – 11:35   **Student Presentation 2**
Downing, Timothy A., Olago, Daniel O.; Nyumba, Tobias O.
Perceptions of Ecosystem Services and Climate Change in the Communities Surrounding Mt. Kenya and Mt. Elgon, Kenya

11:35 – 11:50   **Student Presentation 3**
Yimer Assefa, Franklin Opijah, Joseph Mutemi
Evaluation of the Skill of Seasonal Rainfall and Temperature Forecasts from Global Prediction Models Over Ethiopia

11:50 – 12:00   **Q and A**

Session 2a
Session chair: Prof. Francis Nyongesa

12:00 - 12:20   **Short Lecture 4**
Robinson Musembi and Mwende Mbilo
Ab-initio Computation of Structural, Elastic, Mechanical and Optical Properties of Cs2ScAgI6 Double Perovskite Semiconductor Compound for Photovoltaic Applications

12:20 – 12:40   **Short Lecture 5**
Sebastian Waita
Preliminary Study of the Solar Photovoltaic (PV) Potential at Selected Sites in University of Nairobi

12:40 – 12:55   **Student Presentation 4**
Dorothy Museo Mwanzia, Geoffrey. O. Okeng'o, Soumen Mondal,' Sneh Lata and John B. Awuor
Preliminary Study of Photometric Variable Stars in Open Cluster NGC1893

12:55 – 13:15   **Q and A**

Parallel Sessions: Session 2b (Physics) and Session 3 (Biology)

Session 2b Session chair: Prof. Francis Nyongesa

14:00 – 14:15	**Student Presentation 5** **Samo O. Charltone** and G. O. Okeng'o Is our Solar System Stable? Analysis of the Chaotic Motion of the Three Outermost Solar System Planets: Jupiter, Saturn, and Uranus
14:15 – 14:30	**Student Presentation 6** **Mutia M. Lilian,** Geoffrey O. Okeng'o and Andrew M. Kahonge Implementation of Quantum Key Distribution with an Eavesdropper via the Intercept-Resend Attack
14:30 – 14:45	**Student Presentation 7** **Mavyline K. Motari,** Geoffrey O. Okeng'o, Robinson N. Gathoni and Rana Liaqat Ali Precise Solar Declination Angle Determination for Maximized PV Solar Power Output
14:45 – 15:00	**Student Presentation 8** **Kaguamba Minjire Kaguamba,** Geoffrey. O. Okeng'o, John B. Awuor Astronomy and the Earth's Climate Change: Is there a link?
15:00 – 15:15	**Student Presentation 9** **M.O. Abdulmalik**, E. Danladi Doping Concentration and Defect Density Studies on Sodium-Zinc-Tribromide ($NaZnBr_3$) Based Perovskite Solar Cells Via Numerical Simulation
15:15 – 15:40	**Q and A**

Session 3 Session chair: Prof. Catherine Lukhoba

14:00 - 14:20	**Short Lecture 6** **Dickson L Omucheni,** Kenneth A Kaduki and Wolfgang R Mukabana Rapid and Non-destructive Identification of Anopheles gambiae and Anopheles arabiensis Mosquito Species Using Raman Spectroscopy
14:20 – 14:35	**Student Presentation 10** **Roselyne Nyawir Owino,** Edward K. Nguu, Evans N. Nyaboga Cultivable Endophytic Bacteria Associated with Cassava Microbiome as Potential Biocontrol Agents Against Crop Pathogenic Fungi
14:35 – 14:50	**Student Presentation 11** **Callen Nyang'ate Onura**, James Gordon James, Agnes Muthumbi, Virginia Wang'ondu Growth Performance, Nutrient Utilization, and Survival of African Catfish Fingerlings with *Spirulina platensis* and *Eisenia fetida* Nutritional Histories Fed on Raanan and Skretting in Grow-Out Tanks
14:50 – 15:20	**Keynote Address 1** Susan C. Alberts The medicine of life': How social life affects health and survival in wild primates
15:20 – 15:50	**Keynote Address 12** Peter V. Cornish The Role of MRNA Structure in Allosteric Control of Ribosomal Frameshifting

15:50 – 16:05	**Student Presentation 24**
	Benjamin O. Ouma, Kenneth Mburu, Edward Muge and Evans N. Nyaboga
	Genetic Diversity for Drought Tolerance in Pigeon Pea (Cajanus cajan) Landraces for Drought Tolerance and Possible Physiological and Biochemical Mechanisms Involved
16:05 – 16:40	**Q and A**

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Session chair: Prof. Robinson Musembi</td></tr>
<tr><td>15:40 - 15:55</td><td>**Student Presentation 12**
Mwende R. and Waita Sebastian
Effect of Solar Irradiance, Temperature and Relative Humidity on the Performance of a 1.5kW Photovoltaic (PV) System</td></tr>
<tr><td>15:55 – 16:10</td><td>**Student Presentation 13**
Lynet Allan, R.E Mapasha, Winfred M. Mulwa, Julius M. Mwabora, and Robinson J. Musembi
Exploring the Elastic, Electronic, Dynamical, and Optical properties of cubic ZrCoAs half – Heusler Semiconductor: An ab-initio Study</td></tr>
<tr><td>16:10 – 16:35</td><td>**Student Presentation 14**
Annah M. Ondieki, Zephania Birech, Kenneth A. Kaduki, Peter W. Mwangi
Surface-Enhanced Raman Spectroscopy (SERS) as a Label-Free Testosterone and Growth Hormone Assaying Method in Whole Blood</td></tr>
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Newton Odari and Geoffrey O. Okeng'o
The Time-Force</td></tr>
<tr><td>16:50 – 17:05</td><td>**Student Presentation 16**
Otieno Linda Akoth, Sylvester Abuodha, Siphila Mumenya, Muthomi Munyua
Influence of Corn Cob Ash-Silica Fume Blend on the Mechanical and Durability Properties of Concrete</td></tr>
<tr><td>17:05 – 17:20</td><td>**Student Presentation 23**
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Stars And Culture: Insights to the Motion and Life Cycle of Sirius A and Sirius B Stars Based on Kikuyu Semiotics and Philosophy</td></tr>
<tr><td>17:20 – 17:40</td><td>**Q and A**</td></tr>
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Day 2: Thursday 26th October 2023

Session 5
Session chair: Prof. John Onyari

08:30 - 09:00	**Keynote Address 2**
	Abiy Yenesew
	The Role of African Phytochemists Towards Utilization of Natural Products: Recent Examples
09:00 – 09:30	**Keynote Address 3**
	Josphat Matasyoh
	The Search for Bioactive Molecules for the Control of Human, Animal and Crop Disease Pathogens and Vectors
09:30 – 10:00	**Keynote Address 4**
	Heiko M. Möller
	Prospects and Challenges of the Utilization of Natural Products: The perspective of an Analytical Chemist
10:00 – 10:20	**Invited Lecture 2**
	H. Michael G. Lattorff , Solomon I. Chogo, Timothy M. Kegode, Geoffrey O. Bosire, John M. Onyari
	Chemistry of Beehive Products and Their Relation to Bee Health
10:20 – 10:50	**Short Lecture 7**
	Solomon Derese, Abiy Yenesew, Tsegaye Deyou, Martha Induli, Eluid Mushibe, Hoseah Akala, Matthias Heyendreich and Máté Erdélyi
	Antiplasmodial activity of structurally unique secondary metabolites from *Millettia usaramensis ssp. usaramensis* and *Derris trifoliata*
10:50 – 11:10	**Invited Lecture 3**
	Fozia A. Adem, Armelle T. Mbaveng, Victor Kuete, Matthias Heydenreich, Albert Ndakala, Beatrice Irungue, Abiy Yenesew, Thomas Efferth
	Cytotoxicity of isoflavones and biflavonoids from *Ormocarpum kirkii* towards multi-factorial drug resistant cancer
11:10 – 11:30	**Q and A**

Session 6
Session chair: Dr. Fredrick Oduor

11:30 – 11:50	**Short Lecture 8**
	Kithure Joyce G.N. , Ngai M.E.
	Determination of Essential Elements in Selected Nuts Produced in Kenya
11:50 – 12:10	**Short Lecture 9**
	Bridget K. Mutuma
	Hollow Nanostructures for Sensing of Environmental Pollutants
12:10 – 12:30	**Short Lecture 10**
	Veronica M. Muinde, John M. Onyari, Benson Wamalwa and John Wabomba
	Biosoption of Hazardous Malachite Green from Aqueous Solutions onto Chitosan-ZnO Composite: Kinetic and Equilibrium Modelling
12:30 – 12:45	**Student Presentation 17**
	Alice Ndekei, Muigai-Gitita, Njagi Njomo, Damaris Mbui
	Preparation and Characterization of Rice Husk Biochar as a Cost-Effective Adsorbent for Removal of Cadmiun Metal Ions from Aqueous Solution
13:00 – 13:15	**Q and A**

Session 7
Session chair: Prof. David Kariuki

14:00 - 14:30 **Keynote Address 5**
John Mack, Balaji Babu, Rodah Soy, Somila Dingiswayo, Temlandvo Magwaza, Mahlatse Ledwaba, Kristen Burgess, Kaisano Tauyakhale, Pertunia Macigane, Tebello Nyokong
Sn(IV) Chlorin and N-confused Porphrin Complexes as Photosensitizers for Photodynamic Anticancer and Antimicrobial Chemotherapy

14:30 – 14:50 **Invited Lecture 4**
Chetana Deoghare and Nikita Pandit
Indian Cow Urine: Future Antibiotic, Antifungal and Anthelmintic Agent

14:50 – 15:20 **Keynote Address 6**
A. Jean-Luc Ayitou
Molecular Engineering of Donor-Acceptor Dyads for Triplet-Triplet Annihilation-based Photoluminescence Upconversion

15:20 – 15:50 **Keynote Address 7**
Richard Anyah
Rethinking Climate Science Research: "Addressing Challenges and opportunities by Future Demands and Disruptors for Climate and Environmental Services."

15:50 – 16:10 **Q and A**

Session 8
Session chair: Dr. Damaris Mbui

16:10 - 16:40 **Keynote Address 8**
Duke Orata, Daniel Buttry, Dorcas Ngigi and Mukabi Marina
Surface Modified Electrode as a Central Tool in Electrochemical Characterization, Electro-Analysis and Electroenergy Production.

16:40 – 17:00 **Short Lecture 11**
Nguyen Tien Hoang, **Fredrick M. Mwazighe**
Preparation of a $Ti/SnO_2-Sb/La-\beta PbO_2$ electrode for the degradation of prednisolone, 8-hydroxyquinoline, methylene blue and p-nitrosodimethylaniline

17:00 – 17:15 **Student Presentation 18**
Lucia K Kiio, John O. Onyatta, Peter M. Ndangili, Florence Oloo, Carolina Santamaria, Luis M. Montuenga, Damaris N. Mbui
Fabrication of immunosensor for ultrasensitive multiplex detection of cancer biomarkers Carcinoembryonic Antigen (CEA) and YES1 based on electrode surface modification.

17:15 – 17:30 **Student Presentation 19**
Patrick Kinuthia, Solomon Derese, Edith Amuhaya, James Oyim, Margaret Murage and Albert Ndakala
Photosensitisers for Photodynamic Water Disinfection

17:30– 18:00 **Q and A**

Day 3: Friday 27ᵗʰ October 2023

Session 9: Training Session
Session chair: Dr. Solomon Derese

09:00 - 09:45	**Webinar I** **Joy Owango, TCC Africa** Scholarly Communication: Research Tools and Resources to Enhance the Research Life Cycle
09:45 – 10:00	**Q and A**
10:00 – 10:45	**Webinar II** Veresha Dukhi Navigating SciFinder-n for Scientific Discovery
10:45 – 11:00	**Q and A**

Session 10
Session chair: Prof. Andrew Kahonge/Prof. Stephen Luketero

11:00 - 11:30	**Keynote Speaker 10** **Joachim Posegga** and Henrich C. Pöhls Resilience in our Digital Society and the Disruptive Nature of Artificial Intelligence
11:30 – 11:50	**Short Lecture 12** **Evans Kirimi Miriti**, Andrew Mwaura Kahonge, Christopher Chepken Experience of Developing Applications on the Algorand Blockchain
11:50 – 12:05	**Student Presentation 20** **Malungu B. Charles** and Ruhiu N. Samuel Unlocking Mobile Health's Potential for Population-Wide Impact: Scaling Innovative Healthcare Delivery in Low-Resource Settings from Pilot Projects to Scalable Solutions.
12:05 – 12:20	**Student Presentation 21** Ndirangu Ngunjiri Technological Developments Influence the Cybercrime in Juja Sub-County
12:20 – 12:40	**Short Lecture 13** Peter N. Mecha Poisson-Lomax Distribution
12:40 – 13:00	**Short Lecture 14** **Daniel M. Mwanga,** Isaac K. Chumba, George O. Muhua, Damazo T. Kadengye, Charles R. Newton Predicting loss-to-follow-up in Nairobi urban informal settlements for a two-stage population-based epilepsy prevalence study using supervised machine learning
13:00 – 13:15	**Student Presentation 22** **Douglas Andabati Candia**, Patrick Guge Oloo Weke, Moses Mwangi Manene A Multi-Level Analysis of Help-Seeking Behaviour of Male Victims of Intimate Partner Violence
13:15 – 13:30	**Q and A**

Session 11
Session chair: Prof. Duke Orata

12:30 - 13:00	**Keynote Address 9**
	Fethi Bedioui
	Electrochemical detection of nitric oxide (NO) in-vivo: An overview of significant examples
13:00 – 13:15	**Q and A**

Session 12
Session chair: Prof. Christopher Oludhe

14:00 - 14:30	**Keynote Address 11**
	Daniel Olago
	The Importance of Research in Enhancing Water Security and Climate Resilience in Drylands
14:30 - 14:50	**Invited Lecture 5**
	Ontumbi, G. M, Jepkemboi, C and Otiso, K. N
	Environmental Conservation Strategies Among Small and Medium-Sized Enterprises (SMES) With a Focus to Zero Emission Discharges in Kenya
14:50 – 15:10	**Invited Lecture 6**
	Christine Omuombo, Lydia Olaka, Rebecca Williams, Munira Raji, Joel Gill, Cavince Odhiambo, Joseph Oluoch, Samuel Ochola, Dinah Kawino, Natasha Dowey, Hannah Haemmerli, Laura Pozzi, Gareth Hurman and Honor James
	A Roadmap to Strengthen Geoscience Education for Sustainable Development in Kenya
15:10 – 15:35	**Student Presentation 25**
	Wanyonyi Edwin and Kotaro Yonezu
	New Insights into processes of Silica scaling during geothermal production: a case of Olkaria Geothermal Field
15:35 – 16:00	Q and A
16:00 – 16:30	Closing Ceremony

Keynote addresses

Keynote Address 1

The medicine of life': How social life
affects health and survival in wild primates

Prof. Susan Alberts
Dean of Natural Sciences
The Robert F. Durden Distinguished
Professor of Biology and Evolutionary
Anthropology, Departments of Biology and
Evolutionary Anthropology, Duke University
alberts@duke.edu

For social species, including humans and many nonhuman primates, the link between social environments and survival is strong and pervasive. How and why the environment gets 'under the skin' to affect survival is therefore of central interest in biomedical research, but can be difficult to research in humans because of our long lifespan and many environmental and behavioral confounds. Here, I synthesize recent research on the social determinants of health in wild baboons (*Papio cynocephalus*) in the Amboseli basin in southern Kenya. I describe how both early life environments – including social, parental, and ecological influences – and adult social experiences – including social status and affiliative social relationships – are linked to adult and immature survival in this population. I also discuss the extent to which early-life and adult environments act independently of each other. Finally, I describe the strong link between adult lifespan and elevated glucocorticoids (GCs), a biological marker of 'stress.' In doing so I demonstrate that studies of wild primates, which frequently generate prospective, longitudinal data across the full life course, are uniquely positioned to shed light on key questions in biodemography, including the evolutionary history and mechanistic underpinnings of biological and social processes that affect health.

Keynote Address 2

The Role of African Phytochemist
Towards Utilization of Natural Products:
Recent Examples

Professor Abiy Yenesew
Department of Chemistry, University of
Nairobi, P.O. Box 30197-00100, Nairobi,
Kenya;
ayenesew@uonbi.ac.ke

Effective utilization of medicinal plants in alleviating infective diseases requires a combined efforts of scientists in different disciplines. The role of a phytochemist is to isolate and characterize constituents of medicinal plants and avail these natural products to biological scientist to establish the activity of these compounds against different infective agents. In this regard, our laboratory, at the Department of Chemistry, University of Nairobi has availed hundreds of compounds for testing. In the process, we are able to train over hundred postgraduate students towards MSc and PhD degrees. In this presentation, recent examples on two plants *Tephrosia uniflora* and *Kiniphofia foloisa* will be presented.

In the first example, the CH$_2$Cl$_2$/MeOH (1:1) extract of the stems of yielded a new -hydroxydihydrochalcone (*S*)-elatadihydrochalcone-2'-methyl ether (**1**) along with three known compounds elongatin (**2**), (*S*)-elatadihydrochalcone (**3**), and tephrosin (**4**). The structures were elucidated by NMR spectroscopic and mass spectrometric data analyses. The major constituent **2** showed moderate antibacterial activity against the Gram-positive bacterium *Bactilus subtilis.* Based on the comparison of literature data with that obtained experimentally, and with computationally predicted spectroscopic data, we propose the revision of the structure of three β-hydroxydihydrochalcones (**5-7**) to flavanones (**5a-7a**). The characterization, and antiplasmodial of some of these compounds along with biological activities will be discussed.

1 R = CH$_3$
3 R = H

5 R=D-glucose

5a R=D-glucose

6 R$_1$ = R$_2$ = H
7 R$_1$ = R$_2$ = OH

6a R$_1$ = R$_2$ = H
7a R$_1$ = R$_2$ = OH
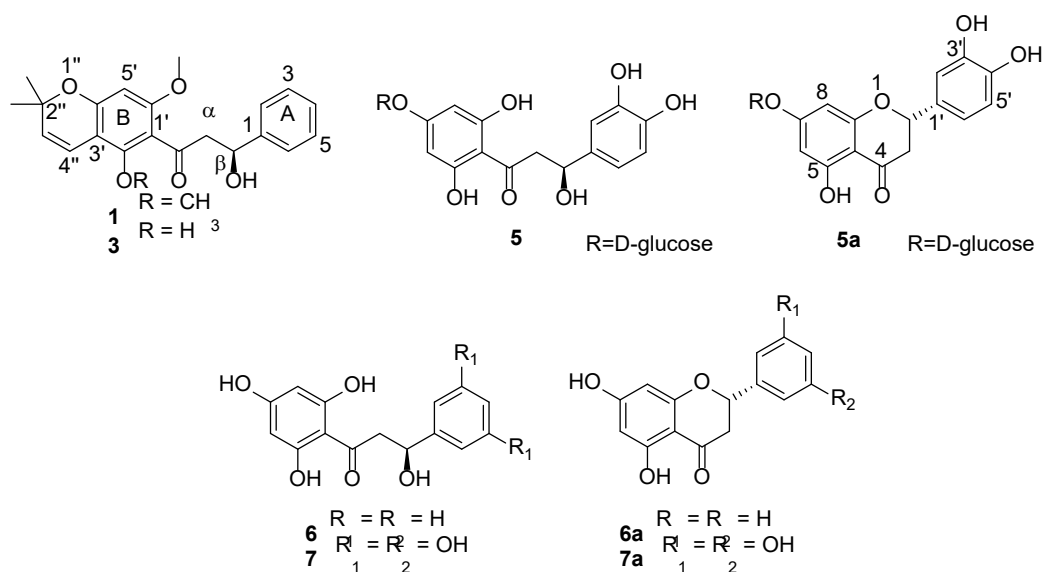
In the second example, reinvestigated *Kniphofia foliosa* and *Bulbine frutescens* and identified novel phenylanthraquinones, including joziknipholone A and knipholone cyclooxanthrone, and anthraquinone dimmers with remarkable biological activities. The roots of *Bulbine frutescens* also gave a new xanthone, 8-hydroxy-6-methylxanthone-1-carboxylic acid, whose structure was confirmed through X-ray crystallography and then used as a reference to propose the revision of six *seco*-anthraquinones into xanthones. The structures, antiprotozoal activities and cytotoxicity of these compounds will be discussed.

Knipholone

Joziknipholone A

Knipholone cyclooxanthrone

8-Hydroxy-6-methylxanthone-1-carboxylic acid
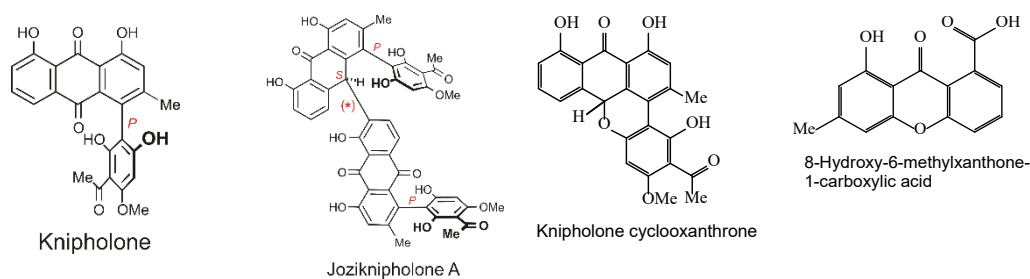
Keynote Address 3

The Search for Bioactive Molecules for the Control of Human, Animal and Crop Disease Pathogens and Vectors

Prof. Josphat Matasyoh
Chemistry Department, Egerton University, P. O. Box 536, Egerton – 20115. Kenya.
jmatasyoh@egerton.ac.ke

Kenya is endowed with a lot of natural resources that can be utilized to solve a myriad of problems. In order for it to achieve the Sustainable Development Goals (SDG's) and in particular, Vision 2030, there will be need for a sustainable use of local resources to develop local solutions to our problems. Poverty in this region may be narrowed down to issues of food and health security. Malaria still remains one of the major killer diseases especially for children under the age of five years. World Health Organization encourages preventive measures like vector control, that is, use of larvicides and insecticides to control the malaria mosquito. Outbreaks of diseases in Kenya including typhoid fever and cholera are very common. This is mainly due to lack of clean water and sanitation facilities to most of the population. Problems with multi-drug resistance have also emerged. Helminthiasis and trypanosomiasis are neglected tropical diseases that are also the cause of serious health problems in Africa. Therefore, there is still need for the search of other molecules that can be candidates for the production of antibiotics and anti-parasitic drugs. Livestock farming plays an important role in the lives of many Kenyans but it is constrained by ticks and tick borne diseases. Therefore, the search for acaricides is important. Due in part to climate change, emerging, re-emerging, and endemic plant diseases continue to be a major challenge in food production, leading to food insecurity. In an effort to contribute to local solutions to the provision of food and health security to Kenyans, we have embarked over the years on the search for biodiversity resources available in Kenya that have utilizable bio-activity. Research findings towards the search for bioactive molecules for the management of human, animal and crop disease pathogens and vectors will be discussed.

Keynote Address 4

Prospects and Challenges of the Utilization of Natural Products: The perspective of an Analytical Chemist

Prof. Dr. rer. nat. Heiko Michael Möller
Institute of Chemistry, University of Potsdam
Potsdam, Germany
heiko.moeller@uni-potsdam.de

Natural products have a long history of being used as remedies against diseases, some of them alleviate symptoms, others even have the ability to cure. Also today, natural products are still a cornerstone of pharmacology. This is true for state-of-the-art therapies, but perhaps more importantly, they are the starting point for drug development.

Nevertheless, natural product and their formulations also pose significant challenges in terms of isolation or chemical synthesis but also in terms of quality control of drugs and drug formulations based on them.

In my talk, I will highlight these aspects with a special emphasis on the perspective and role of analytical chemistry. I will focus on examples with relevance to research and development in Africa and discuss in which areas I see immediate and long term prospects and where I expect significant challenges even on a longer timeline.

Keynote Address 5

Sn(IV) Chlorin and N-confused Porphyrin Complexes as Photosensitizers for Photodynamic Anticancer and Antimicrobial Chemotherapy

Prof. John Mack
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Keywords: Chlorins; N-confused porphyrins; photodynamic therapy; photodynamic antimicrobial chemotherapy; singlet oxygen; molecular modelling.

Introduction

Photodynamic therapy (PDT) is a non-invasive mode of treatment for different types of cancers that can be treated with laser light from a fibre optic that has been developed as an alternative to surgery, chemotherapy and radiotherapy. PDT involves three basic components: a non-toxic photosensitizer (PS) dye, a light source to activate the PS, and ground-state molecular oxygen ($^3O_2$). The basic mechanism for PDT can be conceptualized with a simplified Jablonski diagram (Figure 1a), in which light of suitable wavelength is used to activate the PS to a short-lived S_1 state from where it undergoes intersystem crossing (ISC) to a long-lived T_1 state in the triplet manifold or returns to the ground state by emitting light via fluorescence or through non-radiative decay (Figure 1a). The T_1 state can be deactivated in three ways, (i) phosphorescence or non-radiative decay to the ground state, (ii) a Type I process involving hydrogen abstraction or electron transfer between the T_1 state and a cellular substrate to generate free radicals and reactive oxygen species (ROS), e.g. hydroxyl and superoxide radicals, or (iii) a Type II process where T_1 energy is transferred to surrounding molecular oxygen $^3O_2$ to form highly reactive $^1O_2$.
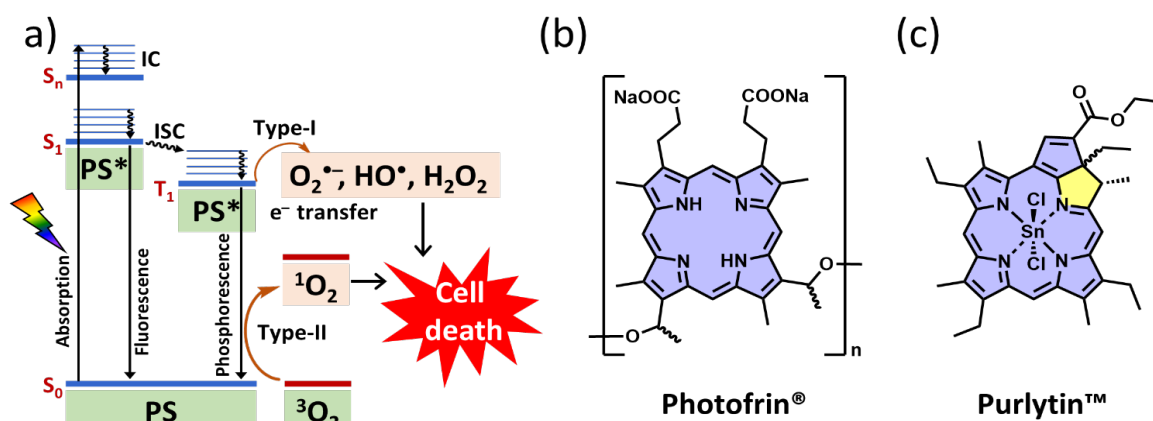
Figure 1. (a) Modified Jablonski diagram showing photosensitizer energy levels and transition involving in PDT process; Structure of (b) Photofrin®, (c) Purlytin™ or Sn(IV) ethyl etiopurpurin (Babu 2023).

In a similar manner to PDT, a PS dye is used to kill the bacteria upon irradiation with light during photodynamic antimicrobial chemotherapy (PACT). Several bacteria have developed resistance against conventional chemotherapeutic drugs over time, which reduces their antibacterial properties. However, in the case of PACT, it is difficult to generate resistance against $^1O_2$ produced by a PS dye. PS dyes with higher $^1O_2$ quantum yield (Φ_Δ, amount of $^1O_2$ produced per photon of light absorbed) values are preferred. The ROS produced by Type I and II processes cause a toxic effect on surrounding cellular substrates, thereby destroying the cancerous cells. PS dyes which absorb in the longer wavelength region between 620–850 nm (the optimal photodynamic therapeutic window) are preferred for the treatment of deeper tumour tissues, since absorption of light by biomolecules such as haemoglobin, proteins, and water is minimal in this spectral region, thereby increasing the PDT efficacy. Photofrin®, the first commercial porphyrin-based PDT drug (Figure 1b), acts *via* the Type I process to treat different cancer types by activating it with red light (630 nm), but is prone to aggregation and only absorbs weakly in the therapeutic window.
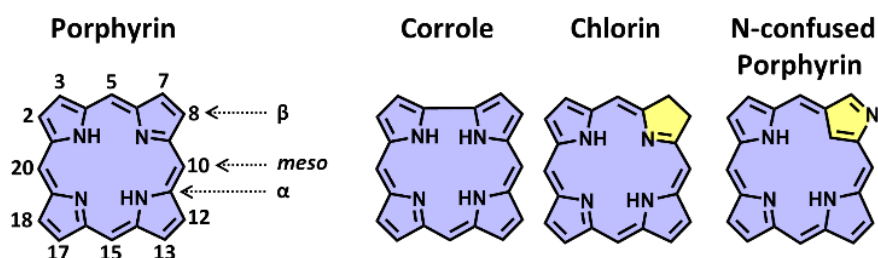
Figure 2. A comparison of the molecular structures of the porphyrin ligand and porphyrin analogues (Babu 2023). Nomenclature related to differing positions on the outer perimeter of the porphyrin ligand is defined.

Metallation of porphyrins and their analogues with tetravalent ions, such as Sn(IV), can provide a six-coordination octahedral geometry. Sn(IV) porphyrins usually have *trans*-diaxial ligands such as Cl⁻ or OH⁻ or O-donor ligands. We decided to focus on the PDT activity properties of Sn(IV) tetraarylporphyrinoids (Figure 2) since bulky *trans*-diaxial ligation can hinder the approach of the Sn(IV) porphyrins, thereby suppressing aggregation effects that can negatively impact the photophysical properties of the PS on which the PDT and PACT activity properties are based. It was clear that the central ion was unlikely to be problematic from the point of view of toxicity since Sn(IV) ethyl etiopurpurin (Purlytin™) (Figure 1c) and Sn(IV) octaethylbenzochlorin are well-established chlorin-based second-generation photosensitizer dyes that are under currently under phase II clinical trials.

Results and Discussion

Over the last three years, considerable progress has been made with a rational structural modification approach (Mack 2017, Babu 2023) guided by TD-DFT calculations to prepare Sn(IV) tetraarylchlorins and N-confused tetraarylporphyrins (Figure 2) with significantly red-shifted and intensified Q bands (Figure 3) that are suitable for use as photosensitizer dyes in photodynamic therapy and/or photodynamic antimicrobial chemotherapy (Babu 2020-23, Dingiswayo 2022 & 2023, Ledwaba 2023, Soy 2023).
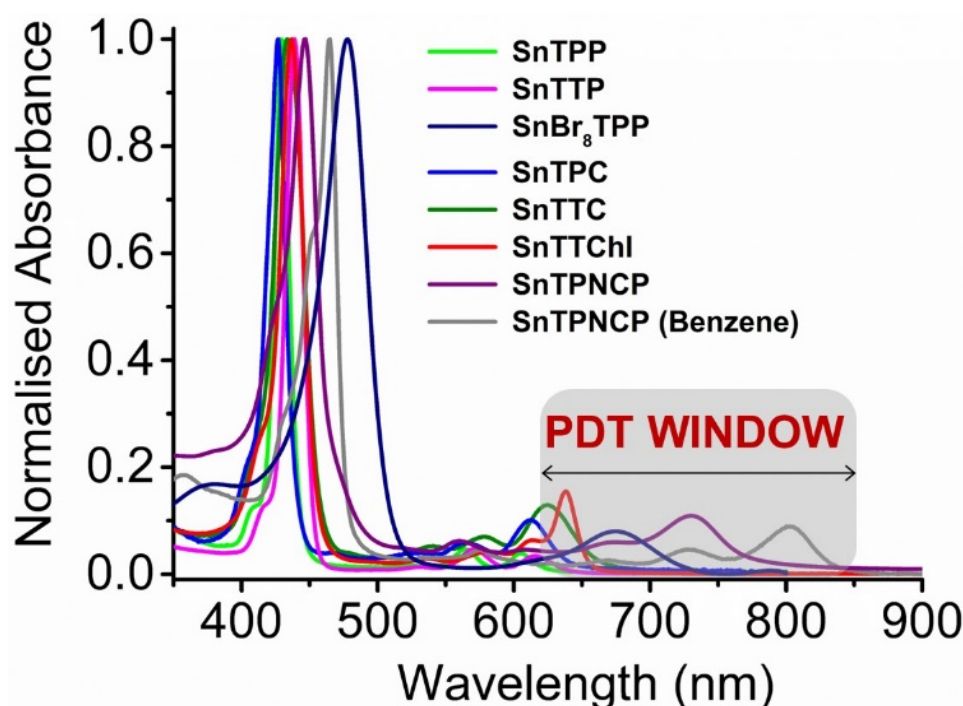
Figure 3. (a) Normalized absorption spectra of the Sn(IV) complexes of tetraphenylporphyrin (**SnTPP**), tetrathien-2-ylporphyrin (**SnTTP**), octabromotetraphenylporphyrin (**SnBr8TPP**), tetraphenylcorrole (**SnTPC**), tetrathien-2-ylcorrole (**SnTTC**), tetraphenylchlorin (**SnTPChl**), tetrathien-2-ylchlorin (**SnTTChl**) and N-confused tetraphenylporphyrin (**SnTPNCP**) in DMF (Babu 2023).

Methodology

Theoretical calculations were carried out using the Gaussian software package at the Centre for High Performance Computing in Cape Town. PDT activity properties were studied against MCF-7 breast cancer cells, while the PACT activity properties were studied against Gram-(+) *S. aureus* and Gram-(−) *E. coli* bacterial strains.

Conclusion

Favourable PDT and PACT activity properties have been obtained for the Sn(IV) complexes of chlorins and N-confused porphyrins. A focus on nanoparticle conjugation (Soy 2021 & 2023b, Magwaza 2023) to enhance the solubility and delivery of the PS dyes is planned.

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Keynote Address 6

Molecular Engineering of Donor-Acceptor Dyads for Triplet-Triplet Annihilation-based Photoluminescence Upconversion

Bi-chromophoric Luminescence Upconversion (UC) is a non-linear photophysical process that generates high-energy photons from low-energy radiation. Although UC is a relatively new photon management science, it has been proven that this process can be used for applications such as fluorescence imaging and biochemical transformations.

Light-harvesting sensitizers/donors are conventionally used in UC processes to absorb low-energy radiation and transfer excited-state energy to acceptor molecules with significant emission quantum. Furthermore, it's widely known that the donor-to-acceptor energy transfer might be affected/altered by various parameters such as ground-state molecular oxygen, non-ideal donor-acceptor interactions, or/and radiationless deactivation of the excited-state molecules. To shortcut the quenching/deactivation channels and improve the quantum efficiency of the UC process, we have designed several donor-acceptor dyads with tuneable spin state(s). In our investigations, we established that i) donor-acceptor interactions (energy or electron transfer) can be modulated using geometrical parameters and ii) the underlying UC photophysical processes can be achieved under ambient conditions if the spin state of the donor-acceptor dyad does not match with that of ground state molecular oxygen.

My presentation will highlight the synthesis and photophysical characterization of several donor-acceptor dyads we employed for UC investigations.

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Keynote Address 7

Rethinking Climate Science Research: "Addressing Challenges and opportunities by Future Demands and Disruptors for Climate and Environmental Services."

Impacts of climate change and extremes are on the rise globally. As a result, the attention has increasingly shifted towards developing robust adaptation and resilience strategies. Global frameworks and initiatives have emerged to mobilize global response to the increasing loss and damage from impacts of increasing extreme events within the context of climate change. Such initiatives include the recent declaration by the UN on "Access to Early Warning Systems for all by 2027". To meet these challenges and develop a truly robust global architecture for early warning and early actions against these impacts, global climate science research must deliver improved services with local impacts. It is anticipated that there will be continuing demands for more accurate and relevant climate and environmental services. How can climate science research be transformed in tune with these new and emerging realities to enable seamless transitioning of science to services?

This presentation will focus on the emerging push for demand-driven climate research that integrates "science of adaptation" and "science for adaptation" for effective transitioning of science to services and policymaking. Climate science and services can no longer be delivered as two ends of the same stick. Rather they should be viewed as a convergence of science(s) to allow co-design and co-production of knowledge, products, and services. For this to be successful it requires a paradigm shift and an emphasis on a 'value-chain' approach in the development of climate science research programs. It will be argued that this can be achieved by reimagining climate research to fully embrace the science-to-services paradigm. Some of the emerging areas of research that consider future demands and disruptors of climate and environmental services will be highlighted to demonstrate the necessity for this paradigm shift in climate research programs. The highlights will be drawn from some of the new research directions identified by the WMO Scientific Advisory Panel, Future Earth, World Climate Research Program (WCRP), among others. These include, but not limited to:- (i)

Capabilities in k-scale modeling and exa-scale computing, which calls for climate research institutions to rethink investments in research infrastructure through establishment of partnerships with big-tech corporates to leverage their cloud storage and computing resources, (ii) Acceleration of climate attribution science and techniques to underpin the links between climate change and extreme events; (iii) Enhance integrated research on meteorological and hydrological modeling and forecasting, to improve services and timely products for multi-hazard early warning systems; (iv) Establishment of regional climate research 'collaboratives' and strategic partnerships with the industry and relevant Public-Private-Engagements(PPEs) to pool and leverage resources for maximum exploitation and incorporation of new technologies, access to 'big data' systems, data analytics, machine learning, and artificial intelligence

The talk will be capped with a few examples of collaborative research on integrated meteorological and hydrological modeling in East Africa that promises to revolutionize development and access to real-time multi-hazard early warning systems.

Keynote Address 8

Surface Modified Electrode as A Central Tool in Electrochemical Characterization, Electro-Analysis and Electroenergy Production

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In this presentation we discuss the role of quartz crystal microbalance (QCM) interfaced with cyclic voltammetry (CV) as a tool to study the redox properties of polyaniline, an electronically conducting polymer. The A-T cut quartz crystal acts as the host matrix for the gold electrode used as working electrode in the electro-polymerization in addition to its role as the electro-gravimetric unit.

The QCM study will also show that when the polymer is switched from its insulating state to the conducting state there is ingress of anions into the polymer matrix in order to maintain electronic charge equilibrium in the polymer. The QCM electrochemical unit is also shown to be able to distinguish the anions migrating electro-gravimetrically based on their molecular weights.

It is also shown that when the working electrode surface is modified by immobilizing a redox active chemical material on its surface, the electrode displays the electrochemical properties of the immobilized material. In this presentation we show that by immobilizing a hydroquinone containing cosmetic on the working electrode surface, the hydroquinone redox properties are displayed. Finally, we also show that electrodes modified using redox active polymers can be used as an active electrode component in an energy production unit.

Keynote Address 9

Electrochemical detection of nitric oxide (NO) in-vivo: an overview of significant examples

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Real-time detection of nitric oxide (NO) in physiological environments is of critical importance for monitoring several biological dysfunctions. Conventional approaches to detect NO rely on indirect colorimetric measurements or direct electrochemical measurements that allow real-time monitoring. Most of these electrochemical approaches are built to evaluate the monitoring of NO produced by model cell cultures. Few studies focus on the implementation of sensors in vivo. Their achievement over the last two decades has mainly focused on the implementation of miniaturized devices, preferably flexible and especially biocompatible, while ensuring selective and sensitive detection.

During the presentation, the most significant examples will be presented, focusing mainly on their design, their in vivo analytical performances and the essential diagnostic and therapeutic information that have been obtained.
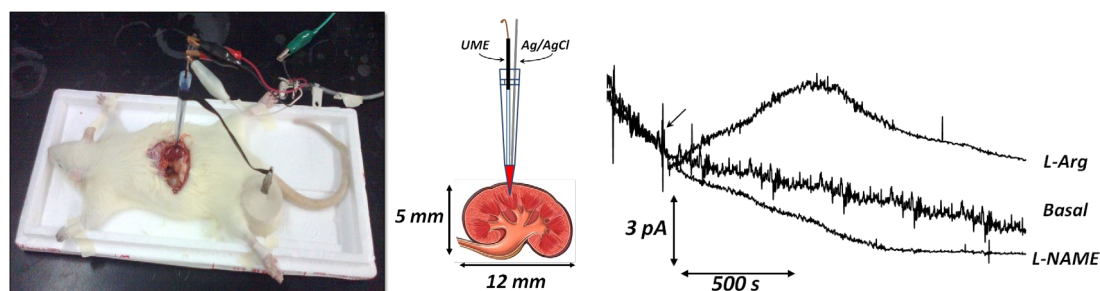
Figure: example of *in vivo* real time & continuous electrochemical detection of NO

(G. RAMIREZ-GARCIA, M. MARTINEZ-ALFARO, S. GUTIERREZ-GRANADOS, A. ALATORRE-ORDAZ, S. GRIVEAU & F. BEDIOUI.

Electrochemical Assessment of Possible Melatonin Effect on Nitric Oxide Production from Kidneys of Sub-Acute Lead Treated Rats. Electrochim. Acta 166 (2015) 88-92.).

Left: Ultra micro electrode disposition into medulla region of rat kidneys

Right: Detection of endogeneous NO after injection of 50 µL of 30 mM L-arginine or 50 µL of 30 mM LNAME within kidneys of healthy rats. E=+0.8 V *vs*. Ag/AgCl. Arrow indicates the injection time.

Keynote Address 10

Resilience in our Digital Society and the Disruptive Nature of Artificial Intelligence

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Artificial Intelligence, in particular machine learning, has a rich and well established scientific history spanning over 50 years. It surprised the general public quite recently with astonishing applications of generative AI based on Large Language Models (LLMs). Systems like ChatGPT have demonstrated near-human performance and are believed to have the potential to revolutionise not only the digital economy but also our society as a whole.

Despite the significant attention given to the potential applications of LLMs, the discussion about the consequences for security and reliability of systems integrated with AI-components has largely been overlooked in public discourse. In this regard, it is essential to shine a light on these concerns and explain that the integration of LLMs into applications significantly increases the risk associated with using such systems due to the non-deterministic nature and unpredictability of neural networks.

Generative AI / LLMs in a Nutshell
Generative AI / LLMs like ChatGPT can be seen as statistic models that generate text based on a prediction of which word most likely comes next in a sequence. The underlying working principle is outlined in Figure 1: LLMs work on tokens rather than words, whereas each token is a vector in a complex vector space representing the result of extensive training of the model [6], which is the basis for word predictions. Notably, we do not understand the semantics of a model underlying LLMs, nor do we have a rigorous theory of the quality of the results they produce.

Figure 1: Working Principle
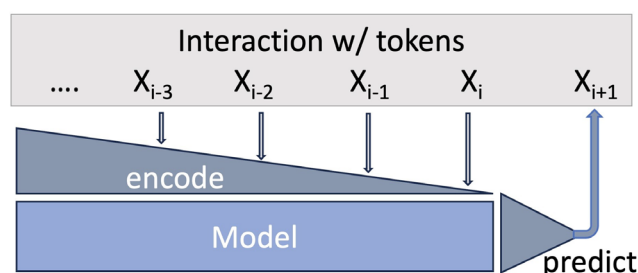
Essentially, LLMs can be seen as Oracles [5] or black boxes delivering answers; effectively, these oracles are also non-deterministic.

Challenges for Digital Security and Reliability

The basic challenge of Generative AI to security and reliability arises from its statistic nature: The results produced are correct with a certain probability, but that probability has no clear interpretation outside the model of the AI. So, how shall we build a dependable system based on a non-predicable component?

There are also plenty of other challenges for building secure and reliable systems based on generative AI beyond this trivial observation; [2] offers an excellent discussion of the underlying problems, we consider the following aspects most problematic from a systems engineering point of view:

1. Quality assessment of training data is hard to impossible, since the size is way beyond what can be assessed by humans. This also concerns possible privacy leaks if personally identifiable data is in the training sets. While training data is of foremost importance all other data sets used in the process[1] require also rigorous quality assurance, yet we only know little how to evaluate the data's quality.

2. Digital "hallucinations" are a frequent phenomenon in LLMs, where the AI simply invents something that is actually not accurate; this is hard to detect in practice.

3. Accuracy over the system's life time is a major challenge, since training data easily contains outdated information, and it is not know how to efficiently deal with the problem of updating a model to "unlearn" data[2].

4. Detecting AI-generated content is crucial, since AI systems tend to "degenerate" when AI-generated content is in their training data. There seems to be no sufficiently robust approach here, yet, and some authors claim it is not possible in principle [4].

All these observations suggest significant challenges for building dependable systems including one or even several AI-components.

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[1] involved data sets are (not exhaustive): training data and evaluation data used to generate a trained model; testing data to decide if a trained model is ready for deployment; finally the data for inference that is taken from the environment and fed into the AI algorithm that is using the trained model to achieve the AI system's task

[2] 2Google recently started its first "Machine Unlearning Challenge"see https://ai.googleblog.com/2023/06/announcing-first-machine-unlearning.html

Furthermore, AI introduces a new attack vector named prompt-injection, which aims at using adversarial inputs for circumventing protection mechanisms of LLMs; whilst these were found manually engineered so far, recent research suggests that finding such attacks can be automated [7]. Effectively, we can expect Generative AI systems to become targets even more vulnerable than today's Web-based applications – refer to [3] for a discussion of this perspective.

Conclusion

Generative AI like LLMs introduce new attack vectors and seriously challenge the transformation of our societies into the digital era. Several properties of these systems confront us with challenges to security and reliability which will turn out to be disruptive – unless research in security and reliability catches up with real-world deployment of AI-components.

On the other hand, AI will certainly also significantly increase the worldwide influence of technology companies to our societies, which also results in significant political challenges [1]. Both effects together can be seen as a disruptive development.

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Keynote Address 11

The Importance of Research in Enhancing Water Security and Climate Resilience in Drylands

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Keynote Address 12

The Role of MRNA Structure in Allosteric Control of Ribosomal Frameshifting

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Keywords: Protein synthesis, Single molecule biophysics, Protein conformational dynamics

Introduction

Protein synthesis is accomplished through a complex and highly coordinated process that requires a substantial amount of cellular energy. The central component in protein synthesis is the ribosome, which is a two-subunit macromolecular complex composed of both RNA and protein components. The ribosome binds to an mRNA molecule and faithfully translates the genetic code into an amino acid sequence. Large-scale conformational motions between and within its subunits facilitate this function. On occasion, translation fidelity can become compromised due to a failure of the ribosome. For example, the ribosome, when encountering specific structured sequences within the mRNA, can shift reading frames in the -1 direction instead of its normal forward progression of 3 nucleotides per amino acid incorporated. This suggests the hypothesis that aberrant changes in the conformation of the ribosome contribute to frameshifting. A series of experiments have been performed and are underway to investigate this process.

Results and Discussion

Identification of the hyper-rotated state of the ribosome. One of the main emphases of our previous work was to investigate the influence that structured mRNA sequences have on the conformational dynamics of the ribosome. The ribosome is composed of two subunits: 30S (small) and 50S (large). During translation, the ribosome transitions between a non-rotated state and a rotated state where the small subunit of the ribosome is rotated in the counterclockwise direction with respect to the large subunit (Figure 1). This rotation has been shown through X-ray crystal and Cryo-EM structures to be approximately 9°. By using smFRET experiments we were able to show that the subunits rotated spontaneously between these two states. Initial studies were designed to determine the influence that structured sequences within the mRNA might have on subunit rotation. In one study, we designed mRNA sequences based on the

Figure 1

highly efficient frameshifting hairpin from the *dnaX* gene (Figure 2) except that the AAA, AAG codons were replaced with AUG, UUU, which code for tRNA^fMet and tRNA^Phe, respectively. We placed this RNA hairpin sequence just downstream of the ribosome with a linker length between the A-site codon and the hairpin of 6 nucleotides. For smFRET experiments, we employed our previously established *E. coli* fluorescent ribosome constructs labeled with Cy3 on large subunit protein L9 and Cy5 on small subunit protein S6. The positioning of these dyes is specifically designed to report on intersubunit rotation. This has been confirmed by several different studies. A FRET state of 0.4 represents the rotated state and a FRET state of 0.56 represents the non-rotated state (Figure 1).

Figure 2

In one set of experiments, we initiated S6(Cy5)/L9(Cy3) ribosomes with an mRNA containing the *dnaX* hairpin and tRNA^fMet (Figure 3B). To our surprise, we observed an additional FRET state at 0.2 in addition to the 0.4 (rotated) and 0.56 (non-rotated) states as compared to unstructured mRNA (Figure 3A). With a lower value of 0.2, we interpreted this as a further counterclockwise rotation of the small subunit with respect to the large subunit and refer to it as the hyper-rotated state. In addition to the 0.2 FRET state, we also observed a significant decrease in the frequency of interconversion among the various conformational states suggesting that structured mRNA traps or stalls the ribosome in a non-productive state. To determine if the distance between the hairpin structure and the A-site was important, we moved the hairpin further away from the ribosome by one codon. In this

Figure 3

case, the 0.2 FRET state was not observed (Figure 4A). However, upon translocation of the

Figure 4

ribosome by the addition of EF-G·GTP, the 0.2 FRET state was restored since the linker was shortened by a single codon (Figure 4B). The existence of the hyper-rotated state was supported by further control experiments including small angle X-ray scattering (SAXS).

In a separate study, we sought to determine more precisely the distance between the A-site and downstream structure. To accomplish this, we designed a series of DNA molecules that hybridized to linear mRNA. Conventional nomenclature refers to the first nucleotide of the P-site codon as +1. These DNA molecules that bound to positions starting at +10 up to position +16 (Figure 5). S6(Cy5)/L9(Cy3) ribosomes were independently initiated with an mRNA·DNA duplex and either tRNA^fMet in the P-site or tRNA^fMet in the P-site and N-Ac-Phe-tRNA^Phe in the A-site and subjected to TIRF microscopy to acquire smFRET data. Remarkably,
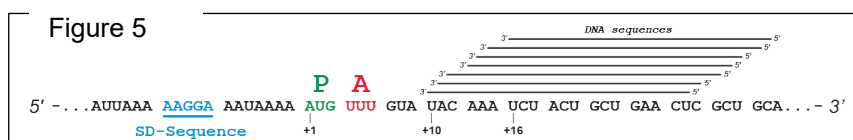
Figure 5

the hyper-rotated state (0.2 FRET) was observed when the DNA molecule was hybridized at either the +11 or +12 position (Figure 6, 2 tRNA data not shown). We interpret this to suggest that beyond the +12 position the ribosome is no longer able to sense the presence of downstream structure. This is consistent with our results where we lengthened the linker between the A-site codon and the *dnaX* hairpin RNA (Figure 4A). We did not observe hyper-rotation with the +10 oligo likely due to the proximity of the DNA to the mRNA entry tunnel. In other words,
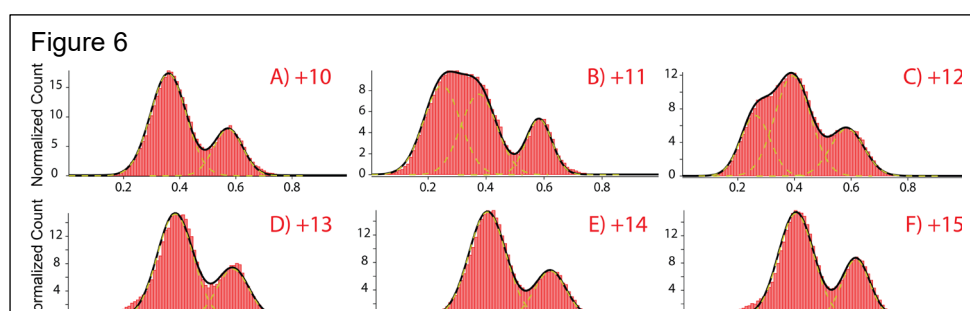
Figure 6

the DNA is too close and is likely unwound since this position only allows for a single strand of nucleic acid.

This distance dependence is quite intriguing when interpreted in the context of frameshifting since it has been known for quite some time that the optimal distance for efficient frameshift stimulation between the A-site codon and downstream structure is 6 to 8 nucleotides, which is the same location where hyper-rotation is observed.

Overall, we have concluded from these studies that structured mRNA positioned a precise distance from the ribosome induces the ribosome into a hyper-rotated state and forces the L1 stalk into an open position. Further, the hyper-rotated state reduces the frequency of interconversion among the non-rotated, rotated, and hyper-rotated states while not

significantly influencing the frequency of L1 opening/closing. <u>We have published the work on the hyper-rotated state using smFRET, we published another study not mentioned here, and we will submit an additional manuscript regarding the mRNA·DNA experiments.</u>

Methodology

Förster resonance energy transfer (FRET). FRET is a fluorescence phenomenon that has proven to be extremely useful in many areas of biological and other sciences. When a fluorescent dye is excited by a light source, the energy can be released/transferred in several ways including fluorescence. If another dye (acceptor) whose absorption spectrum overlaps that of the emission of the excited dye (donor), non-radiative energy transfer can occur between the two dyes if they are within ~ 2 to 8 nm. This process follows an inverse sixth order law due to dipole-dipole coupling. FRET can be monitored as an increase in the emission of the acceptor dye and a decrease in the emission of the donor as the two dyes get closer. The exact FRET efficiency can provide distance information, which can be used to monitor binding events, conformational changes, and many other events in biological systems. There are several experimental methods used to calculate FRET efficiency.   In this study, the emission intensity of both dyes is observed and efficiency is expressed as $I_A/(I_D + I_A)$ where I_A is the intensity of the acceptor and I_D is the intensity of the donor.

Single molecule FRET. The main experimental technique that will be used in these studies is single molecule FRET as measured using total internal reflection fluorescence (TIRF) microscopy. Briefly, TIRF is achieved by directing a laser through a lens and focused through a prism onto a quartz slide. The laser light is totally reflected off the quartz/water interface and generates an evanescent wave that excites only a small area just inside the quartz surface where our samples will be immobilized. Fluorescence emission is directed through an objective, Cy3(donor) and Cy5(acceptor) emission are separated, and subsequently detected using an electron multiplying charge coupled device (EMCCD) camera. Currently, the highest attainable time resolution that we can measure is 2 ms, which should be more than sufficient for our studies. Typical concentration ranges of the dye labeled sample for TIRF experiments are from high pM to low nM depending on dye labeling efficiency and other issues.

Conclusion

Outcomes from these studies will be evaluated to provide a comprehensive understanding of -1 ribosomal frameshifting in both bacteria and eukaryotes from a dynamic, molecular perspective. Our results will have broad reaching implications on the investigation of protein synthesis, which will be of general interest within the scientific community and provide the knowledge base to combat human disease related to protein synthesis.

Invited Lectures

Invited Lecture 1   Experiences of BSc Nursing students at the University of Guyana Berbice Campus during the transition from face-to-face to online learning (1st Cohort)

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Keywords: Transition, Face-to-face learning, Resilience, Online learning, Inequalities

Introduction

In September of 2019, the university of Guyana Berbice campus had enrolled its first batch of nursing students for the Bachelor of Science in Nursing program. These eight (8) students had begun the program via face-to-face learning. Subsequently, in the Month of March of 2020, these students had to transition to a new means of nursing education – Online learning. Unfortunately, only five (5) were able to pass through the transition period successfully.

Over the last few years Online learning has been seen as the new order of education in a rapidly growing technology-oriented world. Online learning is a means of providing information electronically with the use of "multimedia, internet platforms and applications[1]. Online learning has been around for quite some time but it has become even more needful following the COVID-19 pandemic. Online learning and nurses can have a great working synergy if utilized effectively[2]. The prospect of online learning can be a daunting challenge for some whilst it can open the opportunity for a new sphere of learning for others. The benefits of online learning can be numerous when looked at in light of positivity. To overcome the challenges of online learning, researchers have emphasized the importance of assessing persons' perception of technologies in learning, to be able to better meet the needs of students[3].

This discussion goes beyond the level of merely participating in online learning sessions. There have been many disturbances in the world as a result of the 2019 Coronavirus pandemic, let alone the educational sector. This change has seen a movement from face-to-face learning to online learning rapidly. Any degree of change in one's life can and will have an effect on how they transition to change[13]. As a result of the COVID-19 pandemic, many universities around the world had shifted to online mode of learning. For some students across the world who were already exposed to some degree of online learning, transitioning was not a problem[3]. However, in Guyana, where online learning was fairly new to students this had posed quite a challenge. Therefore, it is important that we explore in order to understand those challenges that were faced by students in transitioning from the face-to-face to online learning mode to better prepare for the future.

Methods

A "research design establishes the decision-making processes, conceptual structure of investigation, and methods of analysis used to address the central research problem of your study"[14]. This research was predominantly qualitative, explorative and descriptive study. A focus group interview was utilized to access the participants. The population of students that were a part of the entire cohort that began the Bachelor of Science Nursing Degree program at the University of Guyana Berbice Campus were a total of eight (8). However, that number had decreased to five (5) during the initial transition period from face-to-face to online learning. So essentially, the total population of study was five (5) students. Given the small population size, the design of the study and for validity and reliability purposes, the entire population was sampled. The primary data collection method that was used was a focus group interview.

Results and Discussion

The data collected in this research was solely through the use of a focus group interview. In the focus group interview, the participants were asked the following questions:

(1) During the Transition period; where we moved from face-to-face to online learning, what were your experiences like in regards to the use of technology?

(2) In general, what were some of those emotions that you would have exhibited during that transition? You can describe it however best suits you.

(3) What were your main support systems that you would have depended upon and how did you really get to overcome those challenges?

In order to effectively and coherently present the findings from the data, the Grounded Theory by Glaser and Strauss was used [15]. Using this method, the researcher was able to do an in-depth review of the transcribed interview line-by-line. Common words and phrases were documented that captured the similar expressions. These were placed into categories and themes were formed. Under the different objectives of the study, a number or themes emanated from the research, both positive and negative. Also, critical findings that were not in the objectives were also revealed. In this chapter those findings will be presented.

OBJECTIVE 1: TO EXPLORE STUDENTS' EXPERIENCES WITH TECHNOLOGY DURING THEIR TRANSITION TO ONLINE LEARNING.

As noted above, the students were asked, "*during the Transition period; where we moved from face-to-face to online learning, what were your experiences like in regards to the use of technology?*"

Positive Experiences

Some positive findings noted were, convenience and flexibility, time efficiency, cost effectiveness, good managerial support and acquisition of new knowledge.

Participants comments were:

"I was suffering from hyperemesis gravidarum extreme, so classes were a privilege to be online for the fact that I was vomiting and I was quite ill and really couldn't move around as much. That was like a blessing… but for the fact I was in that state it proved a little good for me… in addition to studying online, while in classes I was able to do more things."

"It actually strengthened my literacy in {computering}, because I never used computers that much. It actually helped me to learn more about different programming, using maneuvers while being online learning."

*"It actually cut down on the cost of me having to travel from where I am – which is on the West Coast of Berbice to go to Tain (*Corentyne – added for emphasis*). So, cost was a big thing for me… I saved a lot in the period of time as compared to having to go from where I am to where I have to go to study."*

"The benefit of the online classes was the fact that many times I would have done night shift and from there I would have to hurry to reach home, prepare a meal for my spouse and then hurry to catch classes, that's when I'm traveling… it was really pressuring to work and to go face to face."

"I had a flexible boss, so I would have related to her my class times. She would have given me some time especially when she knew that it was classes at UG, she would have given me the opportunity to leave. I tried my best not to overdo it but she was flexible so I had time to work with when I had class."

Negative Experiences

The same way in which the transition period proved to be beneficial to students; in like manner, it had some negative impact on students. Those negative experiences were clustered into two large themes: personal and structural. Under those negative personal experiences were, adapting to different learning styles, deprivation of personal time and lack of face-to-face contact with learners and teachers. The structural experiences included poor internet connection and adjusting to the use of technology.

This was her response verbatim:

"The only negative that I think had occurred, was the fact that I had the online, I multi-tasked and I think I deprived myself of the attention that I need, to focus on with the online classes. So, I think that was the only negative for me because I was tasked with so many things at one time."

"I'm a visual learner and I prefer interactive sessions. The challenge was, if you're in a class with a hundred people, then everybody wants to speak – sometimes you'll miss a point. There were times when you had classes, you mixed with total strangers. Not knowing who your classmates are or their personality, I kind of, withhold things that I would want to discuss or carry on in an interactive session."

"From the beginning it was more of a challenge, in terms of having to do the different maneuvers on the computer and learning different programming; incorporating that with your studies."

"For me, getting used to the technology was the difficult part. Not knowing if your camera was on, making sure your camera was not on, making sure you were dressed appropriately, to be entwined with the internet and all that it had to bring was some of the challenges."

OBJECTIVE 2: TO ASSESS HOW STUDENTS WERE AFFECTED EMOTIONALLY DURING THE TRANSITION TO ONLINE LEARNING

In an effort to achieve the second research objective, the researcher asked the following question: "W*hat were some of those emotions that you would have exhibited during that transition? You can describe it however best suits you?"*
The responses received were placed into two different categories – positive and negative. Interestingly, the negative emotions dominated the positive ones and were also among the very first emotions that were exhibited. Those negatives included, fear and fear of the unknown, sadness, confusion, stress, and frustration. In contrast, positive emotions were generally experienced as the transition period progressed. Those positives were happiness, confidence and feeling motivated.

Below were some responses:
"For me, fear of the unknown, that was the first emotion that I would have expressed."
"I had a lot of emotions that were mixed because sometimes you were a little bit confused…"
"…even when I have an exam and I'm working slow and I'm not typing as fast as I should, I was extremely sad about that because I knew that with the writing, I would have done it very quickly but with the typing it was very challenging so that made me a bit sad."
"…sometimes you were stressed. And my husband… For some reason, I don't know if it's a feminine thing because of the hormone but I literally would take out so much frustration on that young man…"

OBJECTIVE THREE 3: TO DETERMINE THE ROLE THAT SUPPORT MECHANISM HAD ON STUDENTS' TRANSITIONING PROCESS

Participants were asked questions in relation to the use of various support systems in the transition process. The researcher asked participants, *"What were your main support systems that you would have depended upon and how did you really get to overcome those challenges?"* Those support systems were categorized in three areas; namely, collegial, familial and spiritual.

Some remarks were stated below:

"For the main support system, for me, it was actually my colleagues because we were in a position where we were experiencing the same thing at the same time… we had a lot of cooperation between ourselves as a small group in terms of that."

"Also, family members who would encourage you on a daily basis to say, don't give up, you can do it. They would try to assist you in everything that you're doing, they would try to make your life a bit easier by assisting you with the household chores and helping you along the way."

"What got me through it all was prayer – a lot and the encouraging words from scriptures which says that I can do all things through Christ who strengthens me. And I wrote that on every article I had to start with at UG. So, the first thing I would see is that I can do all things through Christ. That took me through it."

Other Emerging Theme: Inequalities

A very significant finding was noted from the study – the presence of inequalities and its effect on the students' during the transition from face-to-face to online learning. At the beginning of the transition period a total of 8 students were enrolled in the program. However, due to disparity in the availability of stable internet connection across various parts of the country, two of the persons had to discontinue the program. This was one of the respondent's remarks.

"I remember two of our colleagues that were in the program that didn't get to continue (not two, three). But I know the two particular persons, the internet, the online internet was such a big challenge for them that they would have ended up coming out of the program because where they were stationed, it was very challenging for them to have internet in that area while they were working. I felt a little bit down because I remember them and for some reason, I knew that if there was continuous interpersonal or face-to-face learning, they would have been able to complete the program. My mind sometimes reflects on those two persons…"

Discussion

The data received was placed into themes and sub-themes. In this chapter the themes and sub-themes below will be discussed:

1. Personal
   a. Emotional changes, deprivation of one's self, adjusting to different learning styles, convenience and flexibility, time efficiency, cost effective

2. Structural
   a. Poor internet connectivity, difficulty with technology and online software

3. Social
   a. Familial, spiritual, collegial and faculty support.
4. Resilience
   a. Learning in difficult times, the ability to endure and overcome
5. Inequalities
   a. Geographical challenges, loss of nurses

Theme 1: There's a very common phrase that states, "in a crisis character is revealed." This holds much truth; however, even before one's character is revealed there will be emotional changes that will be portrayed. Given the abruptness of the COVID-19 pandemic and the need for a transition from face-to-face to online learning, many students were highly anxious, fearful and unsure what was happening next. As such, fear, sadness, anxiety and confusion were among some of the emotions that were exhibited among students. Similar findings were noted when comparing this study to that which was done by Natividad et. at. in 2020 and Reeve et. al. in 2013[16,17]. Interestingly, while these emotional changes were generally noted in other studies, in this study, these were the initial emotional responses that were exhibited by students. As the transition period progressed and students became more acquainted with the new mode of learning, there was a great deal of happiness and confidence that was felt while taking part in the online learning.

Conversely, this study and others done in the USA revealed that transitioning to online learning opens the door to many personal benefits including convenience and flexibility[3,7]. Nurses' working schedule and their ability to participate in continuing education programs requires much flexibility to participate. Combining this with personal duties made it even more a necessity. This was often seen among participants as they tried to juggle between work, home duties and studying – often referred to as "work-life" balance. Furthermore, as the old colloquial phrase goes, "time is money" – this was highlighted in the study as a personal benefit to students.

Theme 2: In the use of technology or any machine that is connected to the internet, there is bound for glitches or some up and down waves in the connection. Let alone, a third-world country like Guyana, there's always a possibility for a connection issue. As such, the effects for poor connections, frequent black-outs and unstable bandwidths were often felt by the students during the transition period. While some studies might have touched upon this point, during the review of this study, the researcher did not find other studies with this as a challenge in the online learning mode.

Additionally, it was obvious in this study that many students were unaware of the use of various online and offline software and other technology related devices. This was a striking finding, since all the students who were trained professional nurses had already passed through some level of tertiary training during their professional nursing program. This speaks

volume in regards to the current professional nursing training program and the need for incorporating some level of Information Technology to the curriculum. Moreover, as many hospitals in first world countries are already utilizing electronic records and other electronic health care services, Guyana has a rapidly developing need to consider making some changes. From the University level, there might be a need for having Information Technology, of some sort, as a requirement for entry into the nursing program or incorporating it into the curriculum.

Theme 3: The third theme that emerged from this study was significant, both from a positive and negative perspective. As was observed in this study, support from colleagues had a significant bearing on students' ability to successfully endure the transition period. Similar findings were also noted in studies done by other researchers[10,18]. Similarly, this research studies findings concurred with work done by Reeve et. al. on the notion that nursing students generally rely upon their colleagues and family for support[16]. Furthermore, the obvious impact of religious support was second to none in this study. Other studies that were reviewed did not highlight the positive impact of religious support.

Conversely, in the focus group interview, none of the participants acknowledged any support during the transition from faculty. This was quite interesting because the unexpectedness of the pandemic might have gotten to even faculty members. Maybe, faculty members were also having some degree of technical difficulty and during the transition as noted in work done by researchers at other nursing training institutions[3,19,20]. It can be argued that, had the interviewer probed the participants some more, there might have been some amount of faculty support mentioned. Nevertheless, this opens the door for further research into the aspect of Faculty's experience during the transition.

Theme 4: A strong positive emerging from the study is the ability to go through challenging circumstances successfully with the support of external forces. While numerous challenges were noted, this study confirms what was posited by Bahadir-Yilmaz that, once nurses have a very good support system (whether it be colleagues, family, faculty and/or spiritual support there's a great chance of them being able to adapt to the challenges[21]. As was noted from the findings in the previous chapter, time had an impact on nurses' ability to adapt. The longer they had been involved in the crisis and receiving ample support, this had a positive influence on their adaptability. This finding coincided with Thomas et.al. work on how time and support play a role in nurses' resilience[22].

Theme 5: With the many themes that emerged from this study, this last one is by no means insignificant. The transition from face-to-face to online learning has revealed, in part, the level of inequalities in the nursing fraternity and the country at large. The Bachelor of Science Nursing program at the Berbice campus had begun with 8 nurses in its first cohort but unfortunately only 5 were able to complete and successfully navigate the transition. It was

revealed in the study, that as a result of poor internet connectivity for nurses working and studying in rural areas, two of the eight nurses were forced to withdraw from the program. This is a cause for concern given the recent launching of nurse's continuing education program in the country (2023). It opens the door to many questions: the sustainability of that program given the disparity in internet service around the country; the readiness of the country to provide the service and how would we negate the challenges for people, due to their geographical location, with connection unavailability/instability? This also has implications on the United Nations Sustainability Developmental Goals – specifically goals numbers four and ten that speaks specifically to quality education and reducing inequalities[23].

The other side to the issue is the impact of losing those nurses due to inequalities. In the study, it was noted that apart from those nurses not being able to complete the transition and the program itself, they were also lost through migration. Essentially, the University has lost an opportunity to mold, educate and two more nurses for the future. The nursing fraternity has lost two highly skilled nurses and the country has lost two efficient care givers. While migration will be among us always due to globalization, it is important that it is not as a result of inequalities that needs to be rectified.

Conclusion

The findings indicate that the shift towards online learning has brought about significant changes in various aspects. Personally, students have experienced emotional fluctuations and a sense of self-deprivation while adapting to different learning styles. The convenience, flexibility, time efficiency, and cost-effectiveness of online learning have been acknowledged, but these benefits come alongside structural challenges like poor internet connectivity and difficulties with technology and software. Socially, students have relied on support from family, spiritual connections and colleagues to navigate the online learning landscape. Additionally, the concept of resilience has emerged prominently, as students have displayed the ability to learn even in challenging times, showcasing their capacity to endure and overcome obstacles.

However, the transition to online learning has also exposed inequalities. Geographical challenges have exacerbated the disparities in access to quality education, while the loss of nurses indicates a potential impact on certain professions due to the limitations of remote learning.

In conclusion, the findings underscore the multifaceted nature of the shift to online learning. While it offers advantages such as convenience and flexibility, it also presents emotional, structural, and social challenges. The resilience displayed by students is commendable, but the inequalities and profession-specific repercussions call for thoughtful interventions to ensure equitable and effective online education.

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Invited Lecture 2   Chemistry of Beehive Products and their Relation to Bee Health

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Keywords: Honey, Propolis, Agro-ecological zones, antimicrobial activity, Antioxidant activity

Introduction

Bees amongst others provide an essential ecosystem service by pollinating 75% of the land plants, many of them used as crop plants for human nutrition. However, recent years' research showed that pollinator populations decline globally (Zattara & Aizen, 2021). Reasons for the decline are changes in land management, pesticide use, and climate change (Dicks et al., 2021).

Honeybees (*Apis mellifera*) are excellent pollinators of a range of different plant species as they are broad generalists. Besides the collection of pollen, which is the protein-rich food for the larvae, they also collect nectar, which is the carbohydrate-rich energy food of adults. Nectar is actively evaporated and turned into honey, the long-lasting storage form of carbohydrates for times with ad verse environmental conditions.

Honeybees produce a range of other products that can be harvested from hives. Propolis, a mixture of plant resins, salivary secretions, honey, and pollen, is used to smoothen the inner surfaces of the hive. Due to the high content of secondary plant metabolites, it shows effects against microorganisms.

As these products are derived from plants of the local vegetation, which differs among agro-ecological zones, we hypothesize that the chemical composition and eventually the functional aspects (antimicrobial and antioxidant effects) differ depending on the geographical origin of the bee product. Further, we expect that those differences in chemical composition result in differences in prophylactic and therapeutic effects on bee diseases.

We test these hypotheses using different honey and propolis samples collected throughout different agro-ecological zones of Kenya. We determined the chemical composition, the biological activity, and the prophylactic and therapeutic effects of honey.

Results and Discussion

1. *Chemical Composition*
    a. *Honey*

Honey samples from Kakamega, Mt. Kenya region, Mwingi, and the Coast differed significantly in their contents for carotenoids, proteins, phenols, and flavonoids. Carotenoids were higher in Kakamega and Mt. Kenya compared to Mwingi and Coast, protein content was higher in coast than in the other locations, phenol content was high in Kakamega while being lower in the other locations, and flavonoid content was highest in Coast followed by Mt. Kenya, Mwingi, and Kakamega.

    b. *Propolis*

Propolis samples show on average much higher levels of phenols and flavonoids. The flavonoid content in propolis ranges between 100 and 2,100 mg QE/100 g, while honey shows contents between 13 and 73 QE/100 g. Similar for phenols, propolis shows contents of 520 – 3,700 GAE/100 g, while honey has contents of 32 – 217 GAE/100 g.

Propolis from Baringo, South Kitui, and Nairobi, Kasarani showed highest and samples from Murang'a and Taita Hills showed lowest flavonoid contents. Phenol content was highest in samples from Baringo, Nairobi (Kasarani), South Kitui, and Taveta, while it was low in samples from Taita Hills, Kakamega, and Coast (Gede).

2. *Biological Activity*
    a. *Honey*

Antioxidant activity of honey from Kakamega was high, followed by Coast, Mwingi, and Mt. Kenya. The antimicrobial activity of honey from all regions was quite similar and as high as the Manuka 5+ honey from Australia that served as control. Antimicrobial activity of honey is due to the occurrence of H_2O_2, and removal of the same shows that non-peroxide antimicrobial activity has very high and thus might be due to secondary plant metabolites.

A principal components analysis showed that antimicrobial activity are a function of the phenol and flavonoid contents, while the antioxidant activity is related to the pH of the honey, while phenols and flavonoids also play a substantial role.

    b. *Propolis*

The antioxidant activity of propolis from Baringo, South Kitui, and Taveta was highest, while Coast (Gede) and Taita Hills samples showed lowest levels. Antimicrobial activity was generally higher against Gram-positive (*B. thuringiensis*) compared to Gram-negative bacteria (*E. coli*). Samples from different locations differed with Propolis from Baringo, Taveta, and South Kitui showing highest levels of antimicrobial activity.

3. Environmental Factors Influencing Biological Activity of Propolis

The 59 samples from 10 different locations throughout different agro-ecological zones showed a strong association of environmental factors and the chemical composition and biological activity of propolis. All phytochemicals (flavonoids, phenols, alkaloids, terpenoids) were fused in a single variable through a principal components analysis (PCA). PC1 explaining 68% of the variance showed a strong positive relationship with the yearly mean temperature, and negative relationships with maximum temperature and the relative humidity. The biological activity (antioxidant activity, antimicrobial activity against Gram -ve and +ve bacteria) was merged into a single factor using PCA and the resultant PC1 explaining 53% of the variance showed a significant positive relationship with the yearly mean temperature and significant negative relation to the relative humidity and the maximum temperature.

4. Specificity of Antimicrobial Activity of Honey

Six different honey samples from all over Kenya were tested against five different bacteria. Bacteria were Gram-positive and – negative, associated with honeybees or not, occurring in the crop or the midgut. We found striking differences in the specific antimicrobial activity of the different honey. There were three superior honey samples (Kitui, Kakamega, Nairobi-Karura) acting good against all bacteria. However, every honey was specific against a specific bacterial species indicating that the chemical composition mediates this specificity.

5. Effects of Honey on Bee Health
a. Prophylactic effects

When bees were treated with specific honey for three days exclusively and then get infected with Serratia marcescens, the positive control (Manuka +5) and the Arabuko-Sokoke and the Kakamega sample were highly effective preventing an infection after 24 h. However, the prophylactic effect diminishes quickly and is not present after 48 or 96 hours.

b. Therapeutic effects

When infected honeybees receive specific honey as a treatment, it turned out that Nairobi-Karura and Kitui honey is effective in the short term (24 h) reducing infections, while Taita Hills and Baringo honey reduce infections after 96 h drastically.

Dual choice tests indicated that bees choose specific honeys when healthy or infected. Infected bees choose much faster than healthy bees. When infected bees are given a choice, they select preferentially Kitui honey, while healthy bees rather prefer other honey. The change in choice between healthy and diseased bees correlates strongly with the overall antimicrobial effect of the different honey. A study of the volatile and non-volatile components of those honey in relation to their therapeutic potential revealed the terpenoid cedrol as a key candidate substance promoting the choice of diseased bees towards Kitui honey potentially because of its anti-microbial effect that has been shown in other study systems.

Methodology

Honey samples were collected in different apiaries in Kakamega, Baringo, Nairobi (Karura Forest), Mwingi, Taita Hills, and Mtwapa. From each apiary 50 ml were collected directly from bee hives, while the honey from South Kitui and Arabuko Sokoke were purchased from community beekeeping projects. Propolis samples were taken directly from colonies in Baringo, Murang'a, Nairobi (icipe and Karura forest), Kakamega, South Kitui, Taita Hills, Taveta lowlands, Kilifi (Gede and Mtwapa).

Samples were analysed for total phenol content using the Folin–Ciocalteu method, total flavonoid content using Dowd's method. Propolis samples additionally were analysed for total alkaloid content using the 1,10-phenanthroline method and for total terpenoid content using a colorimetric method (Malik et al., 2017). Protein content was quantified using the Bradford method, and carotenoid content according to an organic solvent extraction method (Alvarez-Suarez et al., 2010).

Antioxidant activity was assessed through in vitro DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity. Antimicrobial activity was assessed using the disc-diffusion assay. Prophylactic activity of honey was assessed in artificial mini colonies kept in cages in the incubator. Freshly hatched bees were introduced into cages and fed for three days using a single type of honey ad libitum. After three days bees were orally infected with *S. marcesens* through feeding a contaminated sucrose solution. Bees were selected after 24, 48, and 96 hours and their guts were extracted and assessed with qRT-PCR using species specific primers to determine bacterial load.

Therapeutic activity was assessed using freshly hatched bees kept in cages in the incubator which were orally infected with *S. marcesens* at day three of their live. Subsequently they were fed using a specific honey ad libitum. After three, four, and six days, bees were analysed using qRT-PCR utilising species specific primers.

Choice tests of healthy and infected bees were done in a Y-tube olfactometer. Ten individual bees per pair of honey were tested, either healthy or infected with *S. marcesens.* Choices were recorded after a maximum of three minutes of observation. The time until the first choice was done was recorded.

Conclusion

Propolis is a healthy natural product that contains very high amounts of phytochemicals. These show good effects in preventing bacterial growth. Propolis bioactivity depends on the vegetation where it was collected and hence on the climatic conditions of the region. Propolis from hot and dry areas has a superior activity.

Honey contains high amounts of phytochemicals, which are responsible for its antioxidant and antimicrobial effects. Different honey show different strength in prophylactically or therapeutically helping bees against bacterial infections. Healthy bees make different choices than diseased bees and the latter preferring honey that has a high antimicrobial activity.

It will be important to understand the effects of different plants in different agro-ecologies on the bee products and finally bee health.

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Invited Lecture 3   Cytotoxicity of isoflavones and biflavonoids from *Ormocarpum kirkii* towards multi-factorial drug resistant cancer

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Background

While incidences of cancer are continuously increasing, drug resistance of malignant cells is observed towards almost all pharmaceuticals. Several isoflavonoids and flavonoids are known for their cytotoxicity towards various cancer cells.

Purpose

The aim of this study was to determine the cytotoxicity of isoflavones: osajin (1), 5,7-dihydroxy-4ʹ-methoxy-6,8-diprenylisoflavone (2) and biflavonoids: chamaejasmin (3), 7,7ʹʹ-di-O-methylchamaejasmin (4) and campylospermone A (5), a dimeric chromene [diphysin(6)] and an ester of ferullic acid with long alkyl chain [erythrinasinate (7)] isolated from the stem bark and roots of the Kenyan medicinal plant, *Ormocarpum kirkii*. The mode of action of compounds 2 and 4 was further investigated.

Methods

The cytotoxicity of compounds was determined based on the resazurin reduction assay. Caspases activation was evaluated using the caspase-Glo assay. Flow cytometry was used to analyze the cell cycle (propodium iodide (PI) staining), apoptosis (annexin V/PI staining), mitochondrial membrane potential (MMP) (JC1) and reactive oxygen species (ROS) (H_2DCFH-DA). CCRF-CEM leukemia cells were used as model cells for mechanistic studies.

Results

Compounds 1, 2 and 4 displayed IC_{50} values below 20 µM towards CCRF-CEM and CEM/ADR5000 leukemia cells, and were further tested towards a panel of 7 carcinoma cells. The IC_{50} values of the compounds against carcinoma cells varied from 16.90 µM (in resistant U87MG.ΔEGFR glioblastoma cells) to 48.67 µM (against HepG2 hepatocarcinoma cells) for 1, from 7.85 µM (in U87MG.ΔEGFR cells) to 14.44 µM (in resistant MDA-MB231/BCRP breast

adenocarcinoma cells) for 2, from 4.96 µM (towards U87MG.ΔEGFRcells) to 7.76 µM (against MDA-MB231/BCRP cells) for 4, and from 0.07 µM (against MDA-MB231 cells) to 2.15 µM (against HepG2 cells) for doxorubicin. Compounds 2 and 4 induced apoptosis in CCRF-CEM cells mediated by MMP alteration and increased ROS production.

Conclusion

The present report indicates that isoflavones and biflavonoids from *Ormocarpum kirkii* are cytotoxic compounds with the potential of being exploited in cancer chemotherapy. Compounds 2 and 4 deserve further studies to develop new anticancer drugs to fight sensitive and resistant cancer cell lines.
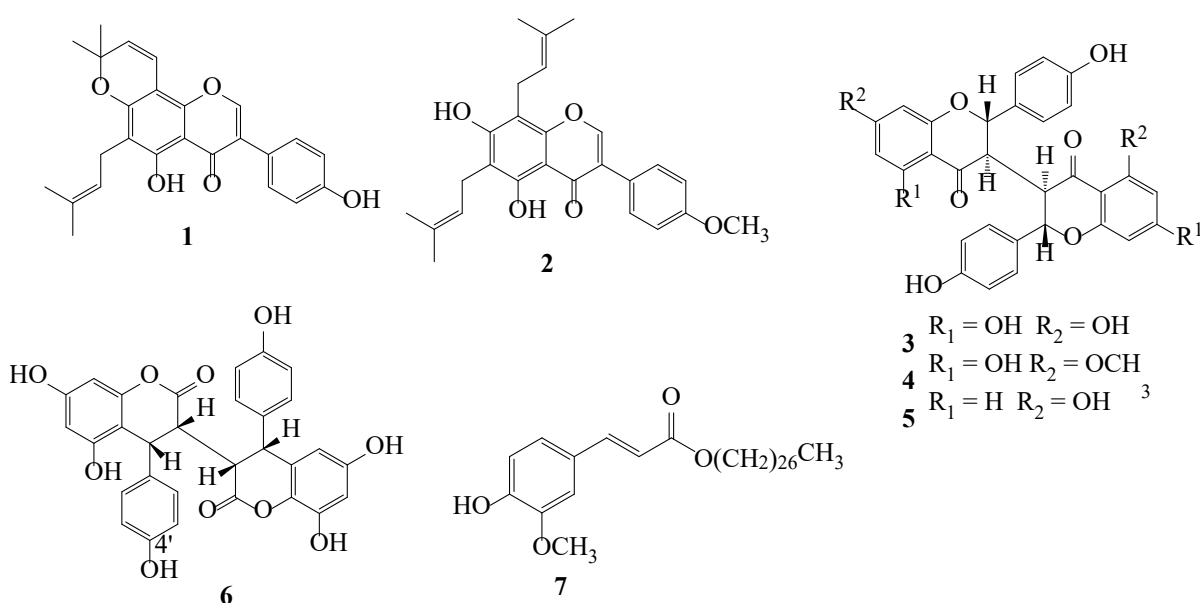
Invited Lecture 4   Indian Cow Urine: Future Antibiotic, Antifungal and Anthelmintic Agent

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Keywords: Ayurveda**,** Cow urine, Antimicrobial, Anthelmintic aactivity, Antifungal, Antibiotic property.

Introduction

Cow urine as contrasted in India mythological scripture 'Veda' too has been used as a remedy for centuries. Being one of the most potent animal secretions, it has countless therapeutic benefits. The value of cow urine increases with age as it is not corrosive. Copper and gold salt, which are elixirs, are found in cow urine. It cleanses the body and the mind (R. kavya). According to a study done by Kiwuso, et al., termites can be controlled with cow urine, wood ash and red pepper. The conidial germination of a plant pathogen was studied by Nargis Akhtar, along with the inhibitory effect of some plant extracts and cow urine (2006). In pathogenic gram +ve and gram -ve bacteria, Dalbergia and Datura stramonium were found to have antibacterial properties in cow urine. While outdoor grazing cows receive a variety of fresh plant material to consume, indoor cows are fed on fodder that has been prepared for animal feeding. There may be a change in the composition of their urine as a result of this. Comparative research on the influence of these urine samples on microbial growth would be interesting. There hasn't been much information on the antifungal activity of cow urine up until now. Thusly, the objective of the ongoing review was to inspect the antifungal capability of cow urine. For therapy of sicknesses: As shown by Sushrut Samhita (Sutrasthana 46/220-221) [6], it is used for therapy of Shoola (colic), Gulma (stomach disease), Udararoga (advancement of the mid-locale) and Aanah (honking), Cow pee is significant for therapies like Virechana karma (purgation), Aasthapanvasti (decoction douche, etc. In ailments which are referred to as reparable by pees, there cow's pee just should be used [7]. According to Charak Samhita sutra sthan 1/102 destroys Krimi (worms) and Kustha (affliction), disposes of Kandu (shivering) and taken inside is helpful in udararoga (expanding of the midriff) achieved by tridosha [8]. According to Astang Samgraha (Sutrasthana 6/141-143), it is significant for therapy of Krimiroga (worm), Shopha, Udararoga (expansion of the mid-locale), Aanah (fart), Shoola (colic), Panduroga (Whiteness), Kaphavikar, Tank vikar, Gulma (stomach malignant growth), Aruchi, Vishvikar, Shvitraroga, Kushtaroga (contamination) and Arshroga (heamorroid). It is used for Virechana (purgation), Aashthapanavasti (decoction douche), Aalepa, Swedana (Sweating). It is Agnideepak, Paachak and Malabhedak [9-12]. The agricultural and medical communities have found great value in using cow urine for its many beneficial qualities. Recently, cow urine received a US patent for its medicinal properties,

especially in combination with antibiotics, to fight bacterial infections and fight cancer (Dharma, 2005a). Currently, India attaches great importance to the medical use of cow urine [15].

Results and Discussion

Zones of inhibition around the well were either present or absent, depending on the results. It was determined that the inhibitory zone around the well was positive and that the absence of a zone was negative because it showed no bacterial growth. The cow urine concentration (CUC) clearly exerted more control over Gram-positive bacteria than it did over Gram-negative bacteria. Finally, a common drug was found to be notably more effective against Gram-positive than Gram-negative bacteria. Out of the tested bacteria, those with a Gram-positive phenotype were more severely inhibited than those with a Gram-negative phenotype. These findings agree with earlier studies on Gram-positive bacteria. The cell wall's permeability barrier or the membrane accumulation mechanism may be to blame for Gram-negative bacteria's resistance. The presence of inhibitory components in CUC may be the cause of the test bacteria's inhibition Test organisms' state measurement diminished on harmed plates, which might show antifungal movement. The CUC showed fixation subordinate hindrance of test organism's development. *A. niger* was viewed as more seriously affected than other tried parasites. The antifungal activity that has been observed may be caused by the presence of active constituents. Both CUC and the gold standard medication showed significant dose dependent anthelmintic activity, paralysing and killing worms. Worms were found to be paralyzed and killed more quickly with CUC concentrations of 1% and 5% than with a standard drug. The presence of active constituents in CUC may be the primary cause of its anthelmintic activity. Numerous powerful biological activities have been found in cow urine and its derivatives. It has been demonstrated that cow urine has antifungal activity by reducing the vegetative growth of test fungi. It has been examined what cow pee means for the germination of parasitic spores. Within the sight of cow pee distillate, a portion subordinate hindrance of test parasitic development and a diminishing in the level of test contagious spores that sprouted were noted.

Methodology

Preparation of CUC

A local breed of cow's urine was collected in a clean container (Amrit Mahal). Filtered cow urine underwent a distillation process. Following distillation, the leftover material was evaporated to create a pasty mass that was then used for anthelmintic and antimicrobial activity.

Antibacterial activity of CUC

Utilizing the circle dissemination strategy, the antibacterial adequacy of CUC was thought about in contrast to the microorganisms. The Public Synthetic Research centre in Delhi was where the test microscopic organisms were gotten. Pure cultures of the test bacteria were

aseptically added to test tubes containing sterile Muller Hinton broth before being incubated at 37°C for 18 hours. Test microbe stock societies were spotted onto sterile Muller-Hinton agar plates using a sterile tip. On immunized plates, sterile Whatman channel paper circles estimating 0.6 cm in measurement and containing standard anti-infection plates (Streptomycin, 11 mcg) and CUC (about 6 mg each) were set. The plates were brooded for 24 hours at 46°C. The zone of restraint was estimated utilizing a ruler after hatching. The analysis was done multiple times.

Antifungal activity of CUC

As test parasites, the genus Aspergillus includes both the fungi *Aspergillus niger* and *Aspergillus flavus*, as well as the fungus *Aspergillus oryzae*. Parasitic inoculums were prepared by adding spore suspension to a test tube of 0.86 percent sterile ordinary saline containing 0.02 percent Tween 90 cleanser. The antifungal activity of CUC (1 and 5%) was determined using the Toxin food procedure. On SDA plates harmed with the CUC by Point immunization, the test parasites were vaccinated. The plates were then brooded at room temperature for 72 hours. By estimating the state measurement on a harmed plate and contrasting it with settlement width on control plates, the effect of the test drug on contagious development was evaluated. The percentage of inhibition was calculated after the experiment was performed in triplicates.

Anthelmintic activity of CUC

Due to the adult Indian earthworm Pheretima pasthuma's anatomical and physiological similarities to the human intestinal roundworm parasite, it was picked for the anthelmintic examine of CUC. In typical saline (0.97%), different centralizations of the Standard medication (Piperazine citrate) and CUC were ready and filled the comparing marked petriplates (60 ml). Every one of the plates was loaded up with six worms that were almost a similar size. The time span it took for every individual worm to become incapacitated and pass on was noticed. At the point when the worms couldn't move in even typical saline, loss of motion was remembered to have happened. The worms were proclaimed dead when they lost their capacity to move, which was trailed by the blurring of their body colors 11. The worms were also dipped in slightly warm water to confirm their death. When all traces of movement had vanished, it was thought that the parasite had died.

Conclusions

The ancient texts "Sushrita Samhita" and "Ashtanga Sangraha" mention cow urine as the most potent substance/emission of creature origin with endless remedial advantages due to its unique antibiotic property. It is considered the water of life, or Amrita, the nectar of God." When the cow urine is completely distilled, CUC is the residue that is left behind. In this study, a prominent antibacterial, antifungal and anthelmintic movement of CUC was noted. The presence of dynamic constituents in CUC might be the essential driver of its inhibitory movement. The CUC could be utilized to treat conditions welcomed on by crafty organisms,

parasitic helminths and pathogenic microorganisms. To help the capability of CUC as an antimicrobial and anthelmintic specialist, extra exploration on the detachment of dynamic constituents and *in vivo* tries should be led.

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Invited Lecture 5   Environmental Conservation Strategies Among Small and Medium-Sized Enterprises (SMES) With a Focus to Zero Emission Discharges in Kenya

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Keywords: Environmental Conservation, Emissions, Green Economy, SMEs and Digitization

The green economy is an important aspect of environmental conservation and this forms the foundation for Kenya's goal towards sustainable development. This well highlighted by the green economy which is anchored in the Constitution 2010 under Articles 42 that recognizes a clean and healthy environment as a right. The constitution is integrated into the country's ambitious development plan, Vision 2030, which aims to attain and sustain a GDP growth of 10 percent per annum in the short to medium term by creating a "just, cohesive and equitable social development in a clean and secure environment". The transformation towards green economy is underpinned to the five thematic areas viz sustainable infrastructure, building resilience, sustainable natural resource management, resource efficiency, and social inclusion and sustainable livelihoods. By adopting green business practices, and providing products and services through sustainable value chains, SMEs can help in driving green growth while at the same time sustaining job creation. A central emphasis of climate change in Cop 26 was that of Decarbonization as observed by World Health Organization. Decarbonization efforts have initiated innovation opportunities and which have similarly triggered business efficiency gains on which businesses are expected to capitalize on. The impacts of climate change present a significant challenge to SMEs, which are often seen as the drivers of economic growth in Kenya. This study intends to generate and provide an evidence and knowledge base to inform advice design, and implementation of public policies in upscaling private green investments that can generate green growth while creating decent employment. This study adopted desk top literature review relevant to the topic, descriptive and cross sectional survey designs. This study identified various strategies adopted by SMEs in environmental conservation with the aim of reducing emissions. These strategies included; digital marketing and digital operations, Policy and legislative frameworks, environmental footprint assessment and Eco innovation. In conclusion; the study observed that Climate change and waste emissions are serious global issues today. Therefore, meeting the challenges associated with it could provide an opportunity to create and trigger tremendous growth for SMEs.

Invited Lecture 6　　　A Roadmap to Strengthen Geoscience Education for Sustainable Development in Kenya

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The role of geoscientists in achieving the United Nations Sustainable Development Goals (SDGs), particularly in the context of Kenya's Vision 2030 has been unexplored in examining education and policies. Kenya, like many nations, faces the intricate challenge of balancing economic, social, and environmental sustainability. The country's strategic Vision 2030 aims to transform it into an industrialized middle-income nation with a high quality of life for its citizens by 2030, closely aligned with the SDGs. Additionally, Kenya is committed to the African Union Agenda 2063 and the East African Community Vision 2050, focusing on Africa's prosperity. This presentation highlights the importance of geoscience education in accelerating the critical goals of Kenya's Vision 2030 and the SDGs. Baseline assessments of the geoscience training courses, including description of modules offered in Kenya's higher institutions, were compiled and analyzed. The extent of the existing geoscience workforce and future workforce requirements to deliver on the ambitions of Vision 2030 and the SDGs was identified through online surveys, focus group discussions, and interviews. Finally, a synthesis of key policy documents was carried out identifying sustainable development priorities at the national and county level in the context of geoscience. The research identified a number of needs, including (1) embedding sustainability concepts into geoscience curriculum; (2) expanding provision of specialist postgraduate courses; (3) strengthening access to field-based training in both undergraduate and postgraduate degrees; (4) increasing the number of trained geoscientists; (5) improving communication between geoscientists and policymakers.

Short Lectures

Harnessing Science and Technology for Resilience and Sustainability of Communities

Short Lecture 1   Bridging the Gap between researchers and Service Agencies to Provide Climate Information to Accelerate Resilience Building for Sustainability

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We are leaving in a time of huge societal problems and challenges which require radical shift in the way science is used to address and provide solutions to current needs. Weather and climate adverse impacts to our welfare have led to the enormous international, regional and even national efforts to fight the common enemy for common good. Are we doing good, or even the best we can to solve the climate problem? What is actually the climate problem? Is it the severe weather and extreme events which sometimes devastate welfare and services including loss of lives? Is it the often talked about up-predicable conditions? It is the attributes of variability and the shifts which entail climate change, especially "human activities" driven global warming and its consequences? What will be the rate of stabilization if the international efforts like zero-Greenhouse Gas are attained during this Decade of Climate Action? Most importantly what will be the outcomes of strengthening the gap between typical weather/ Climate Information provider agencies and researchers across disciplines from "typical sciences" to "socio-sciences"? This paper address these questions with highlights of good results, the lessons we are learning and most importantly how to get things effectively so that services agencies in collaboration with researchers provide weather and climate knowledge which effectively informs societal needs for disaster risk management and running of sustainable activities, and hence contribute to the transformation from the present "high risk low resilience" to "high resilience low risk" world-at least in our geographical areas.

Short Lecture 2   Socio-Cultural Tenets in Water Governance Principles in Urban Development, Case of Nairobi, Kenya

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Keywords: Urban development, Sustainable urban development, Water governance, Nairobi

With a rapidly growing urban population, increased awareness about the significance of water management as new technologies, increased food consumption, land use changes and economic activities that continue to exacerbate competition among water users. Urban population projected to double by 2030, water governance principles play pivotal role in the socio-cultural dynamics of urban dwellers. Thus, water governance encompasses the allocation and management of aquatic resources within the context of a multilayered, competing demand for water resources and water governance principles center on efficiency, effectiveness and trust and engagement. Employing a critical review of relevant literature and situated within Nairobi County, this article examines water governance principles and socio-cultural tenets in sustainable water resources management for sustainable urban development. Nairobi County takes on a unique dynamic in urban development which underscores socio-cultural tenets vital in explicating the water governance principles. Findings reveal that demographic and socio-economic factors play significant roles in household water management decision making. It is also noted that the water legislative environment in Nairobi is characterized by multi-level governance gaps, repressive regulatory arrangements, over-institutionalization, overlapping roles, and lack of coordinated approaches despite the water reforms, which further frustrate the socio-cultural aspects of urban dwellers. Adoption of water governance principles by OECD entrenches the importance of socio-cultural tenets for sustainable urban development. Water governance principles provide a formidable basis for socially oriented outcomes and enhanced implementation within urban settings in Nairobi, fostering sustainable urban development.

Short Lecture 3   Coordinated Efforts in Sustainable Forest Restoration in Nandi County

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Keywords: Restoration, Actors, Inclusivity, Sustainability, Livelihoods

Introduction

Loss of lives, diminished livelihoods, loss of crops and livestock, reduced production, and damage to infrastructure characterize the direct and adverse impacts of climate change that tend to occur at recurring intervals. These impacts significantly hinder the government's efforts in land restoration and the fight against poverty. Kenya is a party to the Paris Agreement (2015) and has committed through the Nationally Determined Contribution to abate GHG emissions by 32%, by 2030, relative to the Business-as-usual (BAU) scenario of the equivalent of 143 mtco2eq. The conservation and management of forests have the potential to positively contribute to climate mitigation and biodiversity conservation (Buotte *et al*., 2020). Land use changes directly influence forest conservation, and it is reported that improvements to land management could provide an estimated 37% of the mitigation required to steady global warming below 2°C by 2039 (Griscom *et al*., 2017). Further, this could help in the achievement of the net zero by 2050 (IEA, 2021) based on the Paris Agreement that committed to maintaining the increasing global temperatures below 2°C.

Consequently, the potential of forests to act as living laboratories for climate mitigation would require the concerted and coordinated effort (Law *et al*., 2018) to inform the conservation and management of forests. Moreover, it is projected that natural forests store more carbon than plantation forests as they can accumulate carbon below ground in the forest floor, therefore, the more natural forests conserved, the more contribution to climate mitigation (Waring *et al*., 2020). While forest conservation and management through afforestation and restoration can help in reducing carbon in the atmosphere, the actors' relationship affects forest ecosystem's functioning, yet is scantly documented.

Methodology

The Nandi county's population is highly dependent on agriculture which is highly rain-fed and approximately 83% of the farming households are affected by climate change. The most prevalent climatic conditions in the county are low temperatures, extreme rainfall, frost, and hailstorms, and changes to the growing seasons (Nandi County Government, 2020). the county's commitment to climate mitigation, it established the climate change fund bill that seeks to have at least 3% of the county's budget allocated to the fund (Nandi County Government, 2020). The bill[1] sought to establish a Nandi County Climate Change Policy whose

major roles would be among other things; to ensure timely disbursement of the fund to the wards and encourage the best practices in terms of projects being implemented to avert climate change and its impacts.

The study employed mixed methods, both qualitative and quantitative data was collected. Primary data was collected through key informant surveys, net mapping, and focus groups discussion to understand forest actors' influence, power, and focus in forest restoration. Secondary data was through review of climate and forest legislations and policies, review of published and gray materials. Primary data was analyzed by use of charts, percentages whereas qualitative data used content analysis.

Results and Discussion

Forest reserves of Nandi County include Nandi North, Nandi South, and Tinderet which provide forest goods and services. Several stakeholders are primarily involved in forest management including government, development partners, community, donor institutions, and financial institutions. 65% of stakeholders are involved in forest conservation, restoration, and afforestation. Actors had different interests in forest governance (71%), community-based forest management (58%), biodiversity conservation (77%), poverty alleviation (76%), adaptation to climate change (60%), and forest restoration related to climate mitigation (41%). Collaboration of many stakeholders was reported to improve forest governance and condition (88%) whereas 78% of the stakeholders strongly disagreed that forest restoration efforts by different stakeholders weaken decision-making and come in handy to strengthen the limited administrative capacity of the state. Stakeholders (88%) view forest restoration as a practical option for reducing greenhouse gas emissions globally and that forest restoration is a financially affordable way to mitigate climate change (94%). Most (82%) agreed that forest restoration benefits should go to those bearing opportunity costs of forest restoration and those that conserve the forest, primarily the community. However, community decried exclusion from decision-making by KFS and county government, expired management plans and agreements, and minimal benefits from NTFP user right. Critical challenges of forest restoration included contradictions among laws and regulations in forestry, agriculture, and other sectors (78%); contradictions among laws and regulations at different jurisdictional levels (23%), low capacity to enforce laws and regulations (60%), lack of finance (71%), achieving effective coordination between state agencies, the private sector, and civil society (53%).

Conclusion

Forest restoration contributes to enhanced ecosystem services and goods. However, stakeholders' efforts in forest restoration are highly uncoordinated besides conflicting laws. The county government needs a more coordinated inclusive mechanism to achieve sustainable restoration efforts.

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Short Lecture 4   Ab-initio Computation of Structural, Elastic, Mechanical and Optical Properties of Cs_2ScAgI_6 Double Perovskite Semiconductor Compound for Photovoltaic Applications

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A novel Cs_2ScAgI_6 double perovskite semiconductor material has been investigated on electronic, mechanical, elastic, and optical properties using the plane wave self-consistent field method by using generalised gradient approximation and Perdew-Burke-Ernzerhof as the exchange correlation functional. The material has an indirect bandgap of 2.06 eV as estimated by GGA-PBE, furthermore using HSE approximation, a bandgap of 2.99 eV was obtained. the states responsible for the electronic bandgap formation were Ag $3d$, I $2p$ and Sc $3d$ for valence band, and Sc $3d$, Sc $4s$, and Cs $3s$ for conduction band with other states contributing insignificantly. The material was found to be mechanically stable and ductile. The optical properties have revealed its suitability for photovoltaic applications.

Short Lecture 5   Preliminary Study of The Solar Photovoltaic (PV) Potential at Selected Sites in University of Nairobi

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Abstract

Currently, electricity costs are high and are likely to remain so or go higher. Some factors contributing to this high cost of electricity include high fuel costs and inflation among others. Although the Government is trying to lower cost of electricity through large investments in the geothermal sector and other strategies, the benefits have not yet been realized since the high costs of investment have to be recovered, leaving the consumer to shoulder the high costs. The University of Nairobi spends an estimated KES 70M per annum on electricity bills. This huge electricity bill can be reduced or eliminated altogether. The Universities strategic location within the tropics and the available space can be exploited to generate significant solar Photovoltaic (PV) power not only to mitigate its huge electricity bills but also store in the national grid system. This paper gives an overview of the preliminary findings of the solar Photovoltaic potential in some specific areas within the University. The study was carried out by selecting some pilot areas in and around main Campus and Chiromo. Some of the electricity consumption data was provided by the University while rest was obtained through data logging at the main distribution boards. Commercials software's were used to do design and simulation. The study reveals that it is technically feasible to power the profiled areas using solar power. This preliminary study can be used as a guide into working on a real project to power the University using solar power. Such an action would:

(1) Put University of Nairobi at the league of the key players in the renewable industry
(2) Be a good example in using and promoting the use of clean green energy
(3) Reduce energy costs and
(4) Contribute to Vision 2030 and SDG no 7 among other benefits.

Key words: Solar, Photovoltaic, PV, electricity, cost, energy, Renewable

Introduction

Energy is critical for any country since it touches on all sectors of the economy. In Kenya, electricity costs are currently escalating due to factors such as fuel cost charge, inflation among others. The Government is putting effort to reduce the cost of electricity by investing heavily in geothermal energy production, but these costs are usually borne by the consumers in the long run. The cost of Electricity for CI1 Tariff category at the time of this study was KES. 12.00/kWh.   (https://www.epra.go.ke/downloads/-Energy   regulatory   Commission;

https://www.kplc.co.ke/content/item/691/new-electricity-tarrifs). One option to mitigate this high electricity demand and reduce pressure on the grid supply to explore renewable energy sources like solar photovoltaic (PV).

The cost of solar PV has gone down compared to some years ago (David Kramer,.2021) making solar more affordable compared to some years ago. Due to the strategic location of Kenya within the tropics, with the equator almost bisecting the country into two equal halves, it enjoys good insolation levels, receiving an average 6.5 sunshine hours per day (Francis Oloo et al, 2016). The University of Nairobi, can benefit a lot from the use of solar PV. It has most suitable for captive solar PV installation and with the net metering regulation, can even store the excess in the grid (Epra, net metering regulations, 2022). The already existing roof structure eliminates use of PV panel mounting structures (as used with ground mounted PV panels), making it cost effective. This will not only reduce the Institutions huge electricity bill (about Ksh. 70 million per annum) but will also reduce green gases.

This paper presents a feasibility study on a solar PV system installed in some places within the campuses of the university as pilot projects with the aim of: 1. Reducing the cost of electricity consumption 2. Setting an example of embracing green energy and 3. Promotion of training and education in green energy.

Method
The method involved going through the following;
Technical assessment
The technical assessment for the project was carried out by assessing the project technical viability. Data was collected on the solar resource, space available and the potential power production capacity.
Energy Consumption
The energy consumption was estimated by data logging and analyzing the data.
Data for the consumption was also obtained from the University bills as well as from the utility company Kenya power and lighting company.

Design and Simulation
The design, simulation and economic analysis was done using a commercial solar PV software- PV sys.

Financing options
The various financial options were obtained from general life cases

Results and Discussion
We present one site
 Faculty of Science and Technology

The estimated roof area for Chiromo Campus is 12,127 m2, translating to 1,819 kWp generation potential. The required 580 kWp system is easily accommodated by the available roof space.

Fig. 1: Chiromo Campus Roof Area with a roof Area of 12,127 m2 with a 1,819 kWp Generation Potential

Current Energy Consumption

The locations considered are listed with the peak loads and average annual kWh consumption.

Location	Proposed Solar PV System Size	Peak Load kW	Average Annual Bill KES
Main Campus A/C:530024	400 kW	262 kW	20,158,546.46
Gandhi Wing A/C: 530015	180 kW	167 kW	9,238,615.63
School of Engineering A/C: 530021	130 kW	80 kW	6,075,185.49
School of Built Environment A/C: 530332	130 kW	90 kW	8,194,081.53
College of Bio & Phy Sciences A/C: 530416	580 kW	420 kW	27,178,670.37
Total	**1,420 kW**	**939 kW**	**70,845,099.48**

Design and Simulation

Chiromo Campus

The load profile below follows almost in synchronism with the solar PV generation curve. This kind of load profile ensures most of the generated energy is used up to a high degree. Subsequently, the return on investment and payback become quite good. The solar PV system would offset 51% of the grid energy. The remainder 49% would be still obtained from KPLC. It is also of interest that the peak demand is reduced from 300 kW to 210 kW. This again goes

further to reduce the demand charges proportionally by 30%. from the previous amount of KES 3,626,057.14 to KES 2,538,240 annually. The savings in demand charges would be KES 1,087,817.14 per annum.

The Energy currently used by Chiromo Campus costs KES 27,178,670.37 annually. Using a 580 kWp system, the energy obtained from the grid would drop from 1,376,761.71 kWh to 674,613.24 kWh and therefore save KES 12,152,001.87 per Annum.

CHIROMO AC:530416 Average Output (System Size 580 kWp)
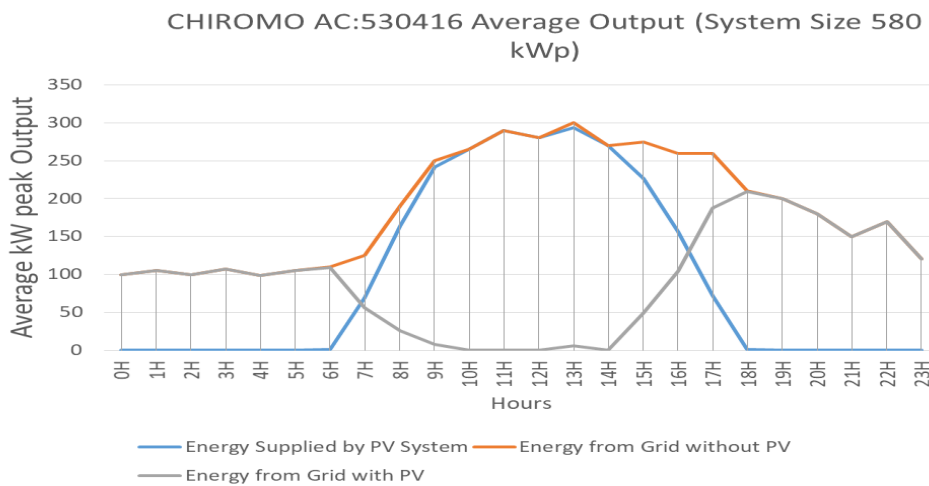
Potential Savings per Annum

UoN KPLC Bills and Potential Savings

% Saved
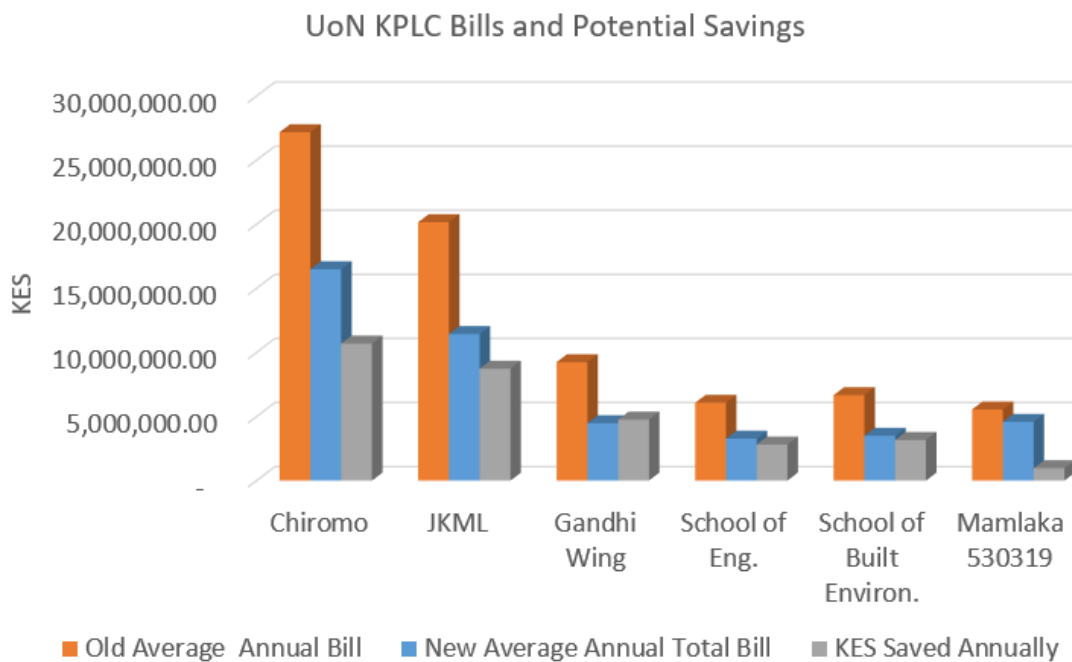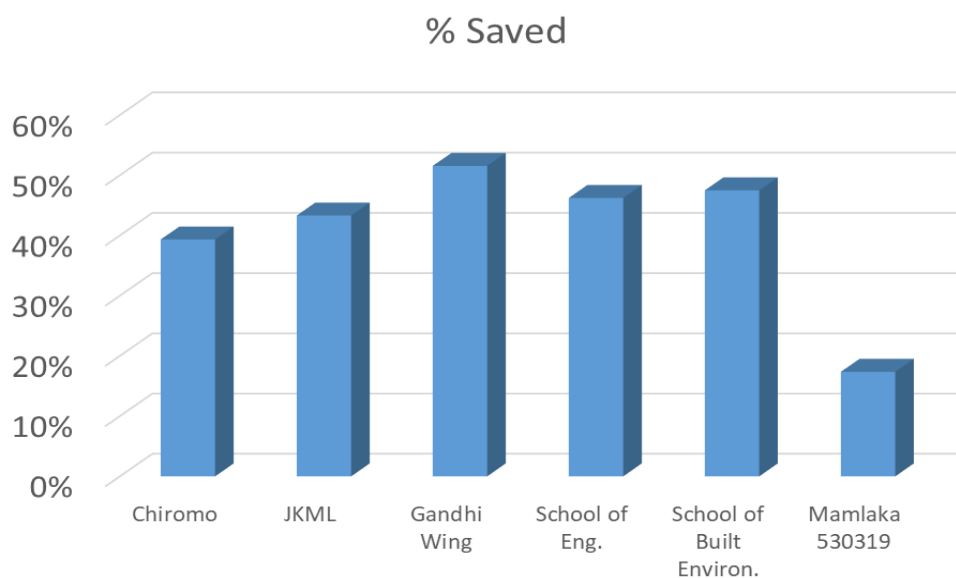
For each of the campuses, potential savings of up to 50% can be realised. However, for Mamlaka hostels, the potential savings is 17% because of the load profile shape.

Conclusion

University of Nairobi is a major consumer of electricity incurring in excess of KES 70M annually. It is proposed that the captive solar PV array be used to mitigate the energy costs. From the analysis carried out, up to 50% of these energy costs can be saved annually. The system can have a payback of between 6-9 years depending on the financing structure chosen.

A detailed feasibility is required to ascertain more accurate savings. However, from the outset, a Solar PV project at the University of Nairobi is technically and financially viable. Installation of these systems will make UoN have a green outlook, as well as saving Energy costs. A showcase of this system shall improve the image of UoN, in line with the carbon emission reduction efforts which is now mainstream.

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Short Lecture 6   Rapid and Non-destructive Identification of *Anopheles gambiae* and *Anopheles arabiensis* Mosquito Species Using Raman Spectroscopy

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Identification of malaria vectors is an important exercise that can result in the deployment of targeted control measures and monitoring the susceptibility of the vectors to control strategies. Although known to possess distinct biting behaviours and habitats, the African malaria vectors *Anopheles gambiae* and *Anopheles arabiensis* are morphologically indistinguishable and are known to be discriminated by molecular techniques. In this paper, Raman spectroscopy is proposed to complement the tedious and time-consuming Polymerase Chain Reaction (PCR) method for the rapid screening of mosquito identity.

A dispersive Raman microscope was used to record spectra from the legs (femurs and tibiae) of fresh anaesthetized laboratory-bred mosquitoes. The scattered Raman intensity signal peaks observed were predominantly centered at approximately 1400 cm^{-1}, 1590 cm^{-1}, and 2067 cm^{-1}. These peaks, which are characteristic signatures of melanin pigment found in the insect cuticle, were important in the discrimination of the two mosquito species. Principal Component Analysis (PCA) was used for dimension reduction. Four classification models were built using the following techniques: Linear Discriminant Analysis (LDA), Logistic Regression (LR), Quadratic Discriminant Analysis (QDA), and Quadratic Support Vector Machine (QSVM). PCA extracted twenty-one features accounting for 95% of the variation in the data. Using the twenty-one principal components, LDA, LR, QDA, and QSVM discriminated and classified the two cryptic species with 86%, 85%, 89%, and 93% accuracy, respectively.

Short Lecture 7   Antiplasmodial Activity of structurally unique secondary metabolites from *Millettia usaramensis ssp. usaramensis* and *Derris trifoliata*

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The genera *Millettia* and *Derris* both belong to the family Leguminosae and are known to have wide use in traditional medicine. The two genera mainly elaborate flavonoids and isoflavonoids. In our continued effort to investigate Leguminosae (subfamiliy Papilnoidea), we studied the phytochemistry of *Millettia usaramensis ssp. usaramensis* (Deyou et al., 2015; Yenesew et al., 1998, 2003) and *Derris trifoliata* (Yenesew et al., 2005, 2006) which led to the isolation and characterization of a number of flavonoids. *Millettia usaramensis ssp. usaramensis* yielded 12a-hydroxyrotenoids with an unusual *6aS*, *12aR* at the B/C ring junction. Some of the compounds reported from this plant showed moderate antiplasmodial activity against chlorquine sensitive and resistant strains of *Plasmodium falciparum.*

While phytochemical investigation of *Derris trifoliata* resulted in a new subclass of rotenoids, rotenoloid, (7a-O-methyl-12a-hydroxydeguelol (**4**) and7a-O-methyl-12a-hydroxydeguelol (**5**))and a spirohomooxaroenoid (spiro-13-homo-13-oxaelliptone (**6**)). In this presentation, the unique spectral properties of these compounds will be discussed.

4   5   6

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Short Lecture 8   Determination of Essential Elements in Selected Nuts Produced in Kenya

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Keywords: Peanuts, Samples, Macadamia nuts, Essential elements, Moisture content, Atomic Absorption Spectroscopy, WHO, and Permissible limits

Nuts, when eaten regularly, have been shown to reduce the risk of developing obesity, diabetes, and cardiovascular disease. They contain healthy fats such as monounsaturated fatty acids and are high in protein, vitamins, fiber, phenolics, phytosterols, and essential minerals. Essential minerals are important in preserving good health and body immunity against infections. They are categorized as macro minerals or microminerals. This study intends to determine the essential elements present in macadamia nuts and peanuts and explain the importance of these nuts to human health and the intake suitable for consumption. The two nuts were collected in triplets from each study area and transported to the University of Nairobi, Department of Chemistry laboratory. The moisture content of the nuts was determined by the gravimetric method. The samples were then wet digested followed by determination of the essential elements using atomic absorption spectroscopy (AAS). Moisture content results were as follows: Macadamia nuts recorded an average moisture content of 15.68% while that of peanuts was 3.89%. The spectrum of correlation coefficients extends from +1 to 0.9036. The results indicated that macadamia nuts from Magumoni had the highest levels of Ca (15.25 ± 0.35 mg/kg), Na (10.99 ± 0.17 mg/kg), Fe (6.96 ± 0.18 mg/kg), Mn (0.465 ± 0.276 mg/kg) and Cu (1.01 ± 0.45 mg/kg). Peanuts from the Kangemi market had the highest levels of Mg (49.45 ± 4.71 mg/kg), K (46.95 ± 0.35 mg/kg), and Zn (0.49 ± 0.01 mg/kg). Mg was the most abundant essential element in both nut samples. Comparing the results with WHO/FAO permissible limits for essential elements in food, the concentration of Fe, Zn, and Cu were within the recommended limits. The levels of K, Na, Mn, Ca, and Mg were below the recommended limits by WHO.

Short Lecture 9   Hollow Nanostructures for Sensing of Environmental Pollutants

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Keywords: Hollow nanostructures, SnO_2, hollow carbon spheres, Ammonia sensing, CO sensing

Introduction

Hollow nanostructures' enormous surface area and accessible pore cavities make them ideal for functional materials for use in gas sensors, catalyst supports, dye adsorbents, super capacitors, and lithium-ion batteries. In particular, hollow SnO_2 and hollow carbon spheres (HCSs) have been immensely used in gas sensors (Sharma et al., 2021; Pavlenko et al., 2022) and catalysis (Zhao et al., 2006; Phaahlamohlaka et al., 2016), owing to their tunable catalytic properties and surface features. Adversely, the microstructure and porosity affect gas sensing catalytic activity and adsorption-desorption. However, most sensor measurements are done at high temperatures, when thermal sintering influences material structure and crystal size (Gyger et al., 2010). The real-time monitoring of toxic compounds such as ammonia, nitrogen dioxide, and volatile organic compounds is essential to human health and environmental safety. Even though recent breakthroughs in nanomaterial synthesis have made it easier to use metal oxide semiconducting gas sensors with the Internet of Things (Gomes et al., 2019) and artificial intelligence (Chen et al., 2019), adapting to new technologies will require inventing catalysts and sensing materials that can be used in industrial applications at room temperature and are affordable.

Room-temperature detection of toxic compounds can be readily achieved by surface engineering of nanostructures, the creation of oxygen vacancies in metal oxides, and the modification of the physicochemical features of carbon nanomaterials. The templating method offers the advantages of manipulating the pore structure, the shell thickness, and the internal diameter of hollow nanostructures (Sasidharan et al., 2011). As such, hollow metal oxide and carbon nanostructures increase gas diffusion length and active site involvement in adsorption and desorption to detect volatile compounds at room temperature (Li et al., 2017). In this study, we have examined the response of hollow tin oxide nanostructures to carbon monoxide under ambient conditions and compared their performance to that of their solid counterparts. By employing a core@shell SiO_2 template, we have investigated the role of the morphology and electrical properties of hollow SnO_2 on its sensor response towards CO. Additionally, the effect of low-temperature annealing of hollow carbon spheres on their sensor response to ammonia vapors under ambient conditions has been explored.

Results and Discussion

The morphological features of the hollow nanostructures were ascertained by scanning electron microscopy and transmission electron microscopy. The surface areas of the templates and hollow nanostructures were investigated using the Brunner-Emmet-Teller method. The core@shell SiO_2 template, hollow SnO_2, solid SiO_2 template, and hollow carbon spheres obtained from the templates exhibited a spherical morphology as observed using a transmission electron microscope and scanning electron microscope, respectively (Figure 1a-d). As expected, the sphere sizes were slightly smaller than those of the SiO_2 templates. The silica template aided in the generation of homogeneous hollow nanostructures.
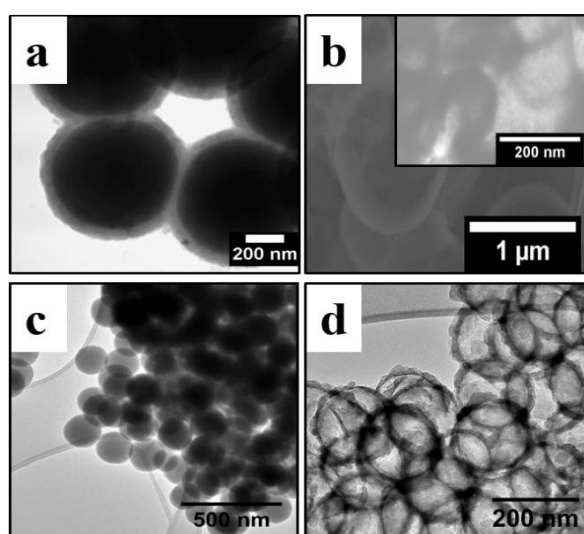

Figure 1: TEM images of (a) core@shell SiO_2 template, (b) hollow SnO_2, (c) solid SiO_2 template and (d) hollow carbon spheres, respectively.

The sensing characteristics of the hollow SnO_2 spheres for CO detection were examined by exposing them to different amounts of CO at room temperature. The sensor responses of the hollow SnO_2 spheres were 20, 30, 53, and 67 for 1 vol%, 2 vol%, 5 vol%, and 9 vol% CO, respectively. These responses were eight times greater than those of template-free SnO_2 spheres. The hollow morphology and reduced domain size of the SnO_2 can be attributed to the superior features of the hollow SnO_2 spheres, which could allow for faster adsorption and more catalytic sites for the CO molecules. Furthermore, gas molecules diffused within the detecting layer can interact with SnO_2 grains on the inner surface, improving sensor performance (Xu et al., 2020). Hollow carbon spheres, on the other hand, were exposed to varied quantities of ammonia vapor under ambient conditions. The sensor responses of pristine and annealed HCSs to 74 ppm NH_3 concentration were 6% and 196%, respectively. The HCSs showed an expected increase in the response with the ammonia concentration. The annealed HCSs exhibited a higher sensitivity value than the pristine HCSs due to the presence of fewer amorphous defects, which resulted in increased ammonia physisorption. In addition, a stronger surface-to-ammonia molecule interaction due to the increase in surface area and

pore volume during the low-temperature annealing process is likely to result in a higher ammonia sensitivity (Singh et al., 2014).

Methodology

Core@shell SiO_2 and solid SiO_2 spheres were synthesized using the Stober method (Mutuma et al., 2016). The hollow SnO_2 spheres were synthesized using a modified hydrothermal method, as shown in Scheme 1. The chemical vapor deposition method was used to cast carbon atoms onto silica templates, followed by the removal of the silica to yield hollow carbon spheres (Scheme 2).

Scheme 1: Synthesis of hollow SnO_2 nanostructures.
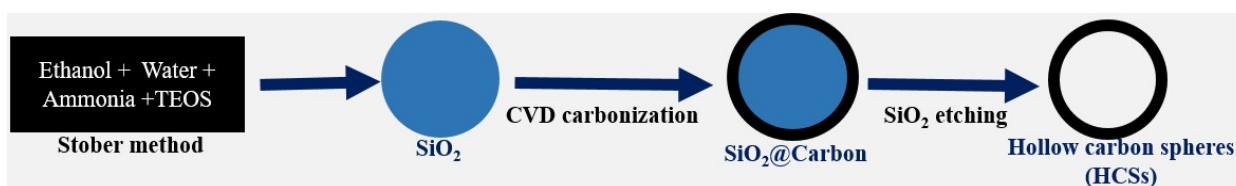
Scheme 2: Growth of hollow carbon spheres from a solid SiO_2 template.

Conclusion

This study demonstrated the use of a templating approach to create hollow nanostructures (hollow SnO_2 spheres and hollow carbon spheres). An interconnected open nanostructure of hollow SnO_2 spheres with lower domain sizes and a porous structure was created using the unique core@shell SiO_2 template. The hollow SnO_2 spheres had a sensor response of 67 toward 9 vol% CO in a simple sensing test at ambient temperature, compared to a response of 7 for their templatefree SnO_2 counterparts. This improvement in CO gas response properties is presumably due to the smaller crystal size and high surface area of SnO_2 brought about by the core@shell templating approach. On the other hand, annealed HCSs displayed sensor responses towards ammonia vapor that were 30 times higher than those of the pristine HCSs. Annealing was found to greatly impact the sensor properties of hollow carbon spheres by decreasing the dependency on relative humidity and increasing the surface area of the carbon. Overall, the study provided insights into modifying the sensor characteristics of hollow nanostructures through surface and structural engineering, allowing for the detection of environmental pollutants under ambient conditions.

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Short Lecture 10   Biosoption of Hazardous Malachite Green from Aqueous Solutions onto Chitosan- ZnO Composite: Kinetic and Equilibrium Modelling

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Keywords: Chitosan, Adsorption, Dyes, Isotherm, Mesoporous.

The presence of synthetic dyes in wastewater poses adverse effects on human health and the aquatic ecosystem and that necessitates their removal from aqueous media. Among the available strategies for purifying dye - contaminated wastewater, adsorption is considered superior owing to its low- cost, flexibility, ease of operation and low energy consumption. Mesoporous (33 nm) chitosan- ZnO composite was synthesized via precipitation route and utilized as an adsorbent for the removal of toxic malachite green (MG) from aqueous solutions. The synthesized material was characterized by various techniques such as Fourier Transform Infrared, Thermogravimetric analysis, BET porosity analysis and X-Ray diffraction. All experiments were accomplished through a batch process where the influence of dye concentration, solution pH, adsorbent dose and contact time were investigated. The progress of the experiments was monitored using UV- visible spectrophotometer. The maximum adsorption of > 90 % for MG in all the experiments was achieved at pH 8, dye concentration of 2.3 mg/L and adsorbent dosage of 0.6 g within an equilibration time of 180 minutes. The Langmuir isotherm model perfectly described the equilibrium data with a monolayer removal capacity of 11 mg/g on a homogeneous surface. The pseudo- second- order rate mechanism illustrated the kinetic data appropriately with a r^2 value of 0.98, implying that chemisorption controlled the removal rate of malachite green dye. This work has demonstrated the potential of chitosan- ZnO as an effective and eco-friendly benign material for the remediation of wastewaters containing textile dyes.

Short Lecture 11   Preparation of a Ti/SnO$_2$-Sb/La-βPbO$_2$ electrode for the degradation of prednisolone, 8-hydroxyquinoline, methylene blue and p-nitrosodimethylaniline

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Keywords: Ti/SnO$_2$-Sb/La-βPbO$_2$ electrode; electrochemical degradation; kinetic degradation; organic; degradation rate

Introduction

Prednisolone, 8-hydroxyquinoline, P-nitrosodimethylaniline, and methylene blue are emerging pollutants which can cause adverse effects on the aquatic systems they end up in (Yin et al., 2018; Prachayasittikul et al., 2013; Ginimuge & Jyothi, 2010). Conventional waste water treatment methods have not been effective in treating these pollutants, therefore, advanced oxidation processes like photocatalysis, electrochemical oxidation, and Fenton oxidation have attracted a lot of interest from researchers (Qian et al., 2022). Electrochemical oxidation is a promising treatment method because it is ecofriendly, cost effective and versatile (Wang et al., 2019).

Ti substrate coated with various layers has been used as an electrode in the electrochemical degradation of organic pollutants showing some effectiveness (Kaur et al., 2018; Cai et al., 2019; Wang et al., 2019). Among these electrodes, Ti/β-PbO$_2$ has been widely used due to its low cost, ease in preparation and high oxygen evolution potential (Hao et al., 2015). A SnO$_2$-Sb interlayer is used to improve the adhesion of the β-PbO$_2$ layer, but it still has a tendency to flake out into solution (Wang et al., 2019). To remedy this, researchers have introduced F, Ni, Bi, Mo, etc., into the β-PbO$_2$ layer (Man et al., 2021a,b). La has also been added to the β-PbO$_2$ layer in a number of studies on degradation of organic pollutants and has shown excellent electrochemical properties (Qian et al., 2022). An electrode with similar components has not been used in the degradation of Prednisolone, 8-hydroxyquinoline, P-nitrosodimethylaniline, and methylene blue. That is where this study comes in. The main objectives of this study were to evaluate the characteristics of the Ti/SnO$_2$-Sb/La-βPbO$_2$ electrode, to compare the degradation efficiencies of Prednisolone, 8-hydroxyquinoline, P-nitrosodimethylaniline, and methylene blue on the electrode, and to investigate the effect of operating parameters like the supporting electrolyte, pH, and current density on the removal of the organic pollutants.

Methodology

Materials

Ti plate (99%, Qixin Company, China), tin chloride pentahydrate (99.0%, $SnCl_4.5H_2O$, Aladdin), antimony trichloride (99%, $SbCl_3$, Aladdin), oxalic acid ($C_2H_2O_4.2H_2O$, Merck, Germany), and nitric acid (HNO_3, 65% - 68%, Sigma - Aldrich) were used. Prednisolone, 8-hydroxyquinoline, P-nitrosodimethylaniline, and methylene blue were of analytical grade from Merck, Germany. The solutions were prepared using distilled water.

Preparation of the Ti/SnO₂-Sb/La-βPbO₂ electrode

The electrode was prepared according to Hoang et al., (2023) and Man et al., (2022).

Electrochemical Degradation of the Pollutants

The electrochemical degradation experiments were carried out in a glass vessel containing 100 mL of the solution to be treated. The prepared electrode and a Pt plate electrode served as the anode and the cathode in a traditional two-electrode system, respectively. The distance between the two electrodes was 10 mm. Constant current was provided by a DC power and the solution was thoroughly stirred during the process at 600 rpm.

Analytical Methods

The surface of the prepared electrode was studied using a scanning electron microscope (SEM, JSM-IT200, Japan) equipped with energy-dispersive X-ray spectroscopy (EDX), and X-ray diffractometry (XRD, D8 ADVANCE ECO, Germany).

The electrochemical properties of the prepared electrode were studied using cyclic voltammetry (CV), linear sweep voltammetry (LSV), and electrochemical impedance spectroscopy (EIS), on an Autolab potentiostat (PGSTAT302N, Netherlands). These experiments were conducted using a three-electrode system: the prepared electrode as the working electrode, a Pt plate electrode as the counter electrode, and a saturated calomel electrode (SCE) as the reference electrode.

The concentrations of the pollutants being treated were monitored using a UV-Vis spectrophotometer (Jascob, V670, Japan). The concentration of H_2O_2 was determined according to Kosaka et al., (1998). Persulfate was measured according to Hoang et al., (2022a,b). COD was measured according to Dedkov et al., (2000). Intermediates of the degradation process were determined using GC-MS (7890A/5975C, Agilent) with Helium as the carrier gas (1 mL min^{-1}).

Data Analysis

Kinetics of the degradation process were determined as per Hoang et al., (2023) and Hoigne et al., (1985). The kinetic degradation of pollutants in the electrochemical process is calculated according to a previous study by Z. Hu et al., (2022).The energy consumption for

pollutant degradation was determined according to Hoang et al., (2022).The average current efficiency (ACE) of anode versus pollutant removal was calculated as per Wei et al., (2021) and Yang et al., (2021).

Results and Discussion

SnO_2-Sb interlayer was successfully deposited as evident from SEM-EDX analysis. Doping with La on the outer layer (β-PbO_2), resulted in the distribution of the particles on the surface being more uniform and the size of the particles reduced. This indicates that doping with La_2O_3 restricts the growth of the β-PbO_2 particles and makes the surface flatter, resulting in high specific surface area with more active sights for electrochemical activity. XRD patterns showed that the typical peaks for SnO_2-Sb were not found in the β-PbO_2 layer indicating that the interlayer was completely covered by β-PbO_2.

A higher oxygen evolution potential (OEP) at the prepared electrode is desirable because it reduces the oxygen produced at the surface. This is beneficial for ·OH production which improves the current efficiency of the electrochemical degradation process. Ti/SnO_2-Sb/La-βPbO_2 doped with either 5 or 10 g L^{-1} of La_2O_3 had higher OEP producing optimal current efficiency limiting oxygen evolution. However, doping with La_2O_3 reduced the conductivity of the electrode. Nonetheless, other tests should be considered in gauging the effectiveness of the electrode. Doping with 10 g L^{-1} La_2O_3 was also the optimal dosage for anticorrosion properties of the electrode.

The steady state concentration of ·OH was optimal on the electrode doped with 10 g L^{-1} of La_2O_3. ·OH is responsible for the indirect oxidation of pollutants (Duan et al., 2018). The degradation rates of the pollutants were different under the same conditions and higher pollutant removal was achieved using the Ti/SnO_2-Sb/La-βPbO_2 electrode.

Increase in current density resulted in an increase in the degradation rates. This is because, the increased current density enhanced the number of electrons transferred to the surface of the anode promoting formation of ·OH which enhances the degradation efficiency. However, when it was too high, the self-quenching reaction of ·OH, which resulted in the formation of H_2O_2 and O_2 evolution, occurred on the surface, thus wasting the electrons which were transferred on the surface (Dong et al., 2021). The rates of degradation of the pollutants increased in $H_2PO_4^-$/HPO_4^{2-} relative to the case in SO_4^{2-}. SO_3^{2-} and HCO_3^- scavenged ·OH producing less reactive radicals that reduced the degradation rates (Friestad, 2009).

Acidic conditions were more favorable than alkaline conditions in the degradation process. The efficiency of the electrochemical process depended on: distribution of fractions of pollutants under different conditions; the ability of the anode to generate ·OH under different conditions. It has been proposed that the electrode can be dissolved and passivated in highly

alkaline conditions reducing the production of ·OH (Maharaja et al., 2016). The reactive species can also be transformed under different pHs.

Conclusions

The La-doped β-PbO$_2$ surface provided excellent electrochemical properties for the degradation of pollutants and should be considered for application in wastewater treatment of various organic pollutants.

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Short Lecture 12   Experience of Developing Applications on the Algorand Blockchain

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Abstract

Algorand is a layer 1 blockchain technology that supports the pure proof-of-stake consensus mechanism. It allows users to post transactions related to payments, assets, smart contracts and smart signatures. In this paper, we present our experience in setting up and coding on an Algorand LocalNet, which is a sandbox environment where developers can test their solutions before deploying them to the mainnet or testnet. We also share our experience in organizing a hackathon for students on the Algorand platform.

Background

A blockchain can be defined as a technology for storage of electronic transactions in a distributed manner (Yli-Huumo et al., 2016). The transactions are stored in units known as blocks where a block is a grouping of several transactions that occur over a specific time period. These blocks are "chained" together using an electronic signature that links the current block to the previous one. Usually, this link is a hash value of the previous block's header. The previous block is similarly linked to the block before it and the chain goes on till the first block which is known as the genesis block. For the genesis block, the hash of the previous block is a string of zeros since no other block precedes it. Every node participating in the blockchain network will contain all the blocks that have been added to the chain from the first block.

Blockchains rely heavily on the concept of Consensus. Consensus techniques are used by blockchain networks to determine which node in the network should have the right to verify and publish a new block into the block chain (Dylan et al., 2018). The node that publishes the next block is rewarded by earning a miner's reward, miner's fees and or transaction fee. Consequently, nodes compete to win the right to add the next block. In the proof-of-work consensus algorithm used by the Bitcoin blockchain, the mining node that is first to win a cryptographic puzzle wins the right to add the block. This block is then transmitted to other nodes in the network. In the proof-of-stake consensus algorithm, each publishing node stakes some crypto in the native currency of the network. The value of the stake determines the chances of a node getting the right to publish the next block. Proof-of-work methods usually take longer to solve the cryptographic puzzles and consequently, take longer to add a new block to the chain compared to proof-of-stake mechanisms.

Algorand is a blockchain technology that uses the pure-proof-of-stake (PPoS) consensus mechanism to select the next block to be added to the chain. The block validation process

takes several rounds with participants in each round selected at random based on the amount of cryptocurrency they have staked (Gilad et al, 2017). In the first round, participants are selected to propose blocks, then in the second round participants are selected to vote for proposed blocks. A participant will vote for the highest priority block it has received so far. Algorand consensus method is meant to reduce the likelihood of a malicious participant forcing the publishing of invalid blocks. It is also meant to prevent forking of the chain. The mechanism also ensures that block validation takes less time (in the order of a minute) and therefore users wait a much shorter time (about a minute) to get confirmation of their transactions (Gilad et al, 2017).   Transactions on Bitcoin on the other hand take about an hour to be confirmed. The proof-of-stake methods are also more energy efficient and greener because they avoid the computational costs associated with proof-of-work validation mechanism.

The native cryptocurrency on the Algorand blockchain is the Algo. As of 11th October 2023, on the Coinbase crypto exchange, one Algo was exchanging at 0.0936 USD. The Algo is usually split into microAlgos. One Algo is equivalent to one million microAlgos. The minimum transaction fees on the blockchain is 1,000 microAlgos although this may increase based on the size of the transaction (Algorand, 2023). The easiest way to start trading in the Algorand blockchain is to install the Pera Algo Wallet App. The wallet allows connection to the TestNet for testing applications.

Development on the Algorand Blockchain

Algorand applications usually run on the Algorand blockchain network. The two main networks that are available are the *MainNet* and the *TestNet*. In order to test applications, one needs a node connected to the *TestNet*. In the *TestNet* a development account can be loaded with test Algos from the *Algorand Testnet Dispenser* website (https://dispenser.testnet.aws.algodev.network/). The *MainNet* is used for production purposes. In the *MainNet*, every transaction will lead to spending in terms of the associated transaction cost.

Algokit is a set of tools and libraries that together are used for building applications for the Algorand blockchain (Algorand, 2003). Algokit installs a network known as a *LocalNet* on the local computer. A developer can then create local wallets and test accounts on this local network. The local network can be explored using a web based tool known as *DappFlow*. *DappFlow* can be used   to view the local wallets, accounts, account status, transactions and even dispense Algos to the local accounts for testing purposes.
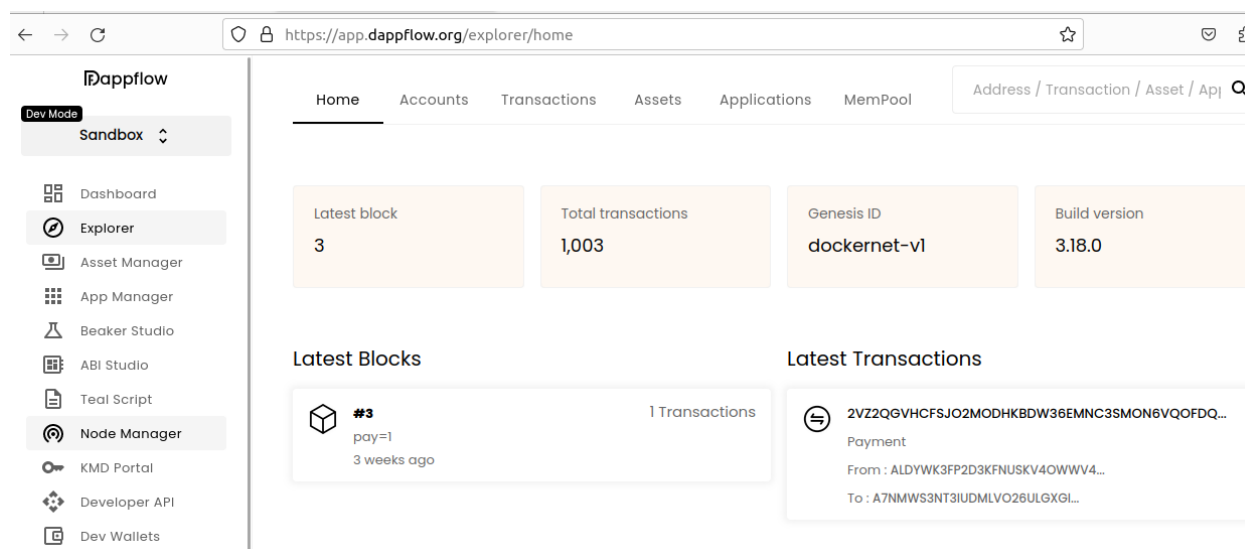
Figure 1: DappFlow homepage for a LocalNet sandbox node

As an example, to develop using Javascript, a developer will need to install *node.js*, on their server, then install the *algosdk* node.js library using node package manager (npm). In such a case, the blockchain application will run as a *node.js* service. Such applications will interact with either the key management daemon (kmd), the indexer and the main blockchain daemon (algod). Kmd is used to manage local wallets and accounts in the LocalNet. The indexer runs on *localhost* port *4002*. The indexer is used for fast querying of the blockchain status information such as account balances. The indexer runs on localhost port 8980 by default. Algod is the main blockchain daemon and stores and updates a copy of the blockchain ledger. Algod runs on localhost port 4001 by default.

It is possible for one LocalNet installation to be shared by several developers. This can be done via port forwarding so that the LocalNet services are available outside the virtual machine instances. This is illustrated in figure 2.
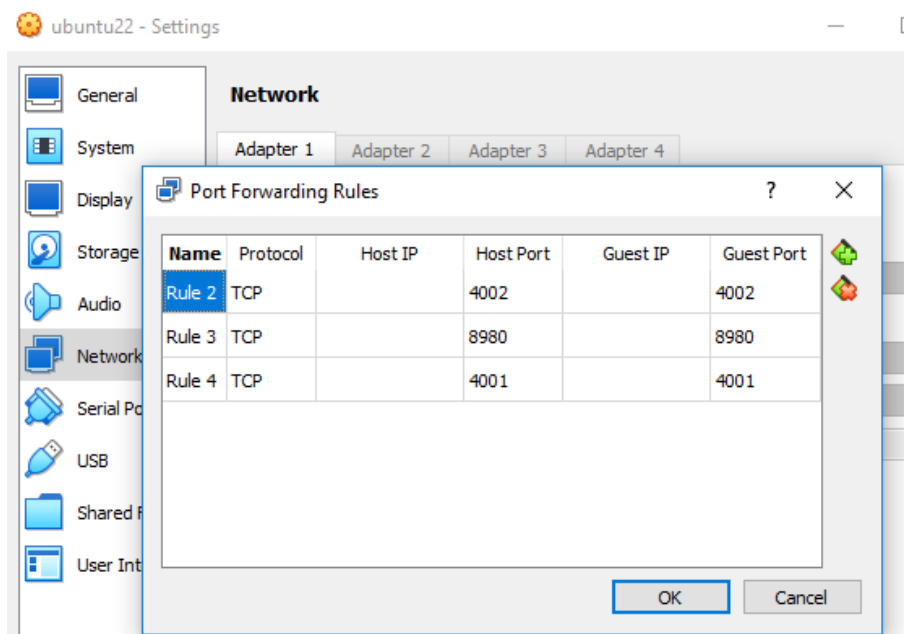
Figure 2: Put forwarding to enable LocalNet to be accessible outside the installation host

To develop smart contracts and smart signatures, a developer will install *pyteal* and *beaker-pyteal* python packages. These are used to create expressions that are compiled to TEAL for execution by the Algorand virtual machine (AVM). Smart contracts and smart signatures are stored on-chain and are callable from applications running on client machines.

Algorand Hackathon

The Multidisciplinary Educational Global Alliance for Algorand Center of Excellence (MEGA-ACE) is a collaborative project between the seventeen partners including University of Nairobi led by Purdue University funded by the Algorand Foundation.Its purpose is to support research and building of blockchain applications especially on the Algorand Blockchain. Promotion of the use of Algorand blockchain among students in one of the major objectives of the project. In pursuance of this goal, a hackathon was held on 14ᵗʰ to 16ᵗʰ April 2023 and winners were selected by a panel of judges. The hackathon had two types of challenges categorized as technical and open. The technical challenge was further sub categorized as advanced, medium and beginner. The technical challenges were assessed by an industrial partner (CoinFabric) from Argentina. A participant was free to propose their own project for the open challenge. For the technical challenge, there was a closed list of projects proposed by CoinFabric and are listed in table 1 (Waissbein, A. Argimiro, 2023).

Table 1: Technical challenge projects

Beginner Level	
Developer's helper	Help generate routing code for a developer
One-stop NFT Creator	Create an NFT
Medium Level	
Tic-tac-toe smart contract champion	An dApp to plays tic-tac-toe with a human player
Box-based indexing	Store game status in the blockchain
Advanced Level	
Improve TEAL smart contracts	Optimize TEAL smart contracts code
Improve PyTeal transpiler	Optimize PyTEAL smart contracts code

Students from 3 local universities (Nairobi, JKUAT, and TUK) participated in the hackathon and won various prizes. All the students who participated won prizes the amount of which depended on their performance. The global winner of the advanced challenge was a student from the University of Nairobi who worked on the "Improve PyTeal transpiler" problem. The student reported that he used *dead code elimination* and *control flow optimizations* to improve the code.

Conclusion

Hackathons are an essential method of exposing students to new technologies. The students proved that they are able to learn and create solutions using the Algorand developer kit (Algokit) even within a short period. The hackathons should be supported so that students and organizer expenses are covered. Availability of comprehensive documentation goes a long way in reducing the students' learning time. Award of prizes will encourage students to participate and endeavor to perform well.

Acknowledgements

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Short Lecture 13   Poisson-Lomax Distribution

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Keywords: Lifetime, Lomax, Generators, Order, Statistic, Compound, Distribution, Mixture

We propose in this a paper a new lifetime distribution with a decreasing failure rate. The distribution is formed by compounding zero-truncated Poisson distribution and the Lomax distribution. Probability density function, survival function and the hazard function of the resulting lifetime distribution are obtained via generators introduced by Mecha et al. (2021). In additional, statistical properties mean and variances are obtained via r th moments. EM-algorithm and maximum likelihood estimator are used to estimate the parameters of the life time distribution. We extend this paper by applying the new proposed distribution to real data to ascertain the potentiality of the new distribution.

Short Lecture 14   Predicting loss-to-follow-up in Nairobi urban informal settlements for a two-stage population-based epilepsy prevalence study using supervised machine learning

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Keywords: Machine learning, Loss-to-follow-up, EPInA, Epilepsy, Urban settings, Africa, Prevalence

Introduction

Machine learning algorithms are increasingly becoming popular for modeling and predicting outcomes given a set of covariates. Machine learning algorithms have the ability to quickly identify patterns and trends from large volumes of datasets that is then used for prediction. Just to mention a few of the recent applications, these techniques have been applied to aid in clinical decision making (Peiffer-Smadja et al., 2020; Wang et al., 2022) and development of diagnostic applications (Jones et al., 2023), identification of gastrointestinal predictors for the risk of COVID-19 related hospitalizations (Liptak et al., 2022) among other examples.

In this study, we compare different machine learning algorithms and determine the best performing model to predict LTFU for participants screened for epilepsy in the Nairobi urban and health demographic surveillance system (NUHDSS). As a by-product of this analysis, we also determine predictive factors for LTFU among participants screened for epilepsy using machine learning classification algorithms. We hypothesize that socio-demographic characteristics of participants collected at the first stage of the screening can be modelled to predict those at risk of being lost-to-follow-up and this understanding can help researchers plan individualized targeted mobilization for scheduled follow-up visits or future clinical appointments.

Methods

All individuals living in the Nairobi urban informal settlements were screened for epilepsy using two stages of screening. LTFU was defined as individuals identified at the first stage who did not show up at the health facility to be seen by a neurologist (second stage). Preprocessing activities to prepare the dataset for analysis included: one-hot encoding of categorical variables and synthetic minority over-sampling technique (SMOTE) used to address outcome class imbalance and numeric variables were scaled and centered. There were no missing values in all the predictors. We randomly split the dataset into training and testing datasets

in the ratio 7:3 and trained seven machine learning prediction models. To tune the hyperparameters, training data was used to perform 10-fold cross-validation. To test predictive performance of the models, 100 bootstrap samples of the test data was used to compute various predictive performance measures (accuracy, area under the receiver operator curve (AUC), sensitivity, specificity and Brier scores) and summarized using quantiles.

Results

In total, 1126 participants were identified as probable cases of epilepsy from Korogocho and Viwandani. The socio-demographic characteristics of the study participants are presented in Appendix 1. The majority of the participants (69%) were from Viwandani. There was even distribution by sex in both sites and the median age was 27 years (interquartile range: 17-38). Slightly over a third had primary education. About 21% of the participants from Viwandani were in full time or part-time employment, compared to 7% from Korogocho. More than half of the participants were married or living together with a partner. There were differences in the size of the households between the two sites with 58% of Korogocho participants being from larger households (4 or more members) compared to 45% from Viwandani. A total of 253 (22%) participants were lost to follow up in the second stage of the screening. The major reasons for LTFU were outmigration, withdrawing consent and work commitments.

Random forest and eXtreme gradient boosting machine (XGB) were the best performing model when evaluated on the 100 bootstrap samples of the test data (Random forest: AUC=0.97, accuracy=0.94, sensitivity=0.93, specificity=0.95, Brier score=0.06; XGB: AUC=0.95, accuracy=0.90, sensitivity=0.88, specificity=0.92, Brier score=0.08) and the nonsynthetic (actual) dataset (Random forest: AUC=0.90, accuracy=0.91, sensitivity=0.88, specificity=0.92, Brier score=0.08; XGB: AUC=0.89, accuracy=0.84, sensitivity=0.84, specificity=0.84, Brier score=0.10). Based on ranked features from the random forest and XGB algorithms, residential location, age, sex, education level, employment status, marital status, household size and duration since first screening were identified as factors with most predictive value for increased risk of LTFU.

Conclusion

Random forest and eXtreme gradient boost models were found to have the most promising ability to predict risk of LTFU for patients screened for epilepsy in Nairobi urban informal settlements. This study has demonstrated that given sufficient socio-demographic characteristics of participants at baseline, risk of LTFU can be predicted using machine learning models. These models can aid researchers plan targeted mobilization for scheduled follow-up visits or future clinical appointments. Further, residential location, age, sex, education, employment and duration since first screening were identified as factors with most predictive value for increased risk of LTFU. These findings suggest that regardless of when a participant was screened, or how soon the next clinical appointment is for a

participant, effort should be made to mobilize each participant for their next clinical appointment with more attention to those in formal employment, those living in an industrial area with high migration rates, teenagers and young adults, and those with higher levels of education.

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Student Presentations

Harnessing Science and Technology for Resilience and Sustainability of Communities

Student Presentation 1   Influence of Weather Parameters on the Air Quality of Nairobi, Kenya

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Atmospheric pollution is currently an existential threat to people living in urban areas. It affects lives in different ways including health, water and food resources. Concentration of vehicular air pollutants in urban areas has been associated in many studies with aspects such as, the emission rates of sources and transport infrastructure in urban areas. In this study, the causality relationship of ambient weather parameters and that of vehicular pollutants concentrations collected simultaneously in Nairobi was investigated.

This study was achieved by first determining the individual relationship between atmospheric pollutant concentrations with individual meteorological parameters, then determining the relationship between individual atmospheric pollutants with combined meteorological parameters, then investigating the trajectories of pollutants and finally by simulating the concentration of atmospheric pollutants over Nairobi for a period of six years using multiple regression model.

The pollutants concentration data of O3, SO_2 and $PM_{2.5}$ and that of ambient weather parameters of temperature, RH, SR, wind speed and AP collected for a period of 120 hours were used. Other datasets of archived meteorological data for trajectory analysis were collected from NOAA website for the same period of time. Additionally, Monthly data for temperature, RH, AP, SR and wind speed from Dagoretti weather station for a period of 6 years were used. Graphical and statistical analyses were used and results presented in tables, charts and equations.

Individual pollutants from the two data sites showed similar casualty relationships when tested with individual weather parameters except for $PM_{2.5}$ which had contradicting results at the two data sites. Notably, there was a contradicting relationship with how some weather parameters affected atmospheric pollutants individually and when tested combinedly. The results from Hysplit model showed that the South Western part of the city was the most affected by air pollutants even though the simulation of pollutant concentrations using regression model for the six years of 2016 to 2021 showed a general decrease in pollutant concentrations. This study recommends inculcation of atmospheric pollutants observation and forecasting using weather parameters within Nairobi and other urban areas in the country to improve decisions on public health and other sectors that maybe influenced by ambient air pollution.

Student Presentation 2   Perceptions of Ecosystem Services and Climate Change in the Communities Surrounding Mt. Kenya and Mt. Elgon, Kenya

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Keywords: Ecosystem Services; Climate Change; Tropical Montane; Adaptive Capacity; Indigenous Knowledge

Introduction

Mountains are vital ecosystems that support large populations throughout the world. They are uniquely exposed and sensitive to climate change, but the nature of this vulnerability is imperfectly understood (Büchler et al., 2004; Buytaert et al., 2011; Kohler & Maselli, 2009). Ecosystem services are a useful lens with which to examine climate change impacts, as they convert ecosystem function to human terms - the services that the mountain provides to people (MEA, 2005; Pascual et al., 2017). In turn, local communities are best positioned to document these changes as they directly benefit from mountain services, and are able to therefore provide detailed observations of changes- providing a level of specify that is not possible from climate models (Reyes-García et al., 2019; Savo et al., 2016). This is particularly important in remote areas of the world. This study examined examines local observations of climate change in the two tallest mountains in Kenya - Mount Kenya and Mount Elgon (Downing et al., 2023b, 2023a)- to better understand the types of changes occurring in these vulnerable ecosystems.

Methodology

This study used qualitative and quantitative methods to elicit local perceptions of climate change in the montane areas of Kenya. Household questionnaires were administered to 209 individuals around both mountains using a cluster sampling strategy. The purpose of these questionnaires was to provide a quantitative look at how communities perceive ecosystem services from the two mountains, and what changes they have seen in those two mountains. Factors influencing these perceptions were also investigated using an ordinal logistic regression. Finally, qualitative methods were used visa focus group discussions and interviews to provide detail and context to these broad-scale perceptions.

Results and Discussion

Respondents had a high appreciation for ecosystem services. Provisioning, regulating, and cultural services were all rated highly- with most respondents ranking their importance as

high or very high. Respondents pointed to numerous specific services that they received from the mountains including forage for livestock, medicines, water, and air quality. Water supply was rated as the most important service of the mountains (Figure 1).
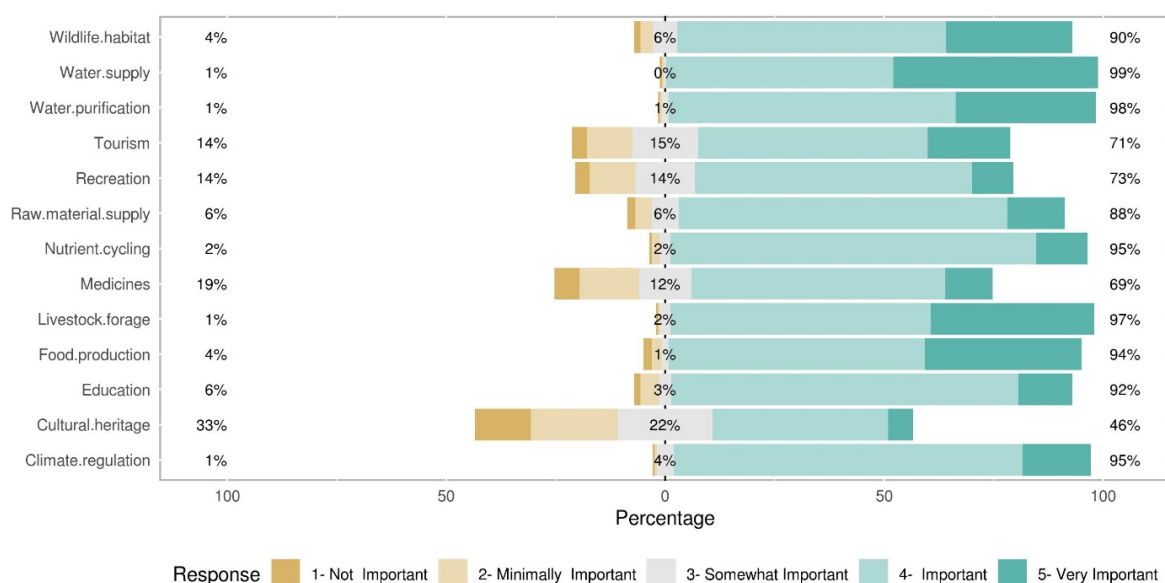

Figure 1: Importance of listed ecosystem services according to respondents (n=209).

There was more variability concerning views of changes in these services, with some reporting very little changes and others reporting very high changes. The majority, however indicated changes had been observed over their lifetimes. These changes were consistent with IPCC reports of changes, including changes in temperature, water availability, vegetation, and soil characteristics (Table 1).

Table 1: Observed environmental changes as compared to climate model predictions

Category	IPCC Observed Changes (IPCC, 2022)	Observation in Alpine areas of Kenya
Temperature	• glacier reduction (very high confidence) • decline in snow cover (high confidence)	• snow line shifting up- to 4200m • ice disappearing • warmer days but colder nights • glacier retreating
Precipitation and Streamflow	• increase in natural disasters such as landslides (medium confidence) • changes in amount and timing of runoff and streamflow (very high confidence)	• daily rainfall pattern changing, less rains in the morning • increase in hail and lightening • rains coming from any and all directions and forming suddenly without warning • increased rain intensity

Category	IPCC Observed Changes(IPCC, 2022)	Observation in Alpine areas of Kenya
	• loss of aesthetics, recreation, and tourism due to glacier and snow decline (medium confidence)	• rain seasonality changing; planting season shorter than before • decline in total precipitation • lake levels sinking; permanent rivers becoming seasonal or drying up
Vegetation and Wildlife	• increase in species in mountains due to upslope shifting (very high confidence), but also declines of cold adapted species on summits (high confidence) • increases in disturbances- such as wildfire (high confidence) • temporary increases in plant productivity (medium confidence)	• plants flowering more often • moss, lichen, and other species growing at higher elevations • giant rosettes plants dying off at lower elevations • new plants species appearing • some plants becoming smaller at higher elevations, whereas others growing faster and bigger • loss of a variety of tree and animal species • animal ranges expanding- birds going lower; lions going higher
Soil and Air	• Decrease stability of mountain slopes due to ice thaw (high confidence)	• loss of soil frost action in the moorlands • soil in the moorland more stable than before • erosion and landslides more frequent • decline in air quality

Demographic factors influenced perceptions, but interestingly spatial variables played an equally large role. The degree to which a community directly interacted with the mountains determined how they viewed the mountains and their resources (Table 4).

Table 4. Ordinal logistic regression between demographic and spatial factors on interaction with the mountains.

Factor	Frequency of Visiting Mountain	Knowledge of the Mountain	Importance of the Mountain
Sex [Male]	0.86***	0.36	0.13
Move Here [Yes]	0.35	-0.52*	0.00
Education [Secondary+]	0.31	0.69**	0.09
Occupation [Other]	-0.54*	-0.08	-0.35
Ethnicity [Kikuyu]	-0.18	1.14*	2.39***
Ethnicity [Other]	-0.37	0.80	0.17

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Factor	Frequency of Visiting Mountain	Knowledge of the Mountain	Importance of the Mountain
Distance Road [Near]	0.37	-0.69	0.37
Distance Alpine [Near]	-0.56**	-0.27	0.26
Study Site [Mt Kenya}	-1.10	-0.41	-4.18***

* = $p < .1$, ** = $p < .05$, *** = $p < .01$

Conclusion

Local observations of the environment can be a valuable resource to understanding climate change impacts, particularly in remote areas. The communities surrounding Mount Elgon and Mount Kenya had a high level of interaction with the mountains and their resources, and had perceptive views on changes in these areas. These observations complement climate change predictions and provide a local specificity lacking in the models.

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Student Presentation 3　　　Evaluation of the Skill of Seasonal Rainfall and Temperature Forecasts from Global Prediction Models Over Ethiopia

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Keywords: Ethiopia; Seasonal Forecast; Domain; Lead time; Model evaluation

The skill of seasonal climate predictions from global forecasting models varies considerably across different regions and seasons. Evaluating the accuracy of these models in predicting rainfall and temperature for various seasons is crucial for enhancing forecast skill and ensuring the efficient utilization of forecast information. This study analyzed the performance of the North American Multi-Model Ensemble (NNME) and Copernicus Climate Change Service (C3S) seasonal forecast models in predicting the June-September (JJAS) and February-May (FMAM) seasonal rainfall and temperature over Ethiopia. The seasonal forecast models were evaluated for the hindcast period of 1994–2016 using the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) as a reference for rainfall and the Climatic Research Unit (CRU) for temperature. The skill assessment is conducted using the recently developed Python-based Climate Predictability Tool (PyCPT). The model predictor domains used were tropical ocean, Western Indian Ocean, Ethiopia itself, Atlantic and Indian Ocean at forecast time leads 2-month, 1-month and 0-month. The models' skill assessment was performed using various skill scores such as Pearson correlation, Relative Operating Characteristic (ROC) and Ranked Probability Skill Score (RPSS).

The results show that the NMME and C3S models show varying levels of the skill of forecasted seasonal rainfall. The better performing models with ROC score exceeding 0.5 are CanSIPS-IC3, ECMWF-SEAS5, DWD-GCFS2P1, CMCC-SPS3P5 and Meteo-France-system8. These models show high promising skill in predicting JJAS rainfall season across Central, Northeastern, Northern, Northwestern and pocket areas in Eastern portion of Ethiopia compared to other models like, (GFDL-SPEAR, RSMAS-CCSM4, NASA- GEOSS2S and NCEP-CFSv2). However, most models have low skill (ROC<0.5) to predict the JJAS rainfall seasons over Southern, Southeastern, Southwestern and Western half of the country. It has been indicated that May and June initialized forecasts show a better skill compared to April initialized forecast during JJAS season. For effective agricultural and water management planning, the preferred choice is the May-initialized forecast. During the FMAM season, the models show high promising skill (ROC >0.5) in forecasting the seasonal rainfall in the Southern, Southeastern, Central, and Eastern Ethiopia, but their skill is low (ROC<0.5 in the Western half of Ethiopia. Among the models assessed, GFDL-SPEAR, CanSIPS-IC3, ECMWF-SEAS5, DWD-GCFS2P1, CMCC-SPS3P5 and Meteo-France-system8 models show high ability in forecasting the FMAM seasonal rainfall compared to other models like, (RSMAS-CCSM4, NASA-GEOSS2S and NCEP-CFSv2). It

has been indicated that the 1-month lead forecast (initialized in January) exhibit a better skill compared to the 2-month and 0-month lead time forecast. The evaluation of various predictor domains' effect on forecast skill shows that the Tropical region (-180W to 180E, -30S to 30N) exhibit higher skill in the JJAS and FMAM seasonal rainfall forecast for Ethiopia when compared to other domains. It has been noted that ability of models in forecasting the below normal rainfall are higher than the above normal rainfall for both JJAS and FMAM rainfall seasons.

The findings indicate that the models perform better in predicting temperature compared to their performance in predicting rainfall. During the JJAS season, the SPEAR, CCSM4, CFSv2, GEOSS2S, GCFS2P1, and SPS3P5 models exhibit better skill (ROC>0.5) in predicting the seasonal temperature across much of the country, with the exceptions being in Northwestern and Southeastern Ethiopia, when compared to other models like CanSIPS-IC3, ECMWF-SEAS5, and Meteo-France-system8. During the FMAM season, the SPEAR, CanSIPS-IC3, SEAS5, CFSv2, GEOSS2S, GCFS2P1, and SPSv3P5 models display high promising ability (ROC>0.5) in forecasting the seasonal temperature across most portions of the country, with the highest ability observed in the Western half of Ethiopia. However, CCSM4 and METEOFRANCE8 models show low spatial skill (ROC<0.5) in their temperature predictions. The ability of models in forecasting the above normal temperature are higher than the below normal temperature for both JJAS and FMAM temperature seasons.

Overall, the C3S and NMME offer hopeful skills for predicting seasonal rainfall and temperature over Ethiopia during the FMAM and JJAS seasons, encouraging further research to evaluate their skill with additional predictor domains.

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Student Presentation 4   Preliminary Study of Photometric Variable Stars in Open Cluster NGC 1893

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Keywords: Open Clusters, Variable Stars, Photometric Observations.

Abstract
Open clusters provide an excellent laboratory for investigating the characteristics and behavior of different types of variable stars. Astronomers gain insights into the physical processes that govern these stars, their intrinsic properties and the evolution of the galaxy by studying the variable stars within the open clusters. From a sample of 1365 light curves using V-band CCD photometry observation, we identified 2 variable stars in one night of observation. From the Lomb-Scargle periodogram analysis, we determined the period of rotation the variable stars. We aim to characterize these variables and check out for any other variable stars that might not have been able to be detected in a one night of observation using archival space-based data.

1 Introduction:

1.1 Open clusters

Stars form in clustered environments (Lada & Lada 2003); hence, young open clusters are excellent laboratories for the study of the star formation mechanism and early stellar evolution (Maurya et al., 2021) as member stars of the cluster are born from the same molecular cloud (Maurya and Joshi, 2020). For instance, they are used to trace the Galactic disk formation and structure (Joshi et al., 2016). Photometric analysis of these open clusters can provide valuable information about a cluster's star population, including variable stars.

The high number of stars present in the open clusters give an opportunity to study thousands of stars which increases the chance of detecting variable stars within the clusters (Joshi et al.,2020). The characteristics of these variable stars at different stages of evolution is used to derive parameters such as their luminosity, radii, masses, and their variability nature gives information on stellar pulsation models (Joshi et al.,2020; Glushkova et al., 2013). This needs extensive photometric observation of the star clusters for a long period of time.

Variability of young stellar members also enhances diagnostics on the accretion or rotation properties of the stars, and how they relate to the circumstellar environments (Morales-Calderon et al., 2011; Lata et al. 2022).

1.2 Variable stars

These are the stars whose flux is observed to vary notably in intensity. These fluctuations in intensity could be periodic, semi-regular, or completely unpredictable in nature. Different types of variable stars are differentiated by criterion such as their period and the magnitude range. Variability in stars can be either as a result of intrinsic or extrinsic parameters. Variable stars which are as a result of intrinsic properties are categorized as pulsating variable stars and eruptive variable stars (Dutta et al., 2018). Variability which is as a result of extrinsic factors can result may be due to the rotation of the star or in a case of eclipsing binaries (Carpenter, Hillenbrand & Skrutskie 2001).

In this work, we present preliminary study of the stellar variability towards the young open cluster NGC 7209 using data of NGC 1983, which is an open cluster located in the Dorado constellation and part of the Large Magellanic Cloud, focusing on the methodology and data analysis in our research work.

The analysis of variable stars in open clusters provides information on the effects of mass transfer, stellar interactions, and the evolutionary pathways on variability. Moreover, observations of open clusters facilitate the determination of their accurate distances which enables the improvement of calibration of various distance indicators.

2 Methodology:

2.1 Observations

The photometric data was obtained using the 104 cm Sampunarnanad Telescope, located at ARIES, Nainital, India.

The telescope is an equatorial mount telescope with Cassegrain focus system. It was equipped with a $2K \times 2K$ CCD detector and having a Field of View of $13.5 \times 13.5\ arcmin^{-2}$. The filter that was used on the Charge Coupled Device (CCD) was the V filter.

The data is of observations made in one night of observation on 21 Nov, 2008.

2.2 Data Reduction and Analysis

We used the three basic steps of image processing in photometric measurements, these are; pre-processing, processing and post-processing.

The aim of pre-processing is to clean the raw images before the extraction of the instrumental magnitudes from the images. Pre-processing involves; bias subtraction, flat-fielding and cosmic ray removal.

The aim of data processing is to obtain the instrumental magnitudes from the image. The packages used in this step is a revised version of Dominian Astrophysical Observatory Photometry (DAOPHOT II) software by Stetson (1987) and the ALLSTAR packages.

The aim of post-processing step is to get the standard magnitude of the detected sources. For this purpose, the DAOMATCH and DAOMASTER subroutines of the DAOPHOT II were used to crossmatch the sources detected in all the frames.

2.3 Astrometry

The world coordinate system (WCS) coordinates of the detected sources were obtained using the Digitized Sky Survey (DSS) point source catalogue. A list of 25 isolated bright sources was chosen from the reference frame from which the astrometry was to be done, and their corresponding Right Ascension (RA) and Declination (Dec) coordinates in the DSS catalogue and pixel coordinates were matched.

Then CCMAP task of the IRAF computes the plate solution for an image using a list of matched pixel and celestial coordinate. CCTRAN applies the plate solution to a list of pixel or celestial coordinates in the text file input which was generated by ccmap. We obtained astrometry accuracy of approximately 0.1 arcsec.

2.4 Periodogram analysis

The Lomb–Scargle periodogram (L-S periodogram; Lomb 1976; Scargle 1982) was used to find the significant periodic signals in the light curves and construct the phase folded light curves. L-S is a widely used algorithm to find the periodic signals in an unevenly spaced time-series data, that uses a Fourier-like power spectrum estimator for the data to determine the period of oscillation. The obtained period was confirmed using the NASA exoplanet archive periodogram service.

For phase folding, the phase for each variable was computed using the following which takes in the input of the period computed by the L-S periodogram.

$$\text{Phase} = \left(\frac{\text{JD} - \text{JD}_0}{\text{P}}\right) \qquad (1)$$
$$- \text{INT}\left(\frac{\text{JD} - \text{JD}_0}{\text{P}}\right)$$

Where JD is the observation time, JD_0 is the arbitrary epoch of observation, and P is the period of the light curve.

3 Results and Discussion

Variable star identification

To identify variable stars, we produced the light curves of all the stars cross-matched in the different CCD frames. Light curves were generated by plotting the magnitudes of the sources against the Julian date. The identification of variable stars was performed by means of careful inspection of the light curves. A few of the light curves seem to show periodic variability but their periodic nature was not obvious in their observed light curves. The phased light curves of all stars were inspected, and we adopted the period value which produces the most consistent phased light curve. The light curves of a few of the detected stars are shown in Fig. 1 as examples. The phased light curves of variables identified are presented in Fig. 2. By eye inspection and periodogram analysis, we have detected 2 variables in one night of observation.

Conclusion

Star No. 730 has a period of 0.15379 days and the amplitude is about 0.4 mag, while star No. 661 has a period of 0.14917 days and the amplitude is about 0.5 mag. After doubling its period, its light curves show two minima that have almost equal depth.

It could be an EW-type eclipsing (W Ursae Majoris eclipsing system). The variability characteristics of this star is similar to a pulsating type star or eclipsing binary (needs confirmation using archival data like TESS).

We aim to characterize these variables and check out for any other variable stars that might not have been able to be detected in a one night of observation using archival space-based data.
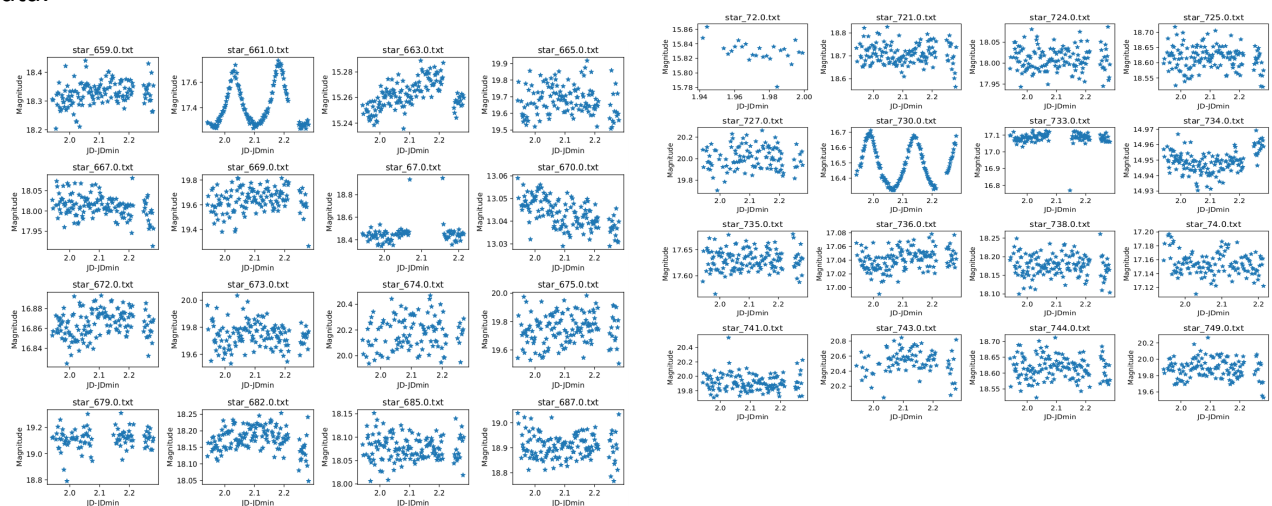

Fig 1. The light curves of a few of the detected stars. Stars 661 and 730 show variability from the shape of their light curves.
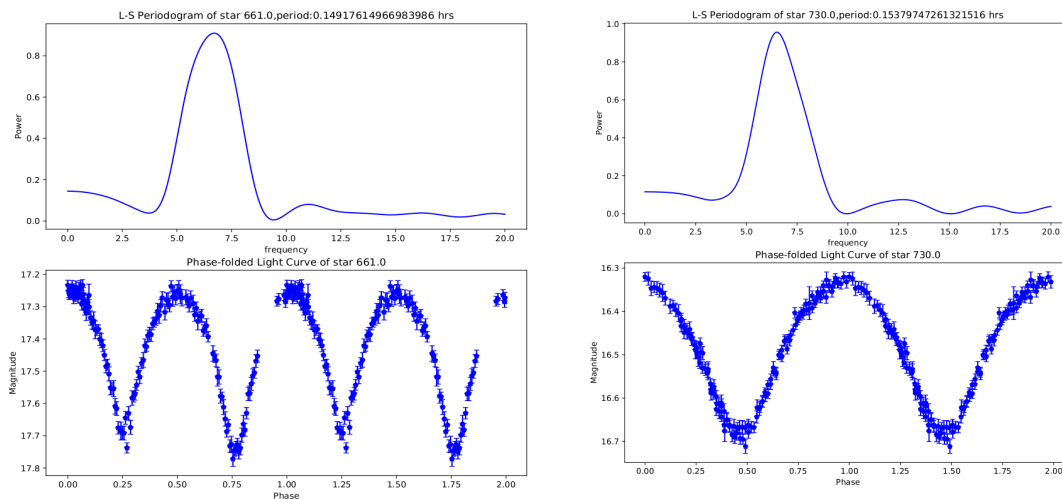
Fig 2. The phased light curves and the L-S periodograms of the two variables identified.

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Student Presentation 5   Is Our Solar System Stable? Analysis of the Chaotic Motion of The Three Outermost Solar System Planets: Jupiter, Saturn, and Uranus

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Keywords: Stability, Perturbations, Resonances, Eccentricities.

Abstract

The question as to whether our solar system is, and shall remain stable forever still remains a major unsolved problem in solar system dynamics and evolution studies. Over the years, research efforts by prominent mathematicians and astronomers (Newton, Lagrange, Laplace, Gauss, Poisson, Poincare, Arnold Moser and Kolmogorov, just to name a few) have to date, failed to establish conclusively whether the currently experienced solar system stability shall last forever and, or establish the possible timeline of any imminent instability, thus posing a serious challenge at the frontiers of our knowledge and understanding on the future fate of our solar system, and in extension our planet Earth. This research work is part of an effort in that remarkable endeavor. We perform an ab initio derivation of the governing dynamical equations describing solar system dynamics with a focus on the spatial perturbations in motion of the three largest solar system planets: Jupiter, Saturn and Uranus, which collectively contain about 99% of the total solar system mass, exclusive of the sun. The derivation of the perturbation equations is performed from the mutual equations considering gravitational attraction within a four-body problem scenario to a first approximation where the sun is considered stationary. The perturbation equations are integrated and evolved in time from the epoch of solar system formation to date, and the results for the possible changes in spatial position and periods analyzed. Analyses of Orbital resonances, and orbital eccentricity for the three planets will be carried out and the eccentricity graphs drawn. Our results point towards a solar system that attained stability within the first half a million years after formation, and continues to remain stable to date. We present and discuss the possible implication of these interesting results and provide a way forward.

Introduction

The solar system consists of the sun, which is a dominant star, and everything bound to it by gravity. These include; the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune; dwarf planet such as Pluto; satellites of the planets; the interplanetary medium; dozens of moons; millions of asteroids, comets and meteoroids.

Each planet moves on its own orbit around the sun. The sun controls the motions of the planets, providing the radiant energy to power the entire solar system. Due to the large mass of the sun, it acts as a gravitational glue, attracting all the planets to itself.

Astronomers and mathematicians of old age have been fascinated and attracted by the problem of stability of the solar system, since the discovery that *wandering stars* (planets) move around the dominant and fixed star. Their efforts focused on finding a regularity in the motion of these planets to help predict their motion around the sun. The outcomes have not yet been settled at to prove that the solar system is stable.

In the last three centuries, prominent physicists who have performed some research on the solar system stability problem include: Boris Delaunay, Andrei Kolmogorov, Vladimir Arnold, Carl, Friedrich Gauss, Jurgen Moser, just to mention a few. New mathematical tools such as perturbation theory and the Kolmogorov - Arnold -Moser theorem have inspired modern research on chaos theory and aimed at a better understanding and resolution of the stability problem.

Methodology

We consider the sun and the three planets, Jupiter, Saturn and Uranus as a four-body system, since the solar system stability is heavily influenced by these bodies and derive the equations of planetary motion, involving analysis in perturbations in their motions. The equations of motion are reduced only to the three, presented below, since the solar mass is massive and its acceleration is negligible.

Jupiter; $\dfrac{d^2 r_J}{dt^2} = G\dfrac{m_\odot}{|r_J - r_\odot|^3}(r_J - r_\odot) + G\dfrac{m_{Sat}}{|r_J - r_{Sat}|^3}(r_J - r_{Sat}) + G\dfrac{m_U}{|r_J - r_U|^3}(r_J - r_U)$ (1)

Saturn; $\dfrac{d^2 r_{Sat}}{dt^2} = G\dfrac{m_\odot}{|r_{Sat} - r_\odot|^3}(r_{Sat} - r_\odot) + G\dfrac{m_J}{|r_{Sat} - r_J|^3}(r_{Sat} - r_J) + G\dfrac{m_U}{|r_{Sat} - r_U|^3}(r_{Sat} - r_U)$ (2)

Uranus; $\dfrac{d^2 r_U}{dt^2} = G\dfrac{m_\odot}{|r_U - r_\odot|^3}(r_U - r_\odot) + G\dfrac{m_J}{|r_U - r_J|^3}(r_U - r_J) + G\dfrac{m_{Sat}}{|r_U - r_{Sat}|^3}(r_U - r_{Sat}).$ (3)

We have defined the position r of any planet from the Sun as:

$$r = \bar{r} + \delta r \qquad (4)$$

where δr is a small perturbation in the position of the planet. The perturbation equations in motion therefore become;

Jupiter; $\delta \ddot{r}_J = -(2Gm_\odot + 2Gm_{Sat} + 2Gm_U)\delta r_J + 2Gm_{Sat}\delta r_{Sat} + 2Gm_U \delta r_U$ (5)

Saturn; $\delta \ddot{r}_{Sat} = -(2Gm_\odot + 2Gm_J + 2Gm_U)\delta r_{Sat} + 2Gm_J \delta r_J + 2Gm_U \delta r_U$ (6)

Uranus; $\delta \ddot{r}_U = -(2Gm_\odot + 2Gm_J + 2Gm_{Sat})\delta r_U + 2Gm_J \delta r_J + 2Gm_{Sat}\delta r_{Sat}$ (7)

This was followed by a derivation of dynamical equations for the periods of the three planets using Kepler's third law, with perturbations in the periods investigated. The equations for the periods are presented as follows:

For Jupiter;

$$P_J = \frac{2\pi}{G(M_\odot + m_J)^{1/2}}(r_{S,J})^{3/2} \qquad (8)$$

For Saturn;

$$P_{Sat} = \frac{2\pi}{G(M_\odot + m_{Sat})^{1/2}} (r_{S,Sat})^{3/2} \qquad (9)$$

For Uranus;

$$P_U = \frac{2\pi}{G(M_\odot + m_U)^{1/2}} (r_{S,U})^{3/2} \qquad (10)$$

We have introduced a small perturbation on the orbital period, given by δp, that causes a corresponding perturbation on the semimajor axis, given by δr. So that the orbital period is given by;

$$P = (\overline{P} + \delta P) \qquad (11)$$

While the semi-major axis is given by the equation:

$$r = (\overline{r} + \delta r) \qquad (12)$$

The perturbation equations for the periods are given by:

$$\text{Jupiter;} \ \ \delta P_J = \frac{6\pi^2}{G(M_\odot + m_J)} \frac{(\overline{r}_J)^2}{\overline{P}_J} \delta r_J \qquad (13)$$

$$\text{Saturn;} \ \delta P_{Sat} = \frac{6\pi^2}{G(M_\odot + m_{Sat})} \frac{(\overline{r}_{Sat})^2}{\overline{P}_{Sat}} \delta r_{Sat} \qquad (14)$$

$$\text{Uranus;} \ \delta P_U = \frac{6\pi^2}{G(M_\odot + m_U)} \frac{(\overline{r}_U)^2}{\overline{P}_U} \delta r_U \qquad (15)$$

The position of the inner and the outer planets of the solar system can clearly be shown by the schematic diagram below.
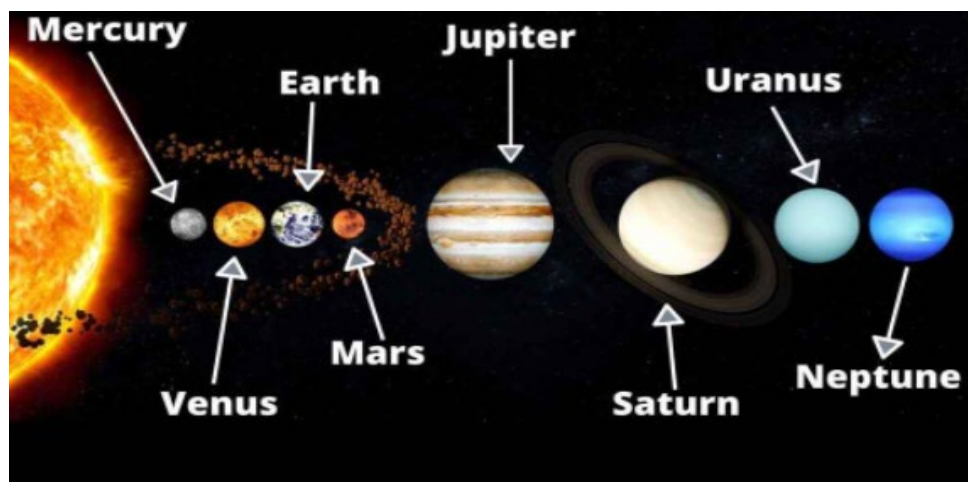

Figure 1:*The solar system showing the arrangement of the planets from the Sun*

Orbital resonances, orbital frequencies and eccentricities are were analyzed by calculation and tabulation. The main source of research data used in this work was the NSSDCA-*NASA* Space Science Data Coordinated Archive, whose URL is, (https://nssdc.gsfc.nasa.gov/planetary/factsheet/)

We used the Ode-int, a package in python, to integrate the perturbation equations of motion of the planets and in the orbital periods using a timescale of 0 — 4.6 billion years. We also used the GNUplot to plot the eccentricity graphs for the planets, from 1750 — 2023.

Results and Discussion

The results indicate that there have been no perturbations in the planetary motions and in the periods of these three planets under study, from about 4,000 years after the solar system formed. A graph illustrating the epoch of stability from the analysis of perturbations in the motion with time is shown below:
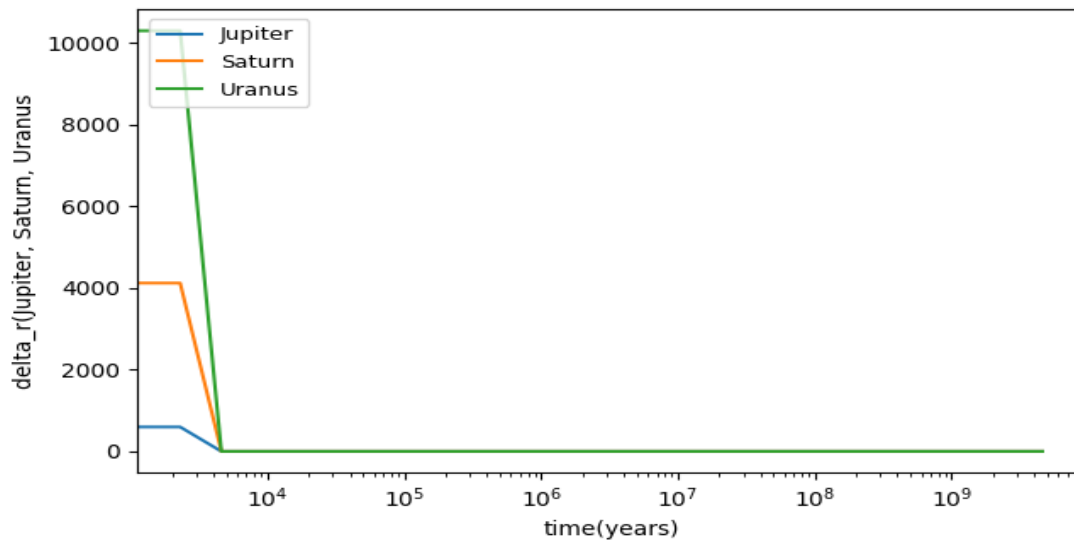

Figure 2: *A graph of δ_r (Jupiter, Saturn and Uranus) versus time (years).*

Results for the perturbations in the periods of the planets indicating the onset of stability are presented from the graph below.
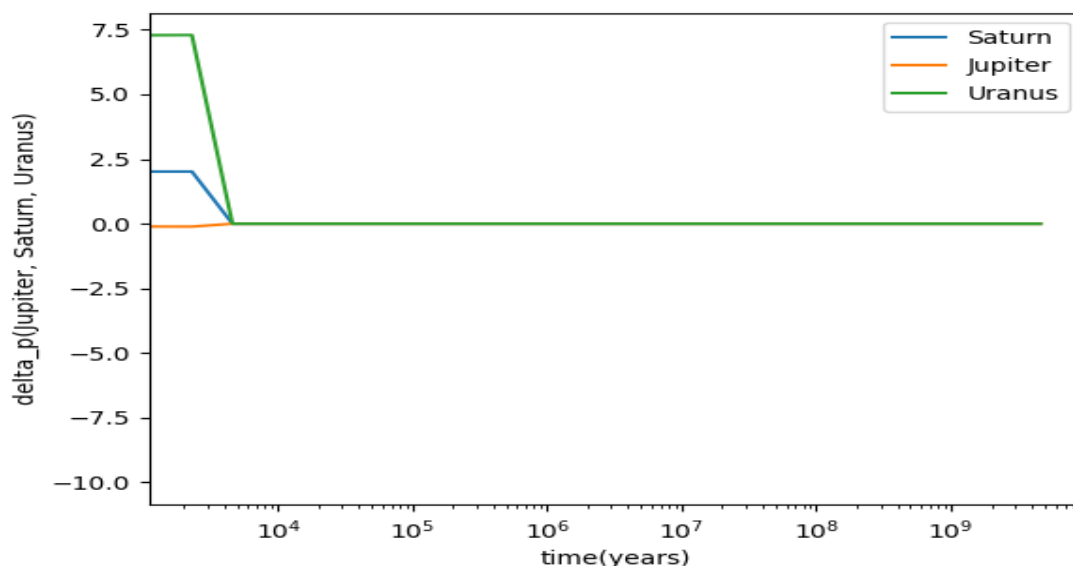

Figure 3*: A graph of δ_p (Jupiter, Saturn and Uranus) versus time (years)*

At the same time, the planets have had a constant eccentricity within the timescale of investigation, with Jupiter at 0.048, Saturn at 0.056 and Uranus at 0.046. These results point towards a proof that their motions are regular. The graph of the maximum value of eccentricity against time for the larger planets showing the curves appearing almost as straight lines, indicating stability, is as shown below:
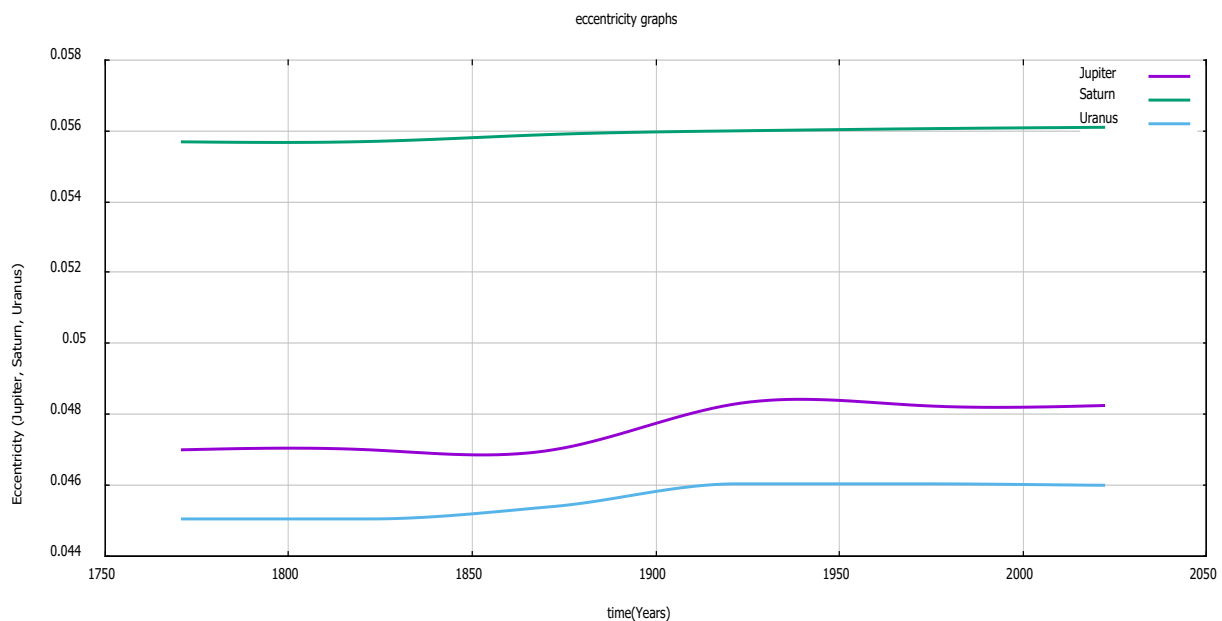
Figure 4: *Graph of eccentricity versus time for Jupiter, Saturn and Uranus.*

The absence of perturbations in the motions and in the periods of the planets, together with the regularity in their eccentricities, draws our attention that there are negligible or no chaotic zones during their motion. It is based on the above results of this research that we conclude the state of the outermost solar system planets as stable, implying that the entire solar system is stable.

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Student Presentation 6   Implementation of Quantum Key Distribution with an Eavesdropper Via the Intercept-Resend Attack

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Key words: Quantum Key Distribution, Eavesdropper, QBER, Implementation.

Abstract

Quantum cryptography refers to the encryption of data using principles of quantum mechanics. The best-known example of quantum cryptography is quantum key distribution, which generates and distributes a secure key between two authorized parties. This key is used with encryption schemes such as the one-time pad to protect data. Quantum Key Distribution is advantageous compared to traditional encryption schemes in that any eavesdropping activity is detectable. The first quantum key distribution protocol, the BB84, was proposed in 1984 by Charles Bennett and Gilles Brassard and used photons as qubits. This protocol takes advantage of the Heisenberg Uncertainty Principle, the no-cloning theorem, and superposition. In this research, we implement the BB84 protocol using IBM's Qiskit, an open-source software that allows for the implementation of the principles of quantum mechanics. We assume a system where there are no errors. Results show that in the absence of an eavesdropper the Quantum Bit Error Rate is equal to zero, while in the presence of an eavesdropper a QBER > 0 is achieved.

Introduction

Quantum Key Distribution protocols are divided into two categories depending on the principles of quantum mechanics that they exploit (Gyongyosi et al., 2019). The entanglement-based protocols rely on entanglement while the prepare and measure protocols rely on the Heisenberg Uncertainty Principle, the no-cloning theorem, and superposition to safeguard information (Elboukhari et al., 2010; Haitjema, 2007). The BB84 protocol, whose first implementation was over 32 cm, is an example of the prepare and measure protocols (Bennett & Brassard, 1984). This protocol involves two authorized parties: the sender, Alice, and the receiver, Bob. Alice generates a random string of classical bits and encodes them into qubits using a randomly chosen encoding basis. She transmits these qubits to Bob via the quantum channel, an example of which is an optical fiber. Upon receiving these qubits, Bob chooses his measurement bases, decodes the qubits, and records the results. Using the classical channel, Alice and Bob compare their measurement bases and discard bits whose bases do not match, leaving behind the sifted key (Ruiz-Alba et al., 2010).

The BB84 protocol makes use of two measurement bases conjugated to each other: the rectilinear basis, and the diagonal basis (Lee et al., 2022). Each measurement basis is made up of two polarization states, which are orthogonal to each other. The rectilinear basis constitutes the horizontal ($\rightarrow$) and vertical ($\uparrow$) polarization states, while the diagonal basis is made up of 45^0 ($\nearrow$) and 135^0 ($\nwarrow$) polarization states. Before implementing the protocol, Alice and Bob agree on which bit value each polarization state will represent. As an example, bit 0 can be represented by $\{(\rightarrow), (\nearrow)\}$ and bit 1 by $\{(\uparrow), (\nwarrow)\}$ (Lee et al., 2022).

An eavesdropper attempting to intercept the information using the intercept-resend attack first measures the qubits then transmits them to Bob in their new state. When Alice and Bob compare a subset of the sifted key in post-processing, they notice anomalies, indicating the presence of an eavesdropper (Lee et al., 2022). This is because upon measurement, Eve collapses the initial state of the qubit, which is impossible to restore.

The Quantum Bit Error Rate (QBER) is used to detect the presence of an eavesdropper. It is the ratio of the number of mismatched bits over the total bits used for comparison.

$$QBER = \frac{No.of\ mismatched\ bits\ in\ K}{K} \tag{1}$$

K is a subset of the sifted key and is determined using equation 2 (Mina & Simion, 2021).

$$K = \frac{|M|}{3} \approx \frac{N}{6} \tag{2}$$

A QBER greater than 11% indicates the presence of an eavesdropper (Lee et al., 2022). Assuming a perfect distribution system, the QBER should be equal to zero in the absence of an eavesdropper.

Methodology

IBM's Qiskit, available at *https://www.ibm.com/quantum,* is an open-source software that makes it possible to simulate quantum principles such as superposition through circuit design. We use the Python3 programming language to write code necessary for the implementation, the *random* module to generate a string of classical bits and choose measurement bases at random, and the *QASM simulator* to run quantum circuits and measure the results.

The measurement bases used in Qiskit are the standard measurement basis (z axis) and superposition. Superposition is created by applying an H gate to the selected qubit. To create superposition starting from a bit value of 1, an X gate is first applied to covert the bit from $|0\rangle$ to $|1\rangle$, since qubits are preset to $|0\rangle$ in Qiskit.

Results and Discussion

This simulation was performed using 100 bits. Results obtained show that in both the absence and presence of an eavesdropper, Alice and Bob pick the same measurement bases with a probability of 0.5. Therefore, in the absence of an eavesdropper, the sifted key is approximately half the original bit string.

Fig. 1: Simulation results for the BB84 protocol without an eavesdropper.

The Quantum Bit Error Rate, which is the ratio of the number of mismatched bits to the selected subset, is used to detect eavesdropping. Using equation (2), a sample size of 17 bits was selected. The probability of detecting an eavesdropper was then calculated using equation (1). Without any eavesdropping activity, the QBER obtained was zero, while in the presence of an eavesdropper the QBER obtained was 29.41%.

Fig. 2: QBER in the presence of an eavesdropper.

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Student Presentation 7   Precise Solar Declination Angle Determination for Maximized PV Solar Power Output

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Keywords: Sun position, Declination angle, Equinox, Solstice

Abstract
Determination of highly precise location-specific position of the sun remains crucial for optimized solar power generation efforts for applications such as the dual-axis trackers and solar trees. Accurate computation of the solar declination angle is key in obtaining other important solar angles that can help to determine the sun's precise position in the sky for any location. These include the solar elevation angle and the solar azimuth angle. This research examines the problem of accurate determination of the solar declination angle and other solar angles for precise sun location determination. We review various formulas, varying from simple sine and cosine approximations to Fourier Series Expansions, to those that account for the changes in the obliquity of the earth's orbital ecliptic.

Introduction
Solar applications such as sun tracking systems, solar concentrators and solar radiation measurement instruments rely heavily on accurate determination of the position of the sun in the sky (Rizvi et al., 2014). The path of the sun to an observer on the surface of the earth is defined through various solar angles that give the sun's position in the sky and those relating the panel surface to the sun (Akram Abood, 2015). These solar angles include the solar declination angle, the solar altitude/elevation, the solar azimuth angle, the surface azimuth angle, the tilt angle, the zenith angle and the hour angle (Chowdhury et al., 2019). The solar declination angle is key in calculation of the aforementioned solar angles and hence need to compute it with high accuracy (Al-Naima & Abdul Majeed, 2011).

Solar Declination angle formulas.
Formulas for calculating the declination angle were grouped into four categories. The first category consists of simple sine and cosine approximations based on the obliquity of the ecliptic taken as $\pm23.45^0$ and the revolution angle treated as a function of the day of the year. The commonly used expression is that of a sine approximation which incorporates a correction (λ) that places the March equinox in the right position in the earth's revolution orbit (P. I Cooper, 1969)

$$\delta = 23.45^0 \sin\left[\frac{360(d\pm\lambda)}{365}\right] \qquad (1)$$

λ takes on different values depending on the date for the vernal equinox. λ = 284 can be added or λ=81 subtracted corresponding to the March 22nd vernal equinox (Kyi & Taparugssanagorn, 2020; Makenzi et al., 2020; Sado et al., 2021). Other expressions based on different dates for the March equinox include

$$\delta = 23.45\left[\sin\left(\frac{360}{365}\right)*(d-\lambda)\right] \qquad (2)$$

where λ=80 for March 21st (Roy et al., 1989)

$$\delta = \sin^{-1}\left\{0.4\sin\left[\frac{360}{365}(d-\lambda)\right]\right\} \qquad (3)$$

where λ=82 for March 23rd (Iqbal, 1983).

$$\delta = -23.45\sin(\lambda - d)*\frac{360}{365} \qquad (5)$$

taking λ = 81 for March 22nd (Roy et al., 1989b).

$$\delta = 23.47\left[\sin\left(\frac{360}{365}\right)*(\lambda+d)\right] \qquad (4)$$

The following expression considers a half cycle for the revolution orbit (Roy et al., 1989).

$$\delta = arcsin\left(-cos(d-1)\left(\frac{180}{182.6}\right)sin(23.45)\right) \qquad (6)$$

The second category is formulas based on the December solstice and the June solstice that assume a cosine approximation with corrections that place the solstices in the correct orbit position

$$\delta = -23.45\cos\left[\frac{360}{365}(d+\lambda)\right] \qquad (7)$$

where λ = 10 (AL-Rousan et al., 2018).

$$\delta = arcsin\left(0.39795\cos(0.98563(d-\lambda))\right) \qquad (8)$$

λ = 173 (Kalogirou, 2009)

The third group consists of formulas based on a Fourier Series Expansion developed with. A common form is developed with an angular frequency of ω=0.017202786 up to four harmonics as shown (Duffie & Beckman, 2013)

$$\delta = [0.006918 - 0.399912\cos\eta + 0.070257\sin\eta - 0.006758\cos 2\eta +$$
$$0.000907\sin 2\eta - 0.002697\cos 3\eta + 0.00148\sin 3\eta]\left(\frac{180}{\pi}\right) \qquad (9)$$

where η is the day angle and is obtained as

$$\eta = \frac{2\pi(d-1)}{365} \qquad (10)$$

T

here are two other variations of the Fourier Series formulas owing to different coefficients and calculation of the day angle (Roy et al., 1989a)

$$\delta = 0.3723 + 23.2567 \sin\eta + 0.1149 \sin 2\eta - 0.1712 \sin 3\eta + 0.7580 \cos\eta + 0.3656 \cos 2\eta + 0.0201 \cos 3\eta \tag{11}$$

Calculating the day angle as

$$\eta = (d - 80)\frac{360}{365.2422} \tag{12}$$

$$\delta = 0.33281 - 22.984 \cos\eta + 3.7872 \sin\eta - 0.3499 \cos 2\eta + 0.03205 - 0.1398 \cos 3\eta + 0.07187 \sin 3\eta \tag{13}$$

$$\text{where } \eta = d\frac{360}{366} \tag{14}$$

The Last category considers the obliquity of the ecliptic (ε) and the mean longitude of the sun (L_0) in calculating the declination angle taking a general expression of the form,

$$\sin\delta = \sin\varepsilon \sin L_0 \tag{15}$$

There are various approaches for calculating the ε and L_0 (Jean Meeus, 1998; Walraven, 1978).

$$L_o = 280.46646 + 36000.76983T + 0.0003032T^2 \tag{16}$$

$$\varepsilon = 0.016708634 - 0.000042037T - 0.0000001267T^2 \tag{17}$$

$$\text{where } T = \frac{JD - 2451545.0}{36525} \tag{18}$$

JD is Julian Day.

$$\varepsilon = 23.4420^0 - (3.56^0 x10^{-7})\tau \tag{19}$$

$$L_0 = 4.900968 + (3.67474 x10^{-7})\tau + (0.033434 - 2.3 x10^{-9}\tau)\sin g_a + 0.000349 \sin 2g_a + \omega \tag{20}$$

where g_a is the mean anomaly of the earth obtained as

$$g_a = -0.031271 - (4.53963 x10^{-7})\tau + \omega \tag{21}$$

$$\omega = 2\pi * \frac{\tau}{365.25} \tag{22}$$

τ is reckoned from 1st January 1980, at the Greenwich Mean Noon and is obtained as

$$\tau = 365\Delta + leap + day - 1 + \frac{Hours}{24} \tag{23}$$

$\Delta = Year - 1980$ and leap is obtained by dividing Δ by 4.

We modelled the variation of the declination angle for a period of one year, from January 1st to December 31st. The predictions for the declination angle value for the day around the equinoxes and solstices was compared to values from obtained from 'Heavens above' astronomical observations.

Results and Discussion

The declination angle plotted against the day of the year assumes a symmetric curve around the 172th day with a value of 23.45^0. This value is zero degrees around the vernal and the autumnal equinox about the 79th and the 265th day respectively as shown in figure 1.

The approach by Rapp and Walraven gave the greatest variation for the errors around the 20th March equinox by 4.56^0 and 2.99^0 respectively while the least error obtained was 0.29^0 from equation by Brinkworth as illustrated by figure 2.

Most approaches gave an exact prediction for the 21st of June solstice apart from the equation by Rapp, Bourges and Walraven. The largest error for the autumnal equinox for 22nd September is by Walraven and Rapp at 2.69^0 and 1.83^0 respectively.
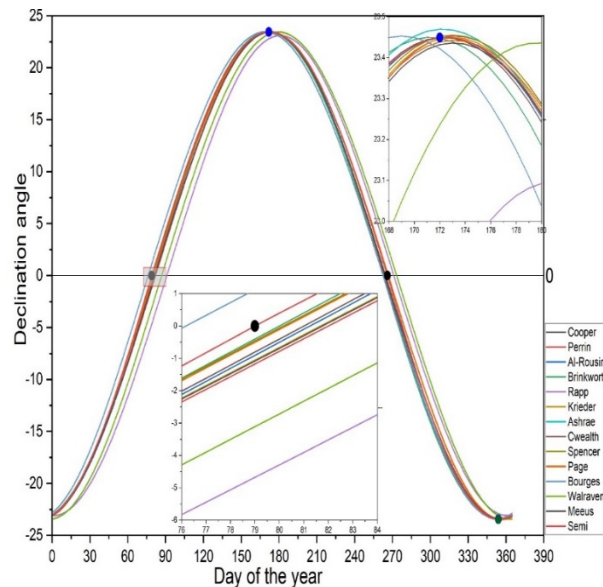
Figure 1: Variation of declination angle for a period of one year.

Conclusion

Thirteen formulas for calculating the solar declination angle were analysed. The formula by Spencer in equation (9) had the least errors in the prediction for the declination angle around the equinoxes and the solstices. The approach by Rapp in equation (6) gave a prediction with the highest error. The commonly used formula by Cooper had an error of up to 1^0 for the March and the September equinoxes.
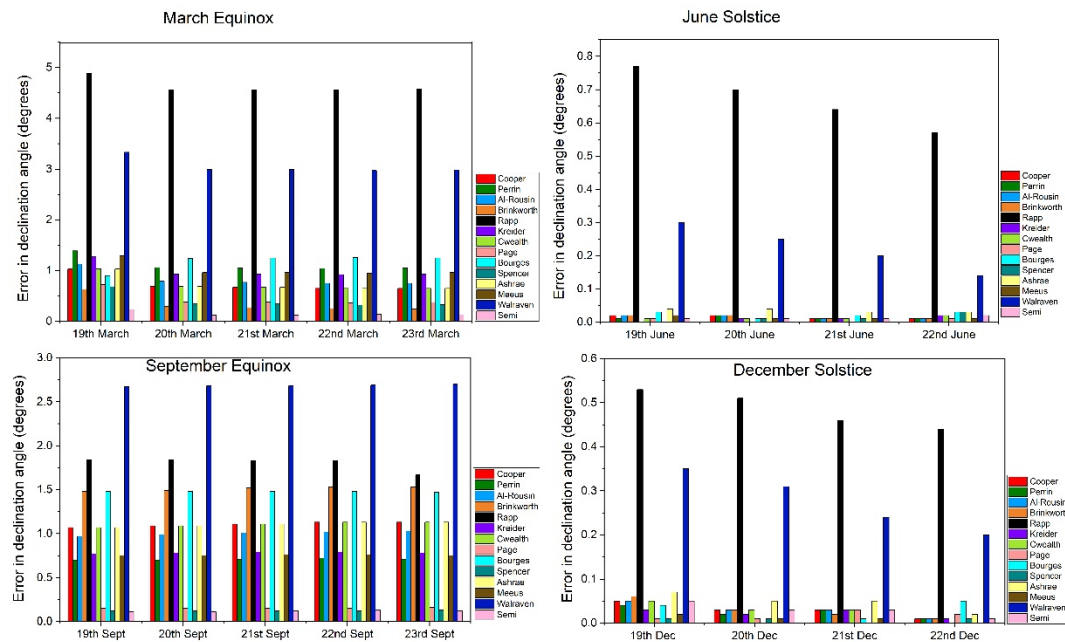
Figure 2: Errors in the declination angle for days around the equinoxes and the solstices.

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Student Presentation 8   Astronomy and the Earth's Climate Change: Is There a Link?

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Abstract
The Earth's climatic changes are mainly attributed to artificial causes such as deforestation, carbon emissions from use of fossil fuels and other greenhouse gases. However, a few studies (Haigh J. 2011) have pointed towards a possible astrophysical and outer space contribution to the Earth's climate change, which requires further investigation given the significance of this problem to the future existence and sustainability of life on our planet Earth. In this research we will carry out a detailed assessment, analysis and modeling of the possible contribution from the astrophysical environment and outer space phenomena to the Earth's climate change. We will use data from various institutions that deal with climate change, and theoretical framework from the scientific disciplines that encompass climate science such as space physics, solar physics, atmospheric physics and astrophysics. This work will involve analysis of observational data that has been acquired from different platforms for instance Solar Radiation and Climate Experiments (SORCE) and Climate Research Unit (CRU). Climate data has been compiled over the years, which has been made available online. The findings of this study will be useful in accomplishing the core intent of this work i.e., to comprehend the role of astrophysical interactions in altering the Earth's climate.

1. Introduction

1.1 Research background

Climate is defined as the approximately 100-year mean condition of the atmosphere and surface boundary layers where terrestrial life thrives (Saltzman, 2002). This typical state of the atmosphere comprises of the average conditions, variances and all upper moments of the probability distributions of all the important physical variables (e.g., temperature, rainfall, water vapor concentration, wind velocity, cloud cover). Temperature, wind velocity, precipitation, relative humidity/water vapor concentration, and sunshine are the key parameters which can be used to describe the Earth's climate. Additionally, evaporation, clouds, snow depth, soil temperature, air temperature, snow-water equivalent, and the incoming solar radiation can also aid in specifying the climate of a particular region.

At the present time there seems to be a scientific consensus that the Earth's climate is changing and human activities are altering concentration of atmospheric components. These constituents absorb and scatter radiant energy. Climatic changes are characterized by the increasing surface air temperatures, subsurface ocean temperatures, rising sea levels,

retreating glaciers and changes in physical and biological systems. The warming being experienced in the present age from the last 50 years is attributed to increase in greenhouse gas concentrations. This study aims to scientifically elucidate whether climate is actually changing and whether this is only driven by human activity.

External climatic forcing refers to all the elements that influence the climate system, however themselves are not affected by the climatic behavior. Solar radiation is an example of climate forcing. Fig 1.1. is a schematic representation of the internal climate system and external forcing. The various external factors which modify the climatic system can be classified into two major categorizes: (1) astronomical or cosmic in nature mainly influenced by the mechanisms contributing in the maintenance and evolution of the solar system and beyond, and (2) tectonic, geothermal or anthropogenic forcing involves energy sources inside the solid part of the planet. This study will mainly encompass the first category i.e., astronomical forcing.

The figure below is a graphic illustration of the component domains of the internal climate system, indicating their characteristic response time constants. The figure also shows the major sources of forcing.
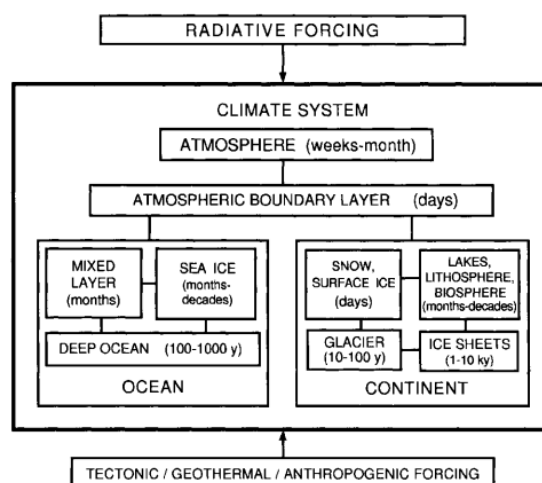
Figure 1.1: The climate system

1.1.1 Astronomical Forcing

1.1.1.1 Solar luminosity changes. The sun's shortwave radiative output, evaluated from the energy flux normal to the outer limit of the Earth's atmosphere also known as the "solar constant", varies to some extent on shorter time scales. These changes are linked to sunspot variations. Inferences from solar-astrophysical considerations (Newman and Rood, 1977) suggest that the sun's output has increased monotonically with time at a rate of roughly 68 x10^{-9} Wm^{-2}y^{-1}. Minor energetic variations of the solar corpuscular flux ("solar wind"), have certainly also taken place. This interacts intensely with Earth's magnetic field. The Sun, as the primary source of Earth's energy, plays a crucial role in influencing climate patterns through solar variability. Solar activity, characterized by variations in solar radiation and sunspot cycles,

can affect Earth's climate on both short and long timescales. The Sun undergoes periodic cycles of high and low activity, with approximately an 11-year solar cycle being the most well-known. During periods of increased solar activity, more solar radiation reaches Earth, potentially contributing to a warming effect. Conversely, periods of reduced solar activity may result in cooler conditions. These solar variations can have implications for Earth's climate, although their exact influence remains a subject of ongoing research (Lean, 2018).

1.1.1.2 Earth-orbital changes. The most steady and well recognized climatic forcing stems from the Earth's varying orbital relation to the sun. Principally the usual seasonal (i.e., diurnal and annual) changes linked with Earth's rotation, tilt, and elliptical revolution about the sun, and their perturbations yield the most significant external forcing on similar extent as the ice ages. These perturbations result from variations in the following orbital elements:
 (1) Eccentricity

$$e = \frac{\sqrt{r_1^2 - r_2^2}}{r_2} \ (1.1)$$

where r_1 is the semi major axis and r_2 the semi minor axis of the elliptic orbit;
 (2) Obliquity or angular tilt of Earth's axis relative to the plane of the ecliptic ε; and
(3) Precessional index (e sin Λ), where Λ is the longitude of perihelion calculated from a fixed point along the orbit, the vernal equinox.

1.1.1.3 Rate of the earth's rotation. Evidence from tidal theory (MacDonald, 1964) and paleontological analyses of layered fossil mollusks (Wells, 1963) hint that there is a gradual decrease in the angular rate of Earth's rotation, (ignoring the minor changes from angular momentum and mass rearrangements that are an internal function of climate change). This extends the length of the day over geologic time a phenomenon that has the tendency to affect the diurnal climate cycle and the global circulation through Coriolis force changes.

1.1.1.4 Cosmic dust. Cosmic dust refers to tiny solid particles present in interstellar space. While the overall amount of cosmic dust entering Earth's atmosphere is relatively small, it may have a subtle but noticeable impact on climate. The deposition of cosmic dust on Earth's surface can influence radiative balance by absorbing or scattering sunlight, potentially contributing to changes in temperature patterns.

 1.1.1.5 Cosmic bolide bombardments. There is growing proof that Earth has been exposed periodically to collisions by cosmic fragments, some are believed to have triggered cataclysmic changes in Earth's climate and biosphere. Such an occurrence is alleged to have happened roughly 65 My earlier, leading to immense instant changes in the Earth's biota, this included the extermination of dinosaurs (Alvarez et al., 1984).

1.1.1.6 Cosmic rays. Cosmic rays are high-energy particles originating from outside our solar system. They are influenced by processes such as supernovae explosions and the Sun's

magnetic field. Cosmic rays from solar and galactic sources have the potential of interacting with the global atmospheric electrical circuit. This causes atmospheric ionization which affects the interchange of charges between the atmosphere, the Earth's surface and the ionosphere. Cosmic rays can also influence the formation of cloud condensation nuclei (CCNs) these are also referred to as cloud seeds. Galactic cosmic rays (GCRs) interact with Earth's atmosphere, producing secondary particles, including cloud condensation nuclei. The role of GCRs in cloud formation and their potential influence on climate has been the subject of scientific investigation. Some studies suggest that variations in GCR flux could modulate cloud cover, subsequently affecting Earth's climate on long timescales (Kulmala et al., 2019).

1.1.1.7 Supernovae and Gamma-Ray Bursts. Supernovae and gamma-ray bursts (GRBs) are powerful astrophysical events that release enormous amounts of energy into the surrounding space. Although relatively rare, their potential impact on Earth's climate has been explored. Some studies suggest that an unusually close supernova or GRB event could have detrimental consequences, such as depleting the ozone layer or triggering global cooling due to the injection of aerosols into the atmosphere (Thomas et al., 2020).

2. Research Problem

Understanding the sources of climate variability remains one of the most puzzling questions in Earth's climatic change studies that have won the attention of climate experts. Until now the observed climate changes have mainly been attributed to global warming attributed to increase in greenhouse gas concentrations. Climate change is a multifaceted phenomenon influenced by various factors, including human activities and natural processes. Over the last decade, detailed analyses and reconstruction of past climatic changes has pointed out to a clear link between the Earth's climate and cosmic rays from solar, galactic and extra-galactic sources, thus providing persuasive evidence on their possible impacts on climate. Cloud cover in recent observations has been linked to the galactic environment, Earth's geomagnetic field, and cosmic rays moderated by solar winds. Our climate is affected by changes in the energy yielded by the Sun however establishing the clear connection between the two has been a difficult task to scientists.

3. Main objective

The pivotal aim of this investigation is to study keenly and highlight the manner in which astrophysical phenomena affect the Earth's climate and whether there exist significant impacts that promote climatic variations.

4. Specific objectives

1. To study the influence of solar changes towards climatic variation.
2. To understand how the Earth's climate has been altered by solar energetic particles, solar wind and cosmic rays such as GCRs in the previous years.

3. To establish the correlation between the sunspot cycle, cloud cover, solar irradiance and cosmic rays variability.
4. To study variations in the Earth's orbit leading to deviation in the Earth-Sun distance.
5. To analyze occasional changes in the environment influenced by celestial objects present between the Earth and the Sun.

5. Justification and significance

Astrophysical processes and contribution of extraterrestrial phenomena such as cosmic rays from solar, galactic and extra-galactic sources have clearly been neglected in accounting for changes in the climate. While human-induced factors such as greenhouse gas emissions have received significant attention in recent decades, it is essential to recognize the potential contributions of astrophysical phenomena to climate change. There remains a possibility that astrophysical contributions such as the sun's evolutions, variability from space could have a significant impact on what we observe in our climate. Our understanding of the complex interaction between climate and solar activity is incomplete at the moment. It would be a remarkable breakthrough in science if we could be able to accurately predict future changes in climate; this is dictated by our precise attribution of previous changes in our environment.

6. Literature review

A good number of previous papers support that correlations between solar variability and climate parameters do exist. Eddy (1976), in a quest to find evidence, probed the historical records of climatic conditions in Europe dating back to the Middle Ages. He examined the intensity of winters in London and Paris, and recommended that there was a decrease in Sun's radiative output for periods when there were few or no sunspots. In a series of classic publications, Labitzke [1987] and Labitzke and van Loon [1988] proposed that it was difficult to see immediate impact of solar activity on temperatures in the stratosphere spanning 10 to 50 km in the atmosphere. There are more noticeable agreements between proxies for solar activity and climate, they include changes in, temperature, precipitation, winds, clouds, ozone, and modes of variability such as the monsoons and the North Atlantic Oscillation (NAO).
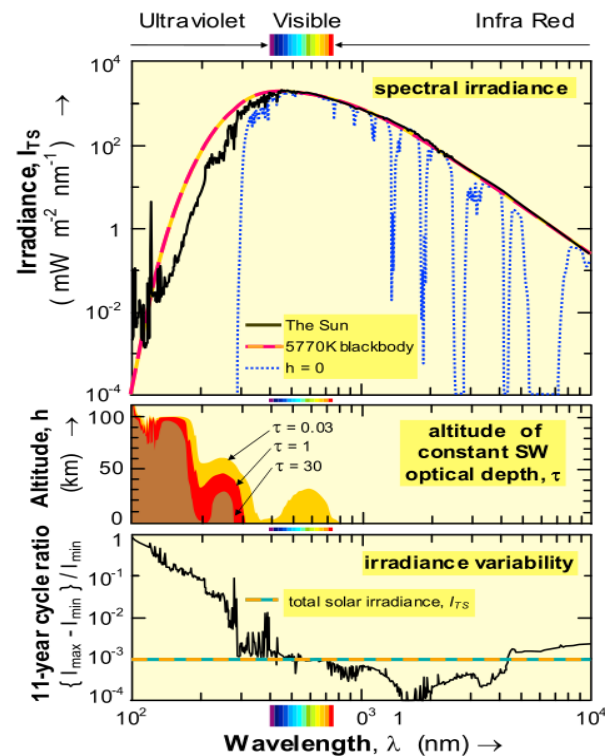
Figure 6.1: Solar spectrum against different variables

In figure 1 the top section shows the spectrum of solar irradiance (I), in comparison to that of a blackbody radiating at a temperature of 5770 K (Lean,1991). Radiation arriving at the surface of the Earth is distinguished by the blue dotted line. The graph in the middle indicates the altitude of permeation of shortwave radiation from the Sun for three distinct smoothed optical depths. The bottom section is based on the previous two solar cycles here the spectral variability of the irradiance, is characterized as the difference between the I_{max} and I_{min} quantities, as a quotient of the I_{min} value. The matching value for the total solar irradiance, I_{TS}, is indicated by the horizontal dashed line, I_{TS} is integrated over all the wavelengths. Climatic records are characterized by numerous natural oscillations from the decadal to the millennial timescales that have not been reproduced by the analytical models, but are present in specific solar, lunar and astronomical records. These oscillations, including the millennial cycle, stress the importance of solar and astronomical effects on the Earth's climate. The figure below illustrates a correlation that includes a significant portion of the warming observed since 1900.

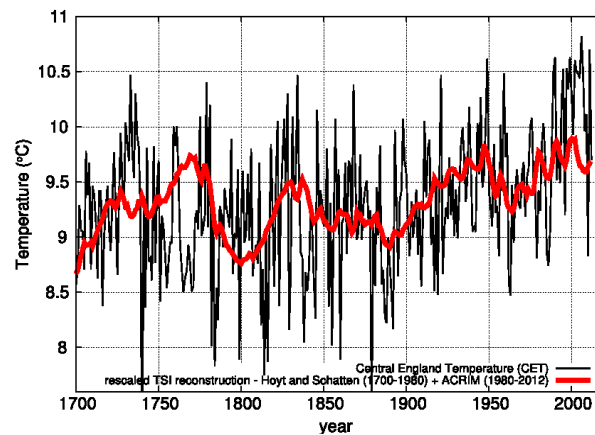*Figure 6.2: Comparison between the Central England Temperature record (black curve) and the solar reconstruction proposed by Hoyt and Schatten (red curve)*

7. Research Methodology

I. Data Acquisition

Data from the Solar Radiation and Climate Experiments (SORCE) will be analyzed in this study. SORCE is a National Aeronautics and Space Administration (NASA) sponsored satellite mission probes incoming x-ray, ultraviolet, visible, near-infrared and total solar radiation. SORCE provided data for more than 17 years of excellent observations of the TSI and SSI between 1nm and 2400nm.

CRU has developed a number of the data sets widely used in climate research, including the global temperature record used to monitor the state of the climate system, as well as statistical software packages and climate models. The study will also make use of data from Solar Resource Variability collection of data and National Solar Radiation Database (NSRDB) from National Renewable Energy Laboratory (NREL).

II. Data Analysis

Scientific packages and programs such as GNU plot and Python will be utilized in the analysis of sun's activity data and the climate data. GNU plot is a command-line program that can generate two and three dimensional plots of functions, data and data fits, Python is a programming language that facilitates scientific processing and manipulation of data.

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Student Presentation 9   Doping Concentration and Defect Density Studies on Sodium-Zinc-Tribromide (Naznbr3) Based Perovskite Solar Cells Via Numerical Simulation

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Keywords: Sodium-zinc-tribromide (NaZnBr$_3$); Perovskite solar cells; Doping concentration; Defect density; Simulation.

1. Introduction

Fossil fuels, for decades have been the major sources of energy utilised by humans, however, it has adverse effects on the environment. There end products (greenhouse gases), being ejected into the environment, causes serious climatic changes. Non-polluting sources of energy such as photovoltaic (PV) energy, wind energy (Kenfack, Thantsha, & Msimanga, 2023), and thermoelectric energy (Kapim, Nangmetio, & Kuatche, 2023), among some many others, can mitigate the draw backs associated with fossil fuels when developed on a large scale.

Photovoltaic energy has the promise of meeting the world's long-term energy needs, and the potential of reducing the harmful environmental impacts caused by heavy industries when used optimally. The development of a low-cost and high-performing PV panel technology is crucial in order to address this global issue posed by the fossil fuel sector (Cheragee & Alam, 2023).

The PV technology that has the possibility of being a highly efficient solar cell while also low-cost in its manufacture are perovskite solar cells (PSCs) which has been a research gateway in the renewable energy community. However, their drawback, such as instability has prevented them from extended outdoor usage (Danladi et al., 2023). To tackle the unstable nature of perovskites, PSCs based on $\text{NaZn}Br_3$ active layer was developed (Emetere, Bello, & Afolalu, 2022).

This study aims to investigate through simulation the intricate interplay between doping concentration and defect density of the $\text{NaZn}Br_3$ active layer in PSCs, and how it affects the photovoltaic parameters; power conversion efficiency (PCE), fill factor (FF), short circuit current density (J$_{sc}$), and open circuit voltage (V$_{oc}$) was investigated using the SCAPS-1D software.

2.1 Methodology

This study aims to investigate the impact of doping concentration and defect density of the perovskite absorbing layer on the performance of a perovskite solar cell (PSC) by optoelectronic simulation method using SCAPS-1D version 3.3.10, developed by Prof. Marc Burgelman and his co-workers, which is suitable for simulating similar PV devices (Burgelman et al., 2013). Three fundamental semiconductor equations that regulates carrier behaviour in solar devices were utilized by the software in modelling the photovoltaic response of the solar cell. They are Poisson's equation (equation 1), the carrier continuity equation (equation 2 & 3), and the drift-diffusion equation (equation 4 & 5).

$$\frac{d^2\Phi(x)}{dx^2} = \frac{q}{\varepsilon_0 \varepsilon_r} \left(p(x) - n(x) + N_D^+ - N_A^- + p_{trap}(x) - n_{trap}(x) \right) \tag{1}$$

$$-\frac{1}{q}\frac{dJ_n}{dx} = R_n(x) - G(x) \tag{2}$$

$$\frac{1}{q}\frac{dJ_p}{dx} = R_p(x) - G(x) \tag{3}$$

$$J_n = qn(x)\mu_n \frac{d\phi(x)}{dx} + qD_n \frac{dn(x)}{dx} \tag{4}$$

$$J_p = qn(x)\mu_p \frac{d\phi(x)}{dx} + qD_p \frac{dp(x)}{dx} + \tag{5}$$

In addition, optical absorption coefficient $\alpha\,(\lambda)$ (equation 6) is another important parameter, which is the average penetrating depth of stream of photons at a given wavelength (λ) permeating into the semiconducting layers with bandgap, E_g before their absorption.

$$\alpha\,(\lambda) = \left(A + \frac{B}{hv}\right)\sqrt{hv - E_g} \tag{6}$$

2.2. Simulation Parameters

The parameters for the semiconducting layers of the PSC were carefully selected and reference, these layers are Fluorine Tin Oxide (*FTO*), perovskite absorbing layer ($NaZnBr_3$), copper iodide (*CuI*) as the hole transport layer (HTL), and *ZnO:Al* as the electron transport layer (ETL). This study was carried out with the work functions of the front and back contact as 4.4 eV and 5.1 eV respectively (Gan et al, 2022), utilizing the conventional illumination of AM 1.5G solar spectrum, with a scanning voltage of 0-1.5 V under an ambient temperature of 300 K.

3.1 Results and Discussion

The modelled structure of the device alongside its energy level diagram is presented in figures 1a and b.
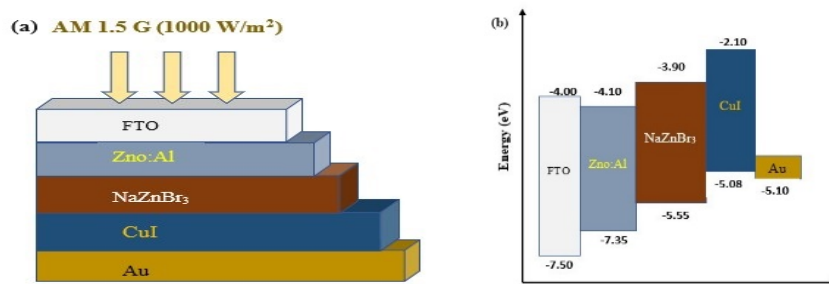

Figure 1. (a) Device structure and (b) Energy band alignment diagram of the device.

3.2 Performance study of the initial device

The current density (J) – voltage (V) characteristics of the initially simulated device has the following photovoltaic parameters: power conversion efficiency (PCE) of 13.1005%, fill factor (FF) of 79.6486%, open circuit voltage (V_{oc}) of 1.1739 V, and short circuit current density (J_{sc}) of 14.0118 mA/cm^2, matching the simulated results of Abdulmalik & Danladi, 2023. At the wavelength value of 360 nm, maximum quantum efficiency (QE) with a value of 84% was obtained.

3.3 Effect of doping concentration of absorber layer

The range of acceptor doping studied in this device was 10^{12} to 10^{20} cm^{-3}. At the doping concentration value of 10^{18} cm^{-3}, PCE and FF shows similar trends by declining sharply, due to increase in charge carrier recombination, also resulting in the decrease in the J_{sc}, resulting in these photovoltaic parameters: PCE = 14.6430 %, FF = 86.2184 %, J_{sc} = 14.5018 mA/cm^2, and V_{oc} = 1.1711 V.

3.4 Effect of defect density of absorber layer

The absorbing layer contributes to the defect of the device, for which the defect was investigated from 10^{12} cm^{-3} to 10^{20} cm^{-3}, the optimized value of absorbing layer defect density was chosen as 10^{12} cm^{-3} with the following photovoltaic parameters: PCE = 13.1285 %, FF = 79.6564 %, J_{sc} = 14.0397 mA/cm^2, and V_{oc} = 1.1739 V.

3.5 Performance study of the initial and optimized device

The optimal performance of the PSC is as follows: PCE = 14.7400 %, FF = 86.6490 %, J_{sc} = 14.5226 mA/cm^2, and V_{oc} = 1.1714 V when illuminated. Appreciable values in the photovoltaic parameters with 11.12 %, 8.08 %, and 3.52 % increase in PCE, FF, Jsc respectively were observed when compared with the initial device.

4. Conclusion

In this study, sodium-zinc-tribromide perovskite solar cell was numerically investigated using SCAPS-1D simulation software. The outcome the absorbing layer doping concentration and its defect density on the performance of the PSC was investigated from 10^{12} to 10^{20} cm^{-3}. The results show that the PSC configuration of FTO/ZnO:Al/NaZnBr$_3$/CuI/Au has an optimal absorbing layer doping concentration of 10^{18} cm^{-3} with its defect density optimal value as 10^{12} cm^{-3} resulting in an overall PSC with the following photovoltaic parameters: PCE of 14.7400 %, FF of 86.6490 %, J$_{sc}$ of 14.5226 mA/cm^2, and V$_{oc}$ of 1.1714 V. The outcomes of this study are expected to offer valuable insights into the design and engineering of high-performance perovskite solar cells based on $NaZnBr_3$ material.

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Student Presentation 10   Cultivable Endophytic Bacteria Associated with Cassava Microbiome as Potential Biocontrol Agents Against Crop Pathogenic Fungi

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Keywords: Endophyte; Endophytic bacteria; Biological control; Cassava; Crop pathogenic fungi

Introduction

Plant diseases caused by pathogens and pests cause yield losses of up to 30% of staple crops globally and result in production losses of hundreds of billions of dollars (Rizzo et al., 2021). Fungal pathogens contribute about 10-20% of these losses causing production losses of $100-200 billion annually. Huge crop losses in crops such as cassava, sorghum and potato are caused by fungal pathogens. One of the most destructive diseases of cassava is cassava anthracnose disease (CAD) caused by *Colletotrichum gloesporiodes, C.siamense* and *C.fruticola* characterised by stem, branch and fruit cankers,leaf spots and tip die-back on aerial plant parts (Obilo et al., 2010). Loss 90% of crop product has been reported (Sangpueak et al., 2021). *C.sublineola* is the most damaging leaf fungal pathogen causing sorghum anthracnose which can lead to 100% yield loss (Koima et al., 2023). Potato late blight disease caused by *Phytophthora infestans* is the most devastating disease of potato globally. *P.infestans* is one of the most aggressive plant pathogens and causes significant annual crop losses (Ivanov et al., 2021).

Chemical methods have been used in control of fungal pathogens for many years; their use however presents negative impacts including development of resistance by pathogens, chemical residues in the soil, non-target effects on plants and animals and hazards on human health. Biological control has been studied as an alternative to chemical methods of pathogen control in recent years as it offers an efficient and environmentally friendly alternative in comparison to noxious synthetic chemicals. Endophytes have potential in use as biocontrol agents (BCAs) due to environmental friendliness and low production costs. Endophytic bacteria can restrict pathogen growth by one or a combination of mechanisms such as competition, antibiosis, induction of systemic resistance and lytic enzyme production (Glick, 2012).

Many studies have reported on endophytic bacteria as biocontrol agents. There is however limited information on endophytic bacteria in cassava. This study therefore aims to investigate the endophytic bacteria community in cassava and their potential as BCAs of 3 fungal pathogens of cassava, sorghum and potato.

Results and Discussion

In this study ,84 endophytic bacteria were collected and purified from 4 cassava cultivars; 4 of these isolates had a high inhibitory effect on growth of all three fungal pathogens. The mean fungal growth inhibitions were *C.siamense,*(62-75%) *C.sublineola* (62-68%) *and P.infestans* (64-75%). The isolates were identified through 16S rDNA sequence analysis as having high sequence similarities to *Bacillus amyloliquefaciens, Bacillus siamensis* and *Bacillus subtilis* (2 strains). *Bacillus spp* are known to form endophytic communities in plants and exhibit biocontrol potential in various plant pathogens(Baard et al .,2022, Sharma et al., 2021). Our findings therefore further affirm the role of *Bacillus spp* in biocontrol of plant pathogens.

The strains also exhibited tolerance to salt and osmotic stress, growth in a broad range of temperatures between 10-50°C and were able to grow in the presence of metal ions up to 200mG/L of $CuSO_4$. These characteristics make them suitable for use as BCAs in a broad spectrum of environmental conditions.

Methods

Endophytic bacteria were isolated from leaves, stems and petioles of four cassava cultivars obtained from Kabete field station, University of Nairobi. The isolates were used to assess the antagonistic activity by *in vitro* confrontation bioassay (dual culture) against plant pathogens *Colletotrichum siamense*, *Colletotrichum sublineola* and *Phytophthora infestans* isolated from cassava, sorghum and potato, respectively. Those that showed fungal growth inhibition properties were selected for further analysis. Antifungal volatile organic compounds (VOC) production by the bacterial isolates was then assayed. Molecular identification of the successful isolates was carried out by DNA extraction, PCR using 16S primers and 16S rRNA sequencing. Sequences obtained were compared with similar sequences using the BLAST tool in the non-redundant NCBI database. Phylogenetic tree building was done to show evolutionary relationships of the bacterial isolates. Bacterial isolates were cultured in different conditions of salinity, drought, temperature and metal ions to assay for their tolerance to abiotic stress and to understand their physico-chemical growth requirements.

Conclusion

The results highlight the biocontrol potential of bacterial endophytes isolated from cassava against crop pathogenic fungi, providing support for ongoing research on disease control in agriculture using environmentally friendly approaches.

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Student Presentation 11   Growth Performance, Nutrient Utilization, and Survival of African Catfish Fingerlings with *Spirulina platensis* and *Eisenia fetida* Nutritional Histories Fed on Raanan and Skretting in Grow-Out Tanks

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Keywords: Nutritional history, *Clarias gariepinus*, Growth, Nutrient Utilizations, Survival

Introduction
Global aquaculture production has risen to 126 million tonnes of live weight valued at USD 296.5 billion in 2021(FAO, 2023). However, Africa has experienced a growth decline from 17.9% in 2018 to 14.5% in 2020, counting for 1.9% to global aquaculture in 2021 (Jones *et al*., 2020; Mair *et al*., 2023). Kenyan aquaculture production increased from 895 metric tonnes in 2009 to 18542 in 2019 (Munguti *et al*., 2021). To sustain this growth, aquaculture requires a cost-effective production system with a sustainable and resilient supply chain. However, the industry faces challenges like shortage of quantity and quality fish seed and feed (Griffin, *et al*., 2019). Therefore, irregular and inadequate quantity and quality supply of fingerling for stocking threatens the upward aquaculture trajectory. This is because hatchery managers have recycled their brood stock over the years to result in the stocking of larvae with diluted quality due to inbreeding. Also, corrupt fish feed dealers and seed suppliers have taken advantage of the demand gap with little attention to quality. As a result, there has been low survival and variable growth in all life stages of cultured fish species. Therefore, fish larvae available for stocking are of inconsistent quality and sizes.

The fish larval stage hinders aquaculture production due to its dependence on the expensive and nutritionally variable live feed. To eliminate hatchery live feed use, larvae are weaned on dry diets based on the finite, scarce, expensive, and nutritionally variable fishmeal, though it competes with human consumption and other animal feed industries. However, finding feed ingredients that are not in competition with human consumption, locally available, nutritionally balanced, and less costly is a challenge. Such an ingredient should also be digestible and should ensure environmental integrity for sustainable aquaculture. Plant proteins like soybean have been used though they are limited due to imbalanced amino acids, the presence of anti-nutritional factors, reduced digestibility and high fibre content (Montoya-Camacho *et al*., 2019). Disadvantages of animal protein alternatives to fishmeal are increased microbial contamination, and fatty acid rancidity (Kobayashi *et al.,* 2015). These variable success of fishmeal alternatives in enhancing fish growth has necessitated the need for further research on feasible protein alternatives to ensure fish feed quality, fish larval growth and ecological sustainability. As such, non-conventional protein sources of Spirulina

(*Spirulina platensis,* Geitler, 1925*)* and earthworms (*Eisenia Fetida,* Savigny, 1826), have gained interest in the recent past. The aim of this study was to determine the effects of hatchery's nutritional based on *S. platensis* or *E. fetida* on growth, nutrient utilization, and survival in African catfish fingerlings fed on Raanan and Skretting commercial diets in grow-out ponds under a greenhouse. The study intends to provide insights into the missing links between a weaning diet and grow-out performance while contributing to the pool of nutritional history literature in aquaculture for its enhanced recognition.

Materials and Method

The mature female was injected with 1ml/kg body weight of pituitary solution on the dorsal musculature lateral to the dorsal fin to induce ovulation. After 12 hours female was stripped, eggs fertilized using milt from the sacrificed male, and incubated on a Kakhaban mat in a 50 L plastic basin filled to 45 L at 29°C. the incubator was continuously aerated with an air stone in a flow-through water system. Hatching occurred 24 hours after incubation.

In the hatchery, larvae were fed on seven formulated diets and a commercial diet (gemma micro) which formed nutritional history in the grow-out. In the formulated diets, *Caridina nilotica* was replaced by either *Spirulina platensis* or *Eisenia fetida* at 25%, 50%, and 75% to give 7 diets (T_1=25% *Spirulina platensis* +75% *C. nilotica*, T_2=50% *Spirulina platensis* +50% *Caridina nilotica*, T_3=75% *Spirulina platensis* +25% *Caridina nilotica*, T_4=25% *Eisenia fetida* +75% *Caridina nilotica*, T_5=50% *Eisenia fetida* +50% *Caridina nilotica*, T_6=75%*Eisenia fetida* +25%*Caridina nilotica*, T_7=100% *Caridina nilotica*). Hatchery feeding trials took eight weeks to become fingerlings in the Aquaculture laboratory in the Department of Biology, University of Nairobi.

Clarias gariepinus fingerlings were transferred from the Aquaculture laboratory to Makindi Fish farm, Muranga County, Kenya, for stocking in the grow-out tanks. Fingerlings were randomly stocked in two separate concrete tanks of 3m x 3m x 1.5 m each holding 24 hapa nets of 0.25 m3 under a greenhouse 4m above the tank tops to allow light to pass through. Fifty *Clarias gariepinus* fingerlings and a total of 150 per weaning diet (nutritional history) were pooled. The pooled fingerlings were randomly but equally distributed into hapa nets in triplicate in each concrete tank at the rate of 25 fingerlings/ hapa net, a third filled with River Makindi water. At stocking*,* fingerlings had significantly different growth (p<0.05) in the range of 0.60g±0.03-1.55g±0.13. These fingerlings were either fed commercial diets Raanan with 46% crude protein or 40% crude protein Skretting at 5% wet body weight, three times a day.

Results and discussion

At the end of eight weeks, fingerling with a historical history of 75% *Eisenia fetida* + 25% *Caridina nilotica* (T6) had the highest and significantly (p<0.05) different weight gains of 13.01±0.11g and 12.85±0.09g for Raanan (A) and Skretting (B) diets respectively in the grow-out tanks. This was replicated in the specific growth rates of 4.45±0.01%/day and

4.17%±0.04/day respectively for Raanan and Skretting though not significantly. p =0.33) different from 4.33±0.02%/day in those fingerlings having 100% *Caridina nilotica* nutritional histories. The increased growth indicated the ability of fingerlings fed on T_6 and T_7 to offset hatchery nutrition effects in the grow-out tanks. Faster growth shortens the time to attain table size and this means the use of low production cost. Enhanced growth was quantifiable economically through the increased number of crop cycles per year. However, 25% *Spirulina platensis* +75% *Caridina nilotica* (T_1 nutritional history) fed fingerlings had significantly (P<0.05) different and the lowest Specific growth rate of 3.44±0.04%/day and 3.22±0.03%/day respectively for Raanan and Skretting diets. Failure of *Clarias gariepinus* fingerlings with a nutritional history of T_1 to accelerate their growth in the grow-out tanks was an economic loss to farmers because more farm inputs like feed were to be used for a longer time to attain market size for disposal.

The best nutrient utilization was observed in larvae fed on control (100% *Caridina nilotica* and 75%*Eisenia fetida* + 25%*Caridina nilotica* of 1.19 and 1.24 for Raanan and 1.39 and 1.40 for skretting diets respectively. However, fingerlings fed on diet T_1 significantly had the poorest Feed conversion ratio of 1.65±0.01 and 1.79±0.01 for diets Raanan and Skretting respectively. Poor feed conversion ratio in *Clarias gariepinus* fingerlings having a T_1 nutritional history offers a reason for their reduced growth.

All Fingerlings had over 80% survival in the grow-out tanks indicating that all starter diets had a positive influence on survival. The highest and significantly (p>0.05) different % survival of 90% – 93% was observed in *Clarias gariepinus* fingerlings with T_2, T_3 and T_7 nutritional histories. However, fingerlings with nutritional history of T_1 and T_6 had the lowest and significantly (p<0.05) different % survival of 86 - 87% for Raanan and Skretting diets in the grow-out tanks. *Clarias gariepinus* larvae with a nutritional history of T_5, T_6 and T_7 improved their growth and nutrient utilization in grow-out, though with reduced survival in T_6-weaned fingerlings. The reduced % survival in fingerlings with a nutritional history of T6 was attributed to physiological costs incurred as they offset hatchery effects on their growth and survival. This is because increased growth does influence the proportionate amount of mortality in an organism (Py *et al*., 2022). The study recommends feeding *C. gariepinus* larvae with diets of different protein levels having *S. platensis* or *E. fetida* and refeeding them with similar protein content in grow-out to evaluate time-to-market size attainment and profitability.

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Student Presentation 12   Effect of Solar Irradiance, Temperature and Relative Humidity on the Performance of a 1.5kw Photovoltaic (PV) System

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Abstract

Increase in demand for energy has led to exploitation of solar energy which is abundant. However, PV power output is greatly influenced by weather parameters. Hence proper modelling and assessment of the impact of environmental parameters on the PV system performance is essential. In this study, a detailed performance analysis of a 1.5 kW PV system installed at the School of Physical Sciences building, University of Nairobi was done to study the effect of solar irradiance, temperature and relative humidity on the power output. To study the effect of weather parameters on the PV system performance, a weather station was setup on the site to provide real-time measurements of the ambient temperature and relative humidity. Solar irradiance was measured using a HT304N reference cell and the PV module temperature measured using a HT instrument PT300N temperature sensor. The current and voltage values of the solar PV system were obtained using a current-voltage solar (I-V) analyzer. Data collection was done daily between 10:00 a.m. to 3:00 p.m. EAT at 30 minutes' interval for a period of 21 days. The study showed that maximum PV power output varies linearly with solar irradiance with strong positive relationship while the PV system efficiency exhibited a negative correlation with solar irradiance. Series and shunt resistance both have a negative non-linear relationship with solar irradiance. The open circuit voltage was found to vary inversely with the module temperature with correlation indicating a weak relationship. The maximum power and module temperature exhibited a positive linear relationship while it decreased with the efficiency of the PV system.

1. Introduction

The availability of sufficient, affordable, and reliable energy is crucial for the wholesome development of any nation. Due to the increasing world populations and advancements in technology that require power, the World's energy consumption is anticipated to rise by 50% by the year 2050 as per the International Energy Agency (Energy, 2019). To date, fossil fuels are the world's main energy source producing about 85% of the world's energy. However, they are non-renewable, unsustainable and have negative environmental impacts, resulting to a rise in the greenhouse gases, degradation of ecosystems, changes in weather patterns, rising sea level and melting of glaciers (IES, 2019). It is for these reasons that world

organizations such as United Nations (UN) have called for adoption of sustainable and renewable sources of energy. Renewable energy sources include solar, wind, hydro power, geothermal, solar thermal, ocean energy and tidal energy. Due to the abundance and availability, the focus of renewable energy has shifted to solar power. Photovoltaics have gained much popularity due to their low maintenance, and production of clean energy (Goswami, 2017). Due to her location at the equator, Kenya receives an abundance of solar energy averaging between 5-7 sunshine hours and 4-6 kw/m^2 insolation daily (Solargis, 2017). The PV sales are estimated at more than 1.2 MW market per year(Mark Hankins Anjali Saini Paul Kirai, 2009).

However, solar power generation is heavily dependent on weather variability. PV power output is directly related by solar irradiance is an established relationship. However PV power output is influenced by other weather parameters such as temperature, relative humidity, dust accumulation and wind speed (Touati et al., 2016)(Khandakar et al., 2019). However most solar panels are flash tested under standard testing conditions (STC) which are ideally unrealistic owing the fact that these conditions during outdoor operations nearly never occur. PV modules are especially highly susceptible to high temperatures and radiation damage which cause overheating of PV panel hence reducing its efficiency considerably. This is because high temperature causes slight increase in photocurrent and decrease in photo voltage. This effect of temperature on solar cell performance is expressed by temperature coefficients given by manufactures data sheet (Zeman et al.,2014). Hence one can therefore estimate the temperature of the module when the temperature coefficient is known. (Bhattacharya et al., 2014) investigated the impact of temperature and wind speed on efficiency of a monocrystalline solar panel for one year. The results showed a positive linear variation of module efficiency with both ambient temperature and wind speed. Whereas (Panjwani & Narejo, 2014)) reported on the effect of humidity on solar power production. The results showed that when the humidity level was high it decreased the power output up to 15-30%. Other environmental factors influencing the efficiency of the PV module were neglected in this research. (Mekhilef et al., 2012) did a study on the impact of humidity, air velocity and dust on efficiency of solar module. Dust accumulation decreased the efficiency while high humidity resulted to cell encapsulate delamination. Humidity and irradiance showed a non- linear relationship; hence humidity has greater impact on the short circuit current than on open circuit voltage. The fast-increasing worldwide installation and use of solar PV systems has made it necessary to carry out research aimed at developing accurate and site-specific techniques and systems able to carry out real-time PV system performance analysis and output power forecasting. This work aimed at analysis of real time effect of irradiance, ambient temperature , module temperature ,relative humidity on the performance of 1.5kW .

2. Method

The solar panels were first cleaned using a clean cloth and plain water. The HT304 cell was used to measure solar irradiance. It was attached to its holder and mounted using a stirrup on the central position on side PV module on hole on the solar panel frame. This was done to ensure the HT304N cell was on the same orientation and level as the PV modules. The HT304 cell was also cleaned using water and clean cloth to ensure accuracy of its readings. A PT300N temperature probe was used to measure the module temperature, was attached to the backside of the PV module using adhesive tape. The positive and negative connection cables from the PV string were connected to the Solar I-V analyzer to measure the I-V characteristics of the string. A weather station was setup on the site to provide real-time measurements of the ambient temperature and relative humidity. The data was collected from 10:00 a.m. to 3:00 p.m. EAT at 30 minutes' interval and data analysis was done using R– software and Origin 9.1 software.

3   Results

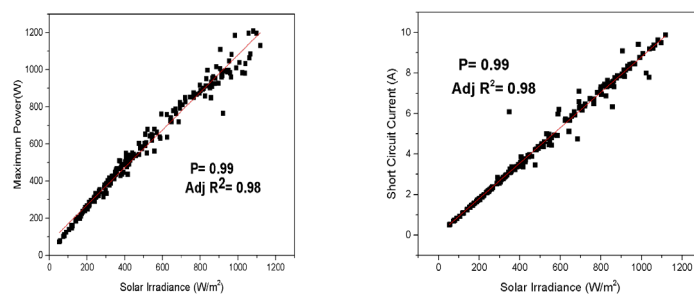*3.1: Effect of solar irradiance on the performance of the Solar PV system*

Fig 5:Variation of maximum power with solar irradiance   Fig 2:Variation of short circuit current with solar irradiance
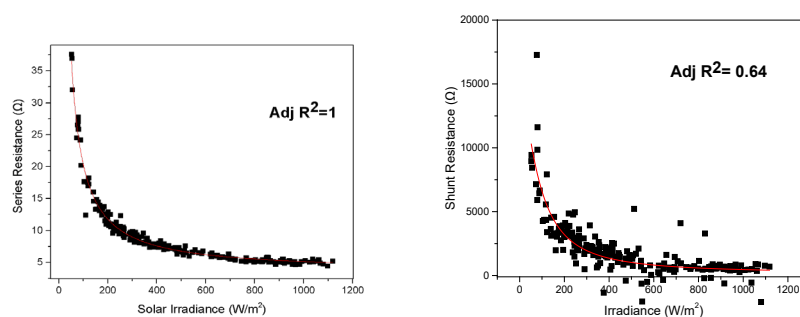

Fig 6:Variation of series resistance with solar irradiance   Fig 7:Variation of shunt resistance with solar irradiance
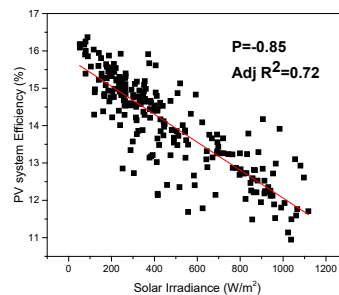
Fig 8:Variation of PV System efficiency with solar irradiance

4   Conclusion

Real-time performance data of the 1.5kW PV system was collected and studied. The study focused on the influence of solar irradiance, ambient temperature and relative humidity on performance of photovoltaic system. From the results it was observed that solar irradiance had a very strong positive linear relationship with the power output generated by the PV system. The short circuit current was also found to increase with increasing solar irradiance with high positive correlation. However, the series resistance and shunt resistance decreased with increasing solar irradiance forming exponential decay curve. The module efficiency decreased with the increasing amount of irradiance falling on the panels.

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Student Presentation 13   Exploring the Elastic, Electronic, Dynamical, and Optical properties of cubic ZrCoAs half – Heusler Semiconductor: An *ab-initio* Study

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Keywords: DFT, Spin Orbit Coupling (SOC), Electronic, Dynamical, Mechanical, Elastic, And Optical Properties, Half Heuslers ZrCoAs.

The electronic, mechanical, elastic, vibrational, and optical properties of ZrCoAs half-Heusler compound have been systematically studied using the plane wave self-consistent field approach. The exchange correlation functional used is Perdew-Burke-Erzerhof of the generalized gradient approximation (GGA-PBE). Structural and electronic properties have been studied with and without Spin Orbit Coupling (SOC) effects. The incorporation of SOC effects leads to a decrease in the Kohn-Sham band-gap. The formation of the electronic bandgap was attributed to Co 3d, Zr 4s, and As 4p, for the conduction band, and Co 3d and As 4p for the valence band without SOC effects. Co 5d, Zr 8d, and As 4p, became dominant in the conduction band while Co 3d and As 4p dominated the valence band when SOC was taken into account. The lattice constant also decreased by 0.063% when SOC was factored into the computations, showing a much-improved agreement with experimental observations. The material exhibited ductility, mechanical stability, and dynamical stability, making it promising for a variety of applications. Also, it was discovered that the material's optical properties are excellent for photovoltaic applications, indicating a potential application in solar energy conversion technology.

Student Presentation 14   Surface-Enhanced Raman Spectroscopy (Sers) as a Label-Free Testosterone and Growth Hormone Assaying Method in Whole Blood

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This work reports surface-enhanced Raman spectroscopy (SERS) studies of testosterone (TE) and growth (GH) hormones mixed separately with water for injection and with male Sprague-Dawley (SD) rat blood. The main objective was to explore the existence of SERS biomarker bands with potential utility in their rapid and label-free detection in blood. Abuse of the two hormones (TE and GH) singly or simultaneously not only has prolonged side effects such as hypertension and liver failure, but their illegal use by athletes is against clean competition. Currently used doping detection methods involve complex and time-consuming procedures, making them less suitable for rapid analysis. Raman spectral profiles for both pure TE and GH displayed common (770, 948, and 1000-1400 cm^{-1}) and unique (668, 914, and 1652 cm^{-1} for TE and 1440, 1518, and 1700 cm^{-1} for GH) bands. In blood, the most concentration-sensitive bands (in both TE and GH), deduced through Principal Component Analysis (PCA), and Analysis of Variance (ANOVA), were observed at 658, 798, 914, 1064, 1382, and 1658 cm^{-1}. These bands can be tentatively attributed to C-O-C stretching, C-C bending, C-O/C–C stretching, C–C stretching, C–C stretching, and carbonyl stretching of proteins respectively. In addition, for GH, some variance was noted at a band centered at approximately 1490 cm^{-1}, attributable to CH_2 stretching, which could be a potential biomarker band for GH in blood. This work has shown the capability of SERS for potential hormone concentration level determination when concentration-sensitive or biomarker bands are employed. This discovery opens new possibilities for the use of SERS in fields such as sports science, clinical diagnostics, and biomedical research.

Student Presentation 15   The Time-Force

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Keywords: Space, Emptiness, Time Force Intensity, Time Event.

Space and time are so far the most mysterious concepts in physics and, by unlocking their mysteries we will have a more comprehensive understanding of the universe. The most successful theory in explaining gravity is general relativity which tells us that is nature of matter to curve space time which suggest one of the few interactions we can use to probe space. Matter exists in space and interacts with space as by mass and volume producing a time force which bounds matter to space.

The force binding matter to space must be very low for extremely small particles of matter at the minutest of scales, the force must also be extremely high for larger amounts of matter for no matter to not have exited space so far as we've observed. This results in a relation which needs a new kind of mathematics to explore. Let us device a theory of math that we will use and call it ROOTMATICS.

If you take the root of any given number N, the result is very much smaller to the original number but, when you do the same for an extremely small number the result is not far apart from the original number.

THE TIME FORCE INTENSITY VARIES ROOTMATICALLY WITH MATTER TO ITS VOLUME
{volume√(Time-force)}^mass=[1+l]
T-f = 1+(v^m !(∑[l])∑n!)/[v^m-1]! .Constant

Analyzing the equation, we can see that for a particle of zero mass occupying zero volume has always a Time Force intensity of 1 and so is for a particle of zero volume or mass
If you want to give matter access to freedom of time you should supply it with counter-energy such that the counter-energy of matter is greater than time-force intensity. We can also find that space is not static;
 space gain due to matter fragmentation (Sg)= change in time force intensity

Sg = space bound by original mass – [space in remaining mass + space in expelled mass]
Sg = [〚(V_x^m !∑l∑n!)/[v_x^m-1]! H〛 ^] – [〚(V_x^m !∑l∑n!)/[v_x^m-1]! H〛 ^]- [〚(V_x^m !∑l∑n!)/[v_x^m-1]! H〛 ^] – 1
For v^m= a non-zero positive and whole integer.

Universal expansion

$S_g = V\_o^m\sum[l]\ \sum\_(n=1)^{(n=N)}n!\ H-\ V\_o^m\sum[l]\ \sum\_(n=1)^{(n=N)}n!H-\ V\_o^m\sum[l]\ \sum\_(n=1)^{(n=N)}n!\ H-1$

For any change in expansion or Sg, the rate might be determined by;

Rate of change of expansion = $\Delta S_g/\Delta\_t$

From this information it's possible to create a device large enough such that we can willingly move a small enough amount of matter through time as we wish.

Experimentation and Methodology

The device was manually constructed and various parameters varied to put hypothesized theory to test.
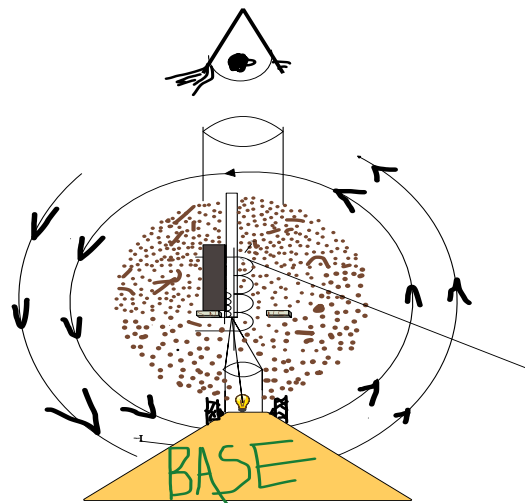
Diameter of the device   2m

Outer magnetic fieldI used strong permanent magnets in concentric rings 3cm apart

Inner material used Wet soil

Inner mass (soil) volume   About 2.35 million cm3

Inner mass density (soil)

Secondary coil - 5000 turns,10 A (DC), Inner diameter ranging from 1cm at the top to 3cm at the bottom
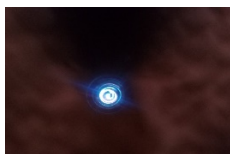
Tertiary coil - 100 turns,5A (DC), 1.5 mm inner diameter

Test Particle size   Circular with a diameter of 0.12mm

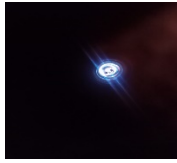## Results and Discussion

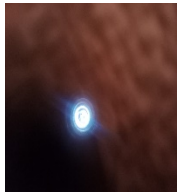The first success was at 197th trial

At start

 There is only 1 test particle

Proceeding

Two observed test particles

Final

No test particle

The second success was 233rd trial

The experiment was repeated 253 times with only observing 2 expected observations (successes) amounting to an average success rate of 0.79%.

Analysis

The test particle is observed to disappear into nothing and after sometimes back. I believe this is due to it entering the other dimension of emptiness where it experiences freedom in time. Proving this is somewhat troublesome because there is no clock to measure time in there, don't know if at all it should disappear when entering emptiness and I have no idea what I should do to move it in either direction in time.

1. Lack of knowledge to the exact parameters for the working and the very low success rate of 0.79% makes it even harder to figure out clearly.

2. Lack of knowledge on how to move the test object either forward or backward in time.
3. The little amount of mass and the high energies needed for the working makes it difficult to use a sufficiently large test object for better observations.

4. The weak nature of gravity makes it difficult to generate larger amounts of it in a smaller space.
5. The torsion resulting is very week even with the concentration to support a bigger object.

Conclusions

The existence of other dimensions is not only likely but actual, its only not proven to be there. Time itself is a multi-motion dimension of a higher order even than space and emptiness and is only know we begin to unravel its secrets. The forward and backward

motion in time is very much possible but we only say its impossible due to our own limitation to create sufficient energies and know how to use it for the goal.

Student Presentation 16   Influence of Corn Cob Ash-Silica Fume Blend on The Mechanical and Durability Properties of Concrete

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Keywords: Corn cob ash, Densified Mix Design Algorithm, High performance, Pozzolanic cement, Silica fume.

Abstract
This research explored the feasibility of corn cob ash-silica fume blend in the production of pozzolanic cement to produce High-Performance Concrete. The cement in concrete was partially replaced by corn cob ash-silica fume blend in 5,10,15 and 20% by weight of cement and was compared to a control mix of 0% replacement. An intelligent mix design, Densified Mix Design Algorithm (DMDA), was used to effectively reduce both water and cement content. In order to create high strength and workability, a polycarboxylate-based super plasticizing admixture was utilized in conjunction with a low water binder ratio of 0.35. Compressive strength was appraised to determine the mechanical properties at days 3,7,14,28 and 56 to determine the optimum percentage replacement and compared to the control at the specific ages. With the optimum percentage replacement, the flexural test was investigated at 28 days. Water absorption and electrical resistivity tests were also investigated as potential indicators of durability. All of the blends that included corn cob ash and silica fume produced a higher strength than the control except for 15 and 20%, with 10% replacement yielding a cube strength of 61 MPa at day 56.

 Introduction
Cement consumption has increased as a result of the requirement for a socioeconomic infrastructure to support the creation of wealthy societies as a result of rapid population development (Kalra & Mehmood, 2018). Concrete has been largely and actively used over time due to its desirable mechanical and durability properties, its fire resistance, its simplicity in application, and its widespread availability.

Methodology
The study evaluated the influence of the CCA-Silica fume blend on the mechanical and durability properties in the production of HPC. Chemical characterization of CCA was carried out, material tests, and design of concrete using CCA, SF, and SP. Fresh and hardened concrete tests were performed and the results were analyzed. Material properties of CCA including; grading, chemical composition, material characterization, and fineness modulus were evaluated. Concrete tests such as compressive strength, flexural strength, electrical

resistivity, and water absorption were carried out. These tests were carried out at The Technical University of Kenya Concrete Laboratory, The Materials Testing and Research Division as well as the Department of Mining Headquarters.

Result and Discussion

Compressive Strength

Figure 1 shows the results of the compressive strength of CCA-SF blend concrete. The results reveal that the compressive strength increased gradually with the increase in curing age except for the 10 and 15% CCA-SF blend. Also, the compressive strengths increased steadily with the increasing percentage of CCA-SF blend up to 10% replacement then dropped. The control sample containing 0% CCA-SF blend, exhibited a high early strength of 29.5MPa by day 3 and steadily rose to 42.5MPa by day 28 and maintained its strength even at day 56. The sample with 5% CCA-SF blend at day 3 also exhibited a very high early strength of 37.5 MPa, which rose steadily. The sample containing a 10% CCA-SF blend proved to be optimum, by attaining the highest early strength of 41 MPa at day 3 and ultimately 61 MPa by day 56 which is within the HPC range of 60 – 125 MPa. At 15% CCA-SF blend, day 3 results attained 35.5 MPa and rose steadily to 48 MPa by day 56. At 20% CCA-SF blend replacement, day 3 results dropped by 7% from 29.5 to 27.5 MPa. The cube strength rose steadily to 39.5MPa by day 56.
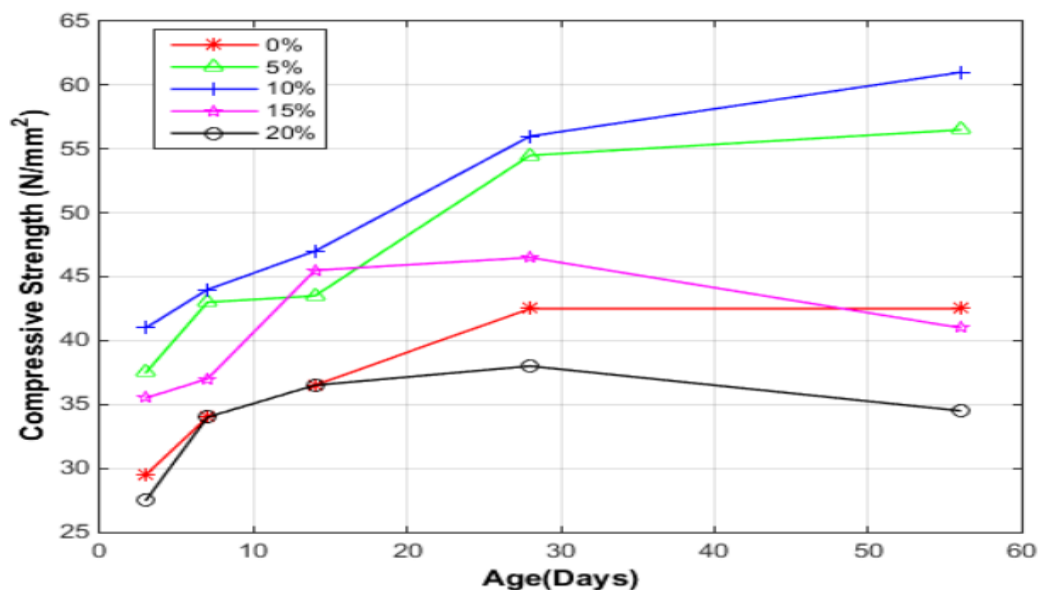
Figure 1.Compressive Strength Against Age (in Days)

Within the first three days of curing, there is a notable increase in strength that can be attributed to the Portland cement's calcium silicates hydrating to form C-S-H gel and release Ca (OH)$_2$. According to a study (Neville, 2011), the initial three days of mixing concrete result in a quick and exothermic reaction.

But between days 28 and 56, the strength for 15 and 20% replacement decreased, indicating that the bond in the concrete's structure had broken. A similar observation (He et al., 2022)

demonstrated that concrete's compressive strength was reduced when silica fume was added more than the recommended amount to Portland cement. This is explained by self-desiccation-induced autogenous shrinkage in cemented concrete. A study (Wu et al., 2017) confirms that autogenous shrinkage is more pronounced in high-performance concrete containing additional cementitious ingredients such as silica fumes that raise the water requirement and have water binder ratios lower than 0.4. Therefore, it is clear that although the test specimen was cured in water, low relative humidity was present as a result of the water's inability to fully penetrate the densified pore structure and reach the inner core of the concrete.

Flexural Strength

The failure on the beam was seen to occur as anticipated in the middle of the loaded length. The results of the flexural strength test performed on beams at 28 days are displayed in Table 1.

Table 1. Flexural Strength Results

Mix	0% CCA-SF Blend	10 % CCA-SF Blend
Cube Strength (MPa)	42.5	56.0
Experimental Flexural Strength	5.0	7.9
Calculated Flexural Strength	6.2	7.4

The flexural strength of the control mix determined from the experiment is 12% of the cube strength and is lower than the calculated flexural strength from EN 2 whereas the experimental flexural strength of 10 % CCA-SF blend is 14% of the cube strength and is higher than the calculated flexural strength.

Water Absorption

Figure 2 plots the samples' water absorption over time on day 28. As water permeates through the loose outer surface of the concrete, it can be seen that during the first 10 minutes, the water absorption for the two mixes steadily increases. However, over time, the 10% CCA-SF blend absorbs a lesser amount of water compared to the control mix (0%) because of its dense pore structure. Since both silica fume and corn cob ash have very fine particles, the spaces between the aggregates and cement will be filled thus ensuring a dense structure.

A study (Zhuang et al., n.d.), on the experimental and analytical analysis of the concrete's water absorption behavior. Their research showed that curing age, water-to-binder ratio, and mineral additive all significantly affected the concrete's drying and absorption curves. Concrete that contained fly ash or slag exhibited a more obvious abnormal absorption

behavior. This describes how the 10% CCA-SF blend, which also contains silica fume and corn cob ash, behaves. The volume, morphology, and structure of C-S-H are all impacted by CCA and SF, which also has an impact on how much C-S-H can swell.
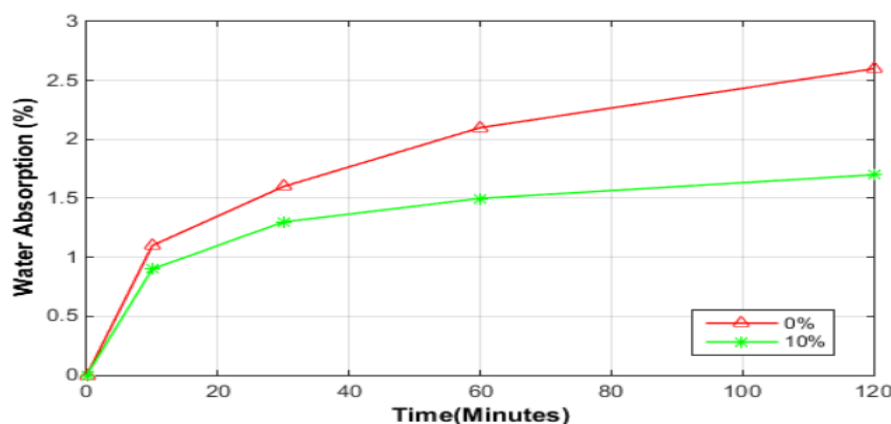

Figure 2. Changes in Water Absorption With Time

A study (Wang et al., 2022) on the factors influencing the capillary absorption characteristics of concrete and their relationship to pore structure. Water binder ratio was one of the factors that were explored and it was found that an increase in w/b increased the porosity of the concrete as a result there was a rapid acceleration of the rate of water uptake. This explains why both the control and 10% CCA-SF blend concrete rate of water absorption was steady. This was due to the use of a low water binder ratio of 0.35 in both mixes, which led to either little or a gradual increase in water absorption.

Electrical Resistivity

The samples' electrical resistivity (ER), with a 10% CCA-SF blend is shown in Table 2 showing a higher ER compared to the control mix.

Table 2. Electrical Resistivity

Mix	0% CCA-SF blend	10% CCA-SF blend
Electrical Resistivity (Ω)	11.0	29.5

According to AASHTO TP 95, an electrical resistivity range of between 9.5 to 16.5 kΩ-cm depicts moderate penetrability whereas a range of between 29 to 199 kΩ-cm depicts very low Cl penetrability which is an indication of a good level of pore density and enhanced durability. This level of durability enhances the long-term performance of the concrete. Mix 2 which is a partial replacement of cement with CCA-SF blend has a higher percentage ER increase of 168 compared to the control which is 0% CCA-SF blend. The reduced electrical resistivity of the 10% CCASF blend can be attributed to the finer particles of CCA and SF which possibly filled the pores with C-S-H and calcium aluminium silicate hydrate (C-A-S-H). Since the matrix is

dense, the pore interconnectivity decreases and so is the porosity. These results coincided with previous studies (Abdalla et al., 2022) (Ofwa et al., 2020).

Conclusion

The following inferences can be made based on the outcomes of the numerous tests that were conducted that compressive strength results at 10% CCA-SF blend replacement produced a strength of 61 MPa at day 56 compared to 42.5 MPa which represented an increase of 44%. Flexural strength results exhibited an increase of 58% from the control mix of 5.0 to 7.9 for 10% CCA-SF blend concrete. Water absorption results showed that there was a decrease of 1.6% for the 10% CCA-SF blend compared to 2.6% for the control mix. Electrical resistivity results decreased from 29.5 kΩ-cm at 10% CCA-SF blend which depicted very low chloride penetrability compared to 11 kΩ-cm which depicted moderate penetrability. Further research should be carried out to figure out ways of reducing the content of potassium in the ash to make it a better SCM. Additionally, further studies should be carried out on the properties of fresh concrete of CCA-SF blend.

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Student Presentation 17   Preparation and Characterization of Rice Husk Biochar as a Cost-Effective Adsorbent for Removal of Cadmium Metal Ions from Aqueous Solution

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Keywords: Heavy metals, Adsorption, rice husk biochar, isotherms models and kinetic models.

This study points out a remedial action needed to mitigate the ecological risk due to heavy metals ions contaminations. The adsorption of Cd^{2+} was carried out using eco-friendly and cost-effective activated biochar from rice husk as a potential adsorbent. The rice husk (*Oryza sativa*) biochars were pyrolyzed at different temperatures between 300 - 700°C in an automated muffle furnace. Characterization of the biochars was achieved by use of Fourier Transform Infrared, Scanning Electron Microscope and Brunauer Emmert Teller. The morphology of the chemically activated optimal biochar (RHBT500) indicated as the best adsorbent. The BET results revealed that specific surface area increased with pyrolytic temperature, was the highest in RHBT600 and lowest in unpyrolyzed rice husk. The optimal conditions were; pyrolysis temperature 500°C, contact time 30 minutes at all the initial metal ions concentrations, adsorbent dosage 0.250 g, initial metal ion concentration was 2 mg/L and the pH was (7.0). The Pseudo second order fitted well with higher linear regression coefficient (R^2) values (0.999). The equilibrium fitted the Langmuir equation well, with higher (R^2) values (0.9804) indicating monolayer adsorption on a homogeneous material. The Freundlich adsorption process was not favorable for Cd^{2+} because n value was less than one (*n>1)* that is 0.23496 indicating a weak bond between rice husk biochar and Cd^{2+} leading to normal adsorption.

Student Presentation 18   Fabrication of immunosensor for ultrasensitive multiplex detection of cancer biomarkers Carcinoembryonic Antigen (CEA) and YES1 based on electrode surface modification

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In this study, we present fabrication of an ultrasensitive sandwich electrochemical multiplex immunosensor for simultaneous detection of cancer biomarkers CEA and YES1. The immunosensor was fabricated using gold nano clusters coupled with thiolated protein G, glutaraldehyde, CEA and YES1 antibodies, bovine serum albumin (BSA) and Horseradish peroxidase (HRP)-functionalized gold nanoparticles to label secondary antibodies on a glassy carbon electrode. Gold nanoparticles (AuNPs) were biosynthesized using air dried *Mangifera indica* leaves extract. They were characterized using UV–Vis spectroscopy, Fourier transform infrared spectroscopy (FTIR) and Dynamic light scattering (DLS). The particle distribution by intensity of AuNPs using DLS showed an average size of 8-40nm.

Through differential pulse voltammetry (DPV) measurements, two separate oxidation signals were detected at −0.18V and + 0.53V indicating presence of YES1 and CEA respectively. Under optimized conditions, the electrochemical immunosensor detection limit for YES1 and CEA was found to be 0.0022 and 0.0034 ng/mL respectively within a linear range of 0.1–50 ng/mL.

When human plasma samples were analyzed using the immunosensor and the results compared with those obtained using the ELISA technique, the relative error values between the two techniques ranged from −4.66 to 6.59 % for CEA and from −7.83 to 1.75 % for YES1. The proposed immunosensor proved to be stable for up to 2 weeks and had negligible cross reactivity towards various interfering compounds in human plasma. This study reports that gold nanoparticles can be bio synthesized using shade dried *Mangifera indica* leaves extract. Gold clusters coupled with thiolated protein G can be used for fabrication of a multiplex

immunosensor for detection of CEA and YES1, bio-synthesized gold nano particles are used for labelling of CEA secondary antibody. The proposed immunosensor can provide a new approach for early diagnosis of circulating cancer biomarkers and holds great promise for application in clinical diagnosis.

Student Presentation 19　　Photosensitisers for Photodynamic Water Disinfection

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Keywords: Photodynamic Antimicrobial Chemotherapy(PACT), Photosensitiser (PS)

Introduction

In 2019, antimicrobial resistance claimed the lives of up to 1.27 million people (Murray et al., 2022). This was indicative of the adaptive power of microbes and the need to continuously develop new techniques to combat harmful pathogens. Antimicrobials, essential not only in human healthcare but also in water treatment to ensure safe consumption, face a growing challenge from antimicrobial resistance in water disinfection (Xu et al., 2016). This means that conventional water disinfection techniques such as chlorination, the most widely used water disinfection technique, require higher concentrations to maintain their efficacy. However, this comes at a cost, manifesting in increased toxic by-products such as halo-methanes, known carcinogens, and a reduction in water quality as the water ceases to be odourless. Thus, there is a need to develop new techniques to which pathogens have not developed antimicrobial resistance and are non-toxic (Xu et al., 2016).

Photodynamic antimicrobial chemotherapy (PACT) is an example of a technique to which bacteria have not developed resistance. PACT is a three-component system that uses light, oxygen and a photosensitiser (PS) to induce microbicidal action. A PS is a compound capable of exciting other molecules upon its excitation. In PACT, when exposed to light of appropriate wavelength, the PS becomes excited and in this excited state, it undergoes intersystem crossing (ISC) to its triplet state, where it can transfer energy through two mechanisms (type I and type II). In type I, the PS transfers energy by reacting as a radical, while type II involves a transfer of energy through an energy exchange mechanism. Oxygen is transformed to its microbicidal state of singlet oxygen ($^1O_2$) through type II. (Khisa, 2020). Singlet oxygen interacts detrimentally with cellular components, ultimately resulting in cell death. PACT stands out as an appropriate water disinfection technique as no bacteria have been able to develop resistance against it. However, the safety of PACT hinges on the PS employed (Xu et al., 2016). Examples of PSs include: phthalocyanines and porphyrins.

In this study, porphyrins were selected because of their non-toxicity to humans and their ability to induce microbicide at relatively low concentrations, notably below 100µM.

Furthermore, porphyrins can be readily modified to change their photo-physical properties, either by incorporating appropriate atoms at their core or other substituents at their *meso*-positions. This is important, since increasing the probability of generating singlet oxygen often entails attaching heavy atoms, which induces heavy atom effect and amplifies the probability of intersystem crossing (ISC) (Oloo, 2020). Two porphyrins were synthesised: *meso*-tetra(5-bromothiophe-2-yl)porphyrin (BTP) and its indium analogue *meso*-tetra(5-bromothiophe-2-yl)porphyrinato indium (III) chloride (In-BTP).

Results and Discussion

Synthesis

Meso-tetra(5-bromothiophen-2-yl)porphyrin (BTP) was synthesised through a modified Adler-Longo method, modified by Sun et al., (2013). It involved refluxing 4 equivalents of pyrrole with 4 equivalents of 5-bromothiophene-2-carbaldehyde in a mixture of propanoic acid, valeric acid and *m*-nitrotoluene (47:47:6) for 2 hours. This yielded BTP, a purple powder, with a yield of 13%. While, *meso*-tetra(5-bromothiophen-2-yl)porphyrinato indium (III) chloride (In-BTP) was synthesised by refluxing indium (III) chloride and BTP in acetic acid for 48hours. The result was In-BTP, a purple powder with a yield of 56%, as shown in Scheme 1.
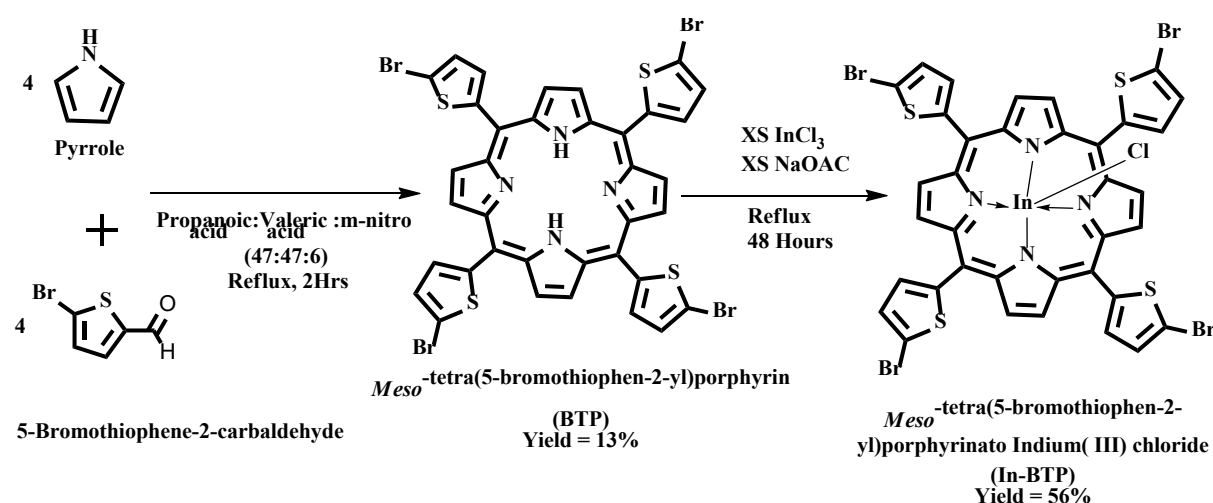
Scheme 1: Synthesis of *meso*-tetra(5-Bromothiophen-2-yl)porphyrin and *meso*-tetra(5-bromothiophen-2-yl)porphyrinato Indium (III) chloride

For both BTP and In-BTP, successful synthesis was confirmed via ^{1}HNMR and UV-Vis spectroscopy. For BTP, a highly shielded peak at δ-3.16ppm was observed, indicative of anisotropic effect acting on the core hydrogens of BTP. Anisotropic effect is important as it confirms that the compound is aromatic, one of the most stable class of compounds. For UV-Vis, the characteristic spectral pattern for porphyrins was observed, with a strong peak in the range 400-500nm (known as the Soret band) and a series of 4 diminishing peaks in the range 500-700nm (known as Q bands). While for In-BTP, ^{1}HNMR lacked a heavily shielded peak at δ -3.16ppm signifying the absence of core hydrogens. Additionally, its UV-Vis spectrum had its Soret band red-shifted while the number of Q bands had decreased from 4 to 2, suggesting

increased symmetry due to the presence of the heavy atom, as shown in Figure 9 and Table 1.
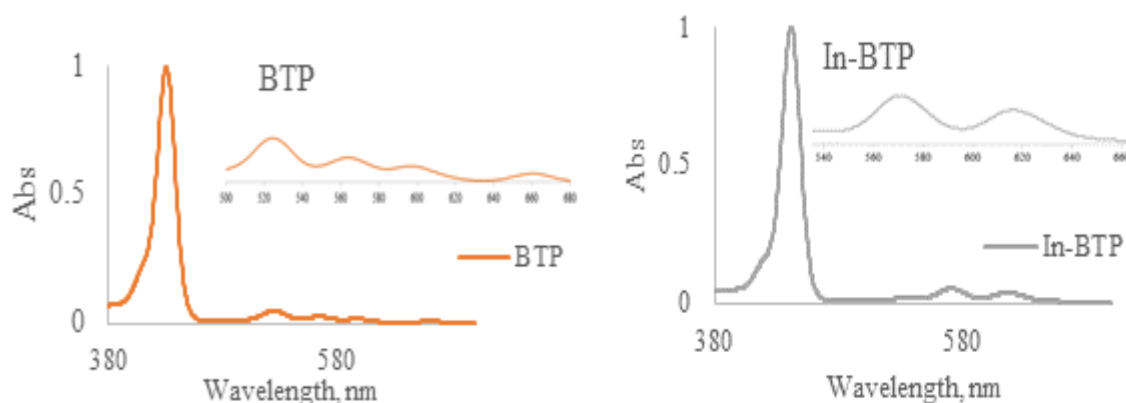

Figure 9: UV-Vis spectra (Q-bands in-set) of *Meso*-tetra(5-bromothiophen-2-yl)porphyrin and *meso*-tetra(5-bromothiophen-2-yl)porphyrinato indium (III) chloride

Photophysical Studies

The criteria for an effective photosensitiser in water disinfection is that it should be: photo-stable, absorb light in the 400 -450nm range, here referred to as the photo-aquatic zone (PAZ), have a high molar absorption coefficient and have a low fluorescence quantum yield. Photo-physical studies were performed to assess whether the compounds synthesised met these criteria and the results are shown in Table 1.

Table 1: Photo-physical properties of *meso*-tetra(5-bromothiophen-2-yl)porphyrin and *meso*-tetra(5-bromothiophen-2-yl)porphyrinato indium (III) chloride

Name	Soret Band (nm) (ε (L/Mol/cm))	Q Bands (nm)				Fluorescence (nm)	Fluorescence Quantum Yield (Φ_f)
		Q_y	Q_y	Q_x	Q_x		
BTP	431 (248,762)	524	563	597	661	675	1.47E-03
In-BTP	442 (430,337)	571		616		649	7.44E-04

Porphyrins are well-known for their photo-stability, meaning their structure remains unaltered in the presence of light. This was confirmed through a comparison of UV-Vis spectra and fluorescence spectra, where if the two are mirror images of each other, this can be taken to be indicative of maintenance of the structure of the compound even in its excited state. The soret bands of both compounds are in the 400-450nm range (PAZ), the importance of this is that, this is the range at which water absorbs the least light. Furthermore, both compounds displayed a molar absorption coefficient that exceeded 50,000L/Mol/cm, well beyond the criteria given by Thandu et al.,(2015) for an effective photosensitiser in photodynamic water

disinfection. The molar absorption coefficient (ε) reflects the number of individual molecules involved in absorbing light at a given concentration. Additionally, both compounds exhibited very low fluorescence quantum yields, suggesting a high probability of undergoing intersystem crossing (ISC). In-BTP had a lower fluorescence quantum yield than BTP indicating that adding indium, a heavy atom, induced heavy atom effect that increased the probability of ISC (Oloo, 2020).

Methodology

The synthesis of BTP was conducted using a slightly modified procedure from Sun *et al,* (2013). This involved adding 5-bromothiophen-2-ylaldehyde (1.911 g, 0.01 moles) and pyrrole (0.6709 g, 0.01 moles) in a 250 mL two-necked round-bottom flask and refluxing in a mixture of 100 mL propanoic acid, valeric acid and *m*-nitrotoluene (ratio, 47:47:6) for 2 hours The resultant product was filtered under vacuum to yield a black cake. The black cake was then dissolved in dry dichloromethane (DCM). The resultant solution was then run through an alumina column eluting with dry DCM to afford a purple powder (yield: 0.345 g, 13%).

The synthesis of In-BTP employed a modified literature method (Khisa, 2020; Oloo, 2020). Indium(III)chloride (41.57 mg, 188 µmoles) and sodium acetate (42.63 mg, 313.3µmoles) were dissolved with stirring in hot acetic acid (60 $^{\circ}$C) in a 100 mL two-necked round bottom flask. BTP (59.8 mg, 62.66 µmoles) was added and the temperature raised to reflux for 24 hours. The reaction mixture was allowed to cool to room temperature and then neutralised with a solution of sodium hydroxide (35 g of NaOH dissolved in 100 mL of distilled water) in a 500 mL separatory funnel. The mixture was extracted with DCM (100 mL x 3). The combined DCM extracts were dried with anhydrous sodium sulphate for 2 hours and concentrated *in vacuo*. The crude extract was purified over a column of alumina with dry DCM as the eluent to provide In-BTP as a purple powder (yield: 37.27 mg, 54%).

UV-Vis spectroscopy was performed using a Shimadzu 1800 spectrophotometer UV-1800 and fluorescence spectroscopy and fluorescence quantum yield were determined via a Shimadzu RF-6000 spectro-fluorophotometer. NMR spectra were obtained from a Bruker 80 MHz NMR spectrometer with residual protons of deuterated chloroform (CDCl$_3$) as the reference standard and CDCl$_3$ as the solvent.

Conclusion

Both In-BTP and BTP met the criteria for good candidates for photodynamic water disinfection. These are: photo-stability, a high molar absorption coefficient, and a low fluorescence quantum yield.

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Student Presentation 20   Unlocking Mobile Health's Potential for Population-Wide Impact: Scaling Innovative Healthcare Delivery in Low-Resource Settings from Pilot Projects to Scalable Solutions

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Background and aims

Healthcare systems worldwide face growing demands to provide high-quality care to larger populations, ideally at lower costs and with greater equity. Mobile Health (mHealth) is recognized as a potential game-changer in healthcare service delivery, offering a means to advance Universal Health Coverage and Sustainable Development Goals, especially in resource-constrained developing countries. Despite the global proliferation of mHealth applications, including in Kenya, few interventions have achieved widespread adoption and demonstrated long-term healthcare improvements. In particular, mHealth holds promise for addressing the healthcare needs of low- and middle-income countries (LMICs), offering affordable access, improved outcomes, and increased efficiency, especially within the public healthcare sector, where the majority of Kenyans seek services. However, the successful implementation and scaling of mHealth applications remain a challenge. Currently, most mHealth projects remain at the pilot stage, with limited research on factors facilitating their scale-up. This study seeks to explore these factors, recognizing that scaling up mHealth projects is a context-dependent and complex process, crucial for realizing their potential in healthcare transformation

Methods

The study will apply both qualitative and quantitative research design. Cross sectional survey using questionnaire, interview and online tools will be used. Data will be analyzed using structural equation modeling (SEM).

Conclusions

The dream of every government and citizen especially those at the lower of the pyramid is having access to affordable healthcare. We believe by availing evidence on mHealth scale up, we can influence investment decisions to incorporate mHealth in healthcare service delivery on a large scale by the government and private sector. The scale up can then aid the country to meet some of the health goals and move towards the attainment of Universal Health Coverage.

Student Presentation 21   Technological Developments Influence the Cybercrime in Juja Sub-County

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Keywords: Cybercrime, Cyberspace, hacking, Cyber-attacks, Computer Crime, Identity Theft

Abstract

Before there was technology growth, the world only had physical threats. However, the emergence of technology creates cybercrime that may be skilled via way of means of anyone. Cybercrimes have grown steadily with perpetrators growing more recent and extra state-of-the-art strategies each day. The maximum distinguished offenses are stalking, hacking, phishing, online frauds, identification thefts, and dispensing viruses. These crimes purpose harm to private identification, fraud, forgery, threat, and financial losses. Cybercrimes cause severe damage in developing countries driving toward a cashless economy.

Purpose

This article ambitions to study the effect of the technology boom on cybercrime in the Juja sub-county as a version of crime that develops with the advancement of technology.

Methodology

The concepts of cybercrimes are introduced and different types of cybercrimes are explored as examples of some of the impacts caused by cybercrimes activities. The analysis in this paper is based on an extensive review of published research works, which provide theoretical and empirical evidence on the effects and impact of the internet on the development

Findings

There are many terrible effects the society suffers from the cybercrimes and why the computer or networking are geared goal for crimes. The paper commonly concludes that the net is overwhelmingly an effective device for development. Paradoxically, the net is a "double-edged sword", presenting many possibilities for people and firms to increase however an equal time, has introduced with it new possibilities to devote crime. The paper argues that the net affords new demanding situations to regulation enforcement in each evolved and growing international location. However, growing international locations go through substantially from the sports of net crime than their evolved opposite numbers as growing international locations have insufficient generation, infrastructure, and inadequate regulation enforcement expertise. Development in Technology allows cybercrimes and creates worry Information Technology widened the verbal exchange sphere making it Borderless and Transnational.

Practical implications

This paper reminds people, agencies, and coverage makers alike that cybercrime has turned out to be an international difficulty that calls for the entire participation and cooperation of each evolved and growing international location on the global level, as net crime investigations regularly require that proof be traced and accumulated in extra that one ICT industries ought to awareness now in designing merchandise which is proof against crime and may facilitate detection and research of crime.

Value

The main novelty of this paper is that it lines the historic evolution of the technology after which sketches out a number of the improvements the net has introduced in addition to thinking about the terrible outcomes related to this generation and its effect on development.

Recommendations

Introduction of a concrete legal framework, establishment, and strengthening of cybercrime regulation enforcement agencies whole with excessive generation tracking gadgets and cutting-edge infrastructure. Empower the youths while in college with entrepreneur skills. Cybercrime may be predicted via way of means of growing safety in the company community while speaking to the outdoor world. There is a want for the Universal Criminalization of Cyber Offences below International legal guidelines and treaties.

Student Presentation 22   A Multi-Level Analysis of Help-Seeking Behaviour of Male Victims of Intimate Partner Violence

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Keywords: Help-seeking, Intimate partner violence, Males, Multilevel, Uganda

Introduction

Globally, many men are victims of intimate partner violence but not many seek help to stop the violence. This study sought to identify the factors associated with the help-seeking behavior of male victims of intimate partner violence in Uganda.

Methodology

This was done using secondary data from the 2016 Uganda Demographic and Health Survey. At the univariate level, frequencies and percentages were used to describe the variables included in the study. At the bivariate level, Pearson's chi-square test was used to test for the association between each independent variable and the dependent variable at a 5% level of significance. At the multivariate level, ordinary and mixed-effects regression models with logit, probit, and complementary log-log link functions were used. The Akaike Information Criteria was used to determine which model fitted the data best. The Likelihood ratio test was used to check if the sample stratum level variance was significant to favor the use of multilevel models instead of ordinary regression models for all possible link functions. A caterpillar plot was also used to graphically display the estimates of the sample stratum effects or residuals obtained from the empty model. Still, the Variance Partition Coefficient was presented to show a summary of the degree of clustering in the data.

Results

Most males (70.6 percent) never sought help after experiencing intimate partner violence. Since the meprobit had the lowest AIC (1378), it fitted the data better than the rest of the models. The reported likelihood-ratio test (chibar2(01) = 23.38, p>=chibar2 = 0.00) showed that there is enough variability between males across sample strata to favor a mixed-effects probit regression model over an ordinary probit regression model. The estimated variance of the random intercept is 0.08 with a standard error of 0.04. This meant that 8 percent of the variation in help-seeking of male victims of IPV lay between sample strata. Marital status (divorced/separated), listening to the radio (at least once a week), physically hurt partner, experienced physical injury, number of control issues (two and above), father ever beat mother (don't know), and severity of violence was significantly associated with the help-seeking behavior of male victims of IPV.

Conclusion

There is a need to come up with interventions that encourage males to report IPV, especially among the married, and also sensitize males not to wait until they have experienced physical injuries or any other severe violence before they seek help. Given that the study found significant variations in help-seeking across geographical sample strata, interventions aimed at boosting the help-seeking behaviors of male victims of IPV should be tailored to the different geographical locations in the country. Given that the sampling methodology used in demographic and health surveys introduces nesting in the data, researchers should consider using multilevel models. Still, most public health studies involving binary outcomes use logistic regression and yet there are other link functions that can be used to model the relationship between outcome variables and selected predictors.

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Student Presentation 23   Stars and Culture: Insights to the Motion and Life Cycle of Sirius A and Sirius B Stars Based on Kikuyu Semiotics and Philosophy

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Abstract

This study is aimed at bridging the gap between the astrophysical knowledge in the motions and life cycles of the currently observed brightest star system in the night sky: Sirius A and Sirius B through the lens of Kikuyu semantics and philosophy. The authors are well aware of the integral parts of the framework of western astrophysics and African philosophy may have incompatible aspects and as such a holistic approach will be utilized. This author hopes that exploring these two topics concurrently will provide context and extensive understanding as well as encourage conversation and research into the African perspective of physical sciences.

1. Introduction

Throughout the scientific community, there has been an increasing sentiment and understanding towards certain realms of physical reality that we have no direct contact with. There are parts of the scientific endeavor that no longer hold the advancement of knowledge and understanding as a tenet but instead seek to understand the implications of these physical laws on the human experience. Thus, there indubitably exists a realm in which physics and philosophy are intertwined[1]**.**

This idea is not at its stage of conception but instead a revisitation. In ancient Greece, scholars were granted the title of 'natural philosopher' allowing the ideas of science and philosophy to merge and become one2**.** However, upon the dawn of instrumentation by pioneers such as Tycho brahe, and the sight of the heavens having the ability to change and be imperfect. The detachment between the two ideas was definite, and words such as progressive and objective[3]**.** Science and philosophy were no longer seen as two dependent ideas that relied upon each other but they instead were forced into independent frameworks.

It is only upon the discovery that the framework of the world we have the ability to interact with does not encompass the entirety of physical reality. Scientists were forced to put into question the implications of their own existence and senses into question when experimenting with scales, sizes and matter that they were not familiar with. From the macroscopic perspective to microscopic and cosmic scales[4]**.**

To thus revisit the domain of investigation where physics and philosophy overlap. This realm, in turn, must take all cultural paradigms into consideration, to revisit the scientific exploitations of the past. It is impossible to talk about the advent of philosophical implications of physical endeavors without taking into account that the entire history of the philosophy of physics is purely seen from a western perspective[5]. Various communities in Africa had brought into question, not only scientific ideals. But the innuendo of these discoveries on their lifestyles and culture[6].

Stars have always had an important role in the ancient world, used mostly as a metric of time for lunar calendars or as a compass to guide adventurers along dangerous journeys. In ancient Egypt, Sirius A was known as solis. And was said to predict the presence of floods. The Egyptian calendar was thus modeled after the heliacal rising of a star in intervals thus summing up to 365 days[7]. For the Kikuyu a community making about 17% of the Kenyan population, being the largest ethnic group[8]. The stars served as a demarcation of time following a lunar calendar that marked the time period of the binary stars Sirius A and Sirius B, with a time period known as 'thunguya ithano' (five decades) and was marked by a spectacular jubilee [9].

The knowledge and dynamics of astronomy in the Kikuyu community was highly sacred and esoteric and only accessible to a specific group of people, known as seers[10]. Seers in the kikuyu community were hierarchical scholars who possessed special powers known as ngugi power that allowed them to make predictions about various which provided them with intricate knowledge of astronomy, mathematics, surgery, herbs, geology and radiation. The community relied on them in observation of heavenly bodies. Utilizing this knowledge for agriculture, dance and other cultural practices[11]. This knowledge has been kept secret and its intricacies are unknown to the general public.

Therefore, there currently exists a gap in our current knowledge of African (particularly kikuyu) horology, in conjunction with astrophysics. There is also the belief that physics is an autonomous process void of any cultural influence[12]. Furthermore, there is a lack of consideration of the philosophical implication of natural phenomena[13]. This research thus, is aimed utilizing quantitative research, and viewing physics research through cultural lens thus, creating a foundation and filling in knowledge of ancient African astronomy, as well as analyzing the cultural and political undertaking of astronomy in antiquity as well as in the present.

In this paper, we analyze data about the motion and life cycle of the binary star with preliminary and introductory knowledge to the philosophy of physics from the Gikuyu community perspective.

2. The Apparent Motions of Sirius A And B

Sirius A (α Canis Majoris) is an A1V spectral type of star, being the brightest in the night sky, found in the alpha major canis constellation. Which dwells in the 5th nearest Binary system. The presence of Sirius A star has been known throughout history, with various cultures across the world[14] . The existence of a massive companion, Sirius B, (α Canis Minoris) was predicted by Bessel in Königsberg (1844) based on the seasonal astrometric perturbations of its proper motion. Historical measurements of Sirius A go back all the way to the 19th century[15].

It must be noted that rarely are the values of time period calculated analytically but instead use approximations of values obtained analytically. Thus, before the determination of the existence of Sirius B causing various fluctuations in motion. Kepler's third law was utilized in the calculation of the time period. Upon the confirmation of the binary stars existence in the 19th century cannot be used due to lack of precision in mass estimates. Thus, values predating this discovery shall not be used.

I.   Determining dynamical masses and radii

The existence of the Sirius B star was in turn visually seen by Alvan G. Clark and his father.(1862). Being to this date one of largest white dwarves ever discovered[16]. Approximated at being 1.05 M☉ . Exceeding the average mass of most white dwarfs with a mean of 0.58 M☉[17]. The period of the binary star system has been studied extensively and its estimate is concluded to be about 50 years analyzed over a 60-year period and determined the orbital photocentric semi-major axis of Sirius A with respect to the system barycenter. This determination relied upon the orbital parameters of the relative visual orbit of Sirius B.

As of 2003, The mass of Sirius A then approximated by these authors was 2.143± 0.056M☉, with a parallax of π = 377.7± 3.31. Due to particularly high precision provided by the Hipparcos satellite launched in 1997. With a parallax of π = 379.22 ± 1.58 mas. Consequently, the sum of the masses has to be diminished by 1.2%, giving for Sirius A a lower mass of 2.12 ± 0.06 M.

The age however of both stars has been of great contention in scientific literature. In one study employing the TYCHO stellar evolution code, approximated the age of the binary star to be 225-220 Myrs, and is dependent on primordial solar metallicity and solar abundance, yet another area of debate. Furthermore, the elusive nature of Sirius B is dependent on the measure of Sirius A, thus the progenitor mass of Sirius B is dependent on the reasoning that the radius and a valid measure of systematic age[18].

Furthermore, the entirety of measurement is based on the assumption that we have relied on the assumption that Sirius A is a member of the Sirius supercluster which in fact is an assumption that may not hold true in future. However, this lack of a substantive basis is not a lack of ability of astrophysics, but instead the limitations of instrumentation as well as the luminosity and size of Sirius A in comparison to its companion. It is progress to notice that as

the instruments used to take more measurements become more precise, as well as deviations falling in line. As of 2017 with the utilization of the Hubble Space telescope, the calculation of the time period of the binary star was 50.1284±0.0043. As well as updated photos on the binary star fig 1.1. Taken at 10.7 arcsecs away in comparison of those taken between the year 1970-1975 being 11 arcseconds away **.**
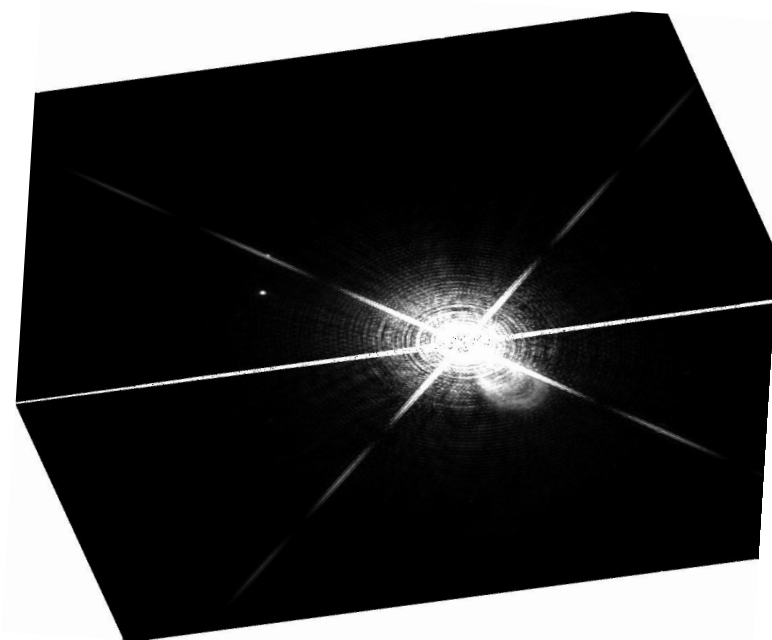

Fig 1.1: From a WFPC2 frame obtained in the near-infrared F1042M filter on 2001 October 27, exposure time 35 s which is consistent with the measurements taken by Gatewood and Gatewood in 1978 of 50.090±0.056 years, utilizing the Hipparcos satellite. Which falls within the minimum deviation**.**
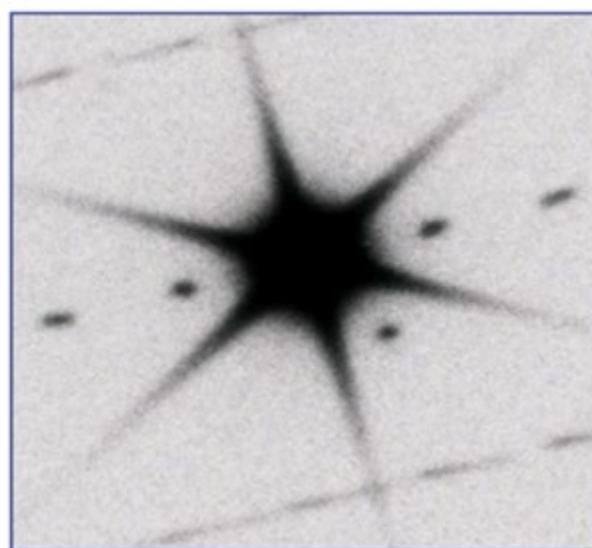

Fig 1.2: Digitized image of Sirius taken from a scan of a photographic plate obtained with the USNO 26 inch refractor.

These types of observations were cumulatively analyzed by Bond. In the most recent analysis of the motion of Sirius A and B. Utilizing methods of observation to chart possible and determine precise mass estimates. The most accurate being the Hubble Space telescope being so exquisite in precision that the deviation in astrometry is too small to be seen in the figure 1.3. It is also noticeable that CCD & MIR overestimates the separation for CCD & MIR, and photographic results dwindle as the motion approaches perihelion thus only HST will be used in the analysis.
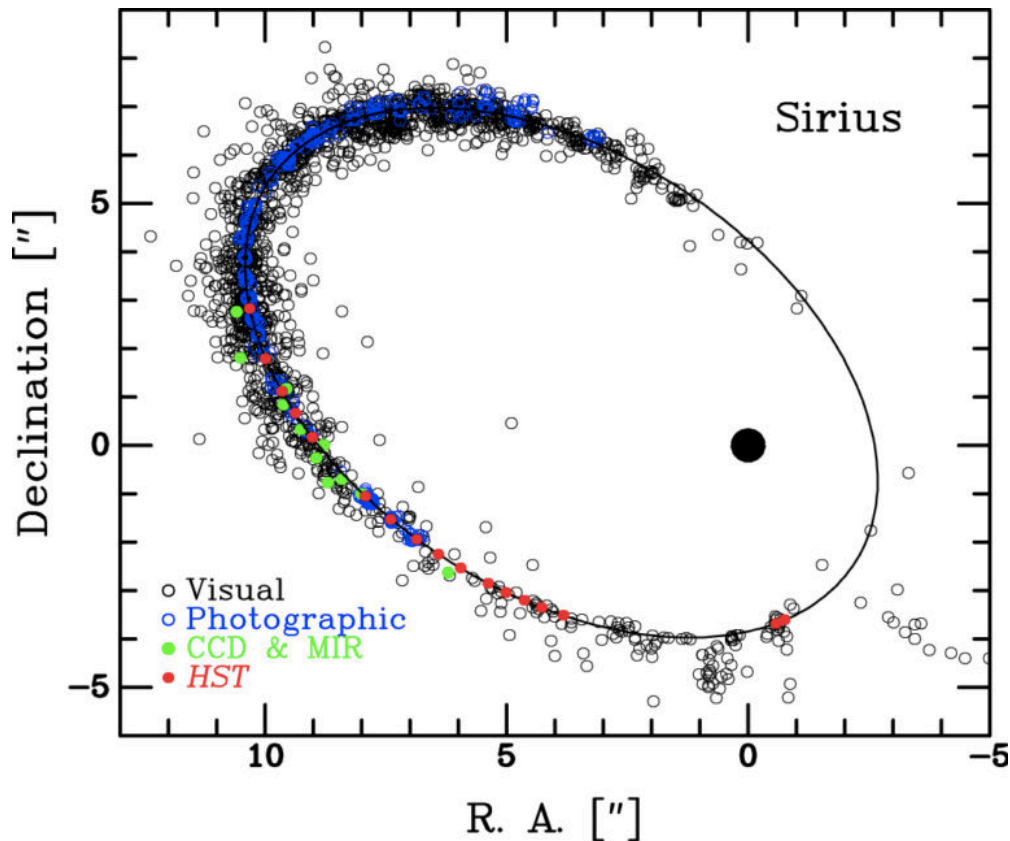

Figure 1.3

The results obtained by these authors found the total mass of the binary star to be   3.081 ± 0.034 Me. With Sirius A having a mass of 2.063 ± 0.023 Me, Sirius B having a mass of 1.018 ± 0.011 Me. Which will be in used in this paper.

 On top of that, the radii taken into question here was also brought about from Bond et al utilizing IFMR to approximate the radius luminosity and temperature

For Sirius A as R = 1.7144 ± 0.0090 R, L = 24.74 ± 0.70 L, and Teff = 9845 ± 64 K. and Sirius B, Teff = 25, 369 ± 46 K, 0.008098 ± 0.000046 R, 0.024480 ± .00033 L. though it must be taken into consideration that the deviation in comparison to previous experiments. In order to test the agreement of models with the authors observationally determined parameters for Sirius A, we will compare with two sets of theoretical evolutionary tracks calculated using YREC and

the Tycho25 code. With the ultimate time period being determined as 50.1284±0.0043. years[19].

The Philosophy of Science
I. Incompatibility of science and philosophy, an African thought
Insouciant attitudes towards African philosophy of science often stem from the belief that African philosophy is contingent on religious and supernatural beliefs not empirical investigation, therefore in turn is truly incompatible with true science[20]. Let alone the general sentiment that science and philosophy are irreconcilable. This belief is founded upon the idea that science has given rise to objective truth, its justification is based on experimental evidence, not scholastic distinctions. It has given rise to some of humanity's greatest achievements[21].

 "Traditionally these are questions for philosophy, but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge." (Hawking and Mlodinov, 2010, pg.5).

However, I wish to argue that scientists view the role of philosophers not as trivial nor view its pursuit as meaningless, but instead have (or wish to) at the very least assume the role which philosophers do in line with the philosophy of science. With the advent of realms we are unable to act intuitively particularly with the incommensurable paradigms that physics has adopted. Questions such as 'What is in the universe, and what does it mean for us?' have become scientific questions just as much as philosophical ones. It is to be noted that these concerns are often not seen in the classical world, this will also be discussed in the paper.

Thus, it is not a ludicrous claim to state that the area of contention is not the endeavors in themselves, but instead the methodology used to achieve them. It is often argued that science is a progressive endeavor. Giving rise to new information and using these discoveries as a predecessor for further questioning and investigation. Does philosophy display the same ideals? Are there ideals of philosophy that are as indubitable as the foundations of scientific methodology?

The difference in methodology of philosophy and science have not always been different, in fact until the dawn of instrumentation by tycho brahe, philosophy and science were seen as inseparable[22]. In antiquity one's ideals and beliefs in turn influenced their scientific outlook of the world. This in turn gave rise to anthropocentrism in the scientific world. However, it is difficult to a

According to the works of A.C Grayling, during the development of the acquisition of knowledge 'agency' was viewed as a tenet. In turn people of antiquity had the ability to use their own analogies to craft reason for the natural phenomena that surrounded them.

Our ancestors are likely to have inferred from their own powers of agency— the feeling of 'I caused that' as when one throws a stone into water and it makes a splash– anything that moves, emits noise, changes in any way, must have an agent, a mover, behind or within it. (A.C Grayling,2021 pg 2.)

Here, Grayling explains that lack of objective analysis in the ancient world in turn was not an act of folly but instead, was rooted in the same methods of investigation that we use today. To grant agency to natural phenomena in itself is absurd, but viewing it in a framework of cause and effect in turn compartmentalizes knowledge into different categories.

In turn this knowledge sought not to explain the phenomena in itself for that was indubitable, but instead what gave rise to this phenomenon. A knowledge that compartmentalized both 'what' and 'how' into a single explanation, thus creating a dependent relationship between Philosophy, and science in itself.

Concurrently, another critique in scientific literature particularly those made by analytic philosophers of science. Is the elusive nature of astrophysics, as the cosmic world is out of reach. The astrophysical endeavor makes up for the lack of empirical knowledge as well as intimate interaction by utilizing simulations, which in turn is argued as not sufficient basis for scientific questioning[23]**.**

The astrophysical endeavor, in turn, has presented itself at the very least as purely metaphysical. Detaching itself from anthropocentric nature that was present in the past. In turn understanding that humanity's thought processes not as influence, but as mere ramifications of our awareness of the heavens. In this way astrophysics has also excluded itself from other physical sciences. For it lacks operationism, Here used as a form of positivism which defines scientific concepts by the operations used to prove them, transcending the realm of pure observation and creating a dependency on mathematics. In this way the role of observer is tarnished completely. A study of radio interferometry for example, would be a study of these bodies independent of human thought, or existence[24]**.**

This idea of fragmentary does not exist in African thought, In fact although most agency is relinquished to a deity, the conception of scientific concepts is reliant on the human experience. According to the Kenyan philosopher John Mbiti, Africans view the undertaking of scientific questioning as well as the events of natural phenomena as an ontological experience as such. Time and space are not metrics of measurements but consequences of our own existence.

As such in line with the philosophy of astrophysics, through which various critiques such as the lack of practical experiment as well as the disparities in accountability of variables given through the African perspective is a futile attempt. The conceptualization of time as well as space is a mere environmental contingency as a result of our perception. Thus 'any' measurement is indeed correct provided that the event anticipated occurs and is perceived by an observer.

Though the conceptualization of this idea may seem strange in line with Newtonian mechanics. The rise of quantum physics has in turn shown the ideas presented not as futile subjective dogma but instead as thoughtful consideration of the totality of all that there is in line with mankind. It is by the virtue of this African perspective that the philosophy of science and specifically astrophysics becomes an indubitable field through which the lukewarm. Objective knowledge that is dependent on our perception is conceived and operates.

It is by this note that one may argue the lack of experimentation in the astrophysical community serves not as a hindrance for the development of science, but instead as justification for the innate separation of humankind by the virtue of scale. As posed by the works of John S Mbiti. Furthermore, the analysis of the stars and their fluctuations in turn seem to go against this idea of kikuyu mythology. The extent of fluctuations measured however in turn seem to deviate, Despite the change from the HIPPARCOS project decreasing the parallax value significantly.

The implications of this particular astrophysical endeavor in line with African science serves as justification for the subjective view of dimensions in the African dilemma particularly with the dawn of quantum and relativistic realms of physics. This idea that has permeated African thought seems to be making its way through western context despite the lack of cultural context. In reference to time, though being described as a temporal dimension objectively has subjective implications in the African context.

It may thus be concluded that the African context through which science operates has different implications than the western tool, not as a form of sovereign utility but instead as a form of interlinked ideas that hinge on the human condition as a precursor to discovery

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Student Presentation 24   Genetic Diversity for Drought Tolerance in Pigeon Pea (*Cajanus cajan*) Landraces for Drought Tolerance and Possible Physiological and Biochemical Mechanisms Involved

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Keywords: Pigeon pea, Genetic diversity, Population structure, SCoT markers, Drought stress, Physiological and Biochemical responses

Pigeon pea (*Cajanus cajan*) holds a pivotal role in global agriculture, ranking sixth in global food legume production and contributing significantly to Kenyan agriculture. Its protein-rich seeds serve as a vital protein source in developing countries. Additionally, it possesses medicinal properties due to various phytochemicals, including alkaloids, flavonoids, sterols, and phenols and acts as a cash crop, benefiting low-income farmers economically. Despite its importance, there's limited information on the genetic diversity and population structure of the Kenyan pigeon pea genotypes. This study aimed to assess the genetic diversity and population structure of pigeon pea genotypes from various regions in Eastern Province, Kenya, using Start Codon Targeted (SCoT) markers. Eight pigeon pea landraces were sampled from different regions, and three seeds from each genotype were grown in pots with pre-weighed soil in a controlled environment. DNA was extracted from four-week-old plant leaves, followed by PCR amplification using Start Codon Targeted (SCoT) markers. In total, 206 alleles were amplified using twenty SCoT primers across the eight genotypes, with an average of 10.3 alleles per locus. The polymorphism information content (PIC) of the SCoT markers ranged from 0 to 0.38, averaging 0.34. Pairwise genetic similarity among pigeon pea genotypes ranged from 0.336 to 0.676, with an average of 0.607. A dendrogram, constructed using the unweighted pair-group method with arithmetic mean (UPGMA), classified the eight genotypes into two major clusters, with the first major cluster further dividing into two sub-clusters representing genotypes from distinct regions. Principal coordinate analysis (PCoA) of the genotypes revealed that the first two principal coordinates explained 43.12% of the genetic variation, effectively grouping genotypes. Analysis of molecular variance (AMOVA) indicated high genetic variation (80%) within populations compared to variation among populations (20%), providing a strong foundation for genetic improvement strategies. The UPGMA analysis also highlighted two primary genetic clusters linked to geographical origin, with the highest genetic diversity observed among Kitui region genotypes. Population structure analysis, using a Bayesian model-based approach, identified three gene pools with no genetic admixture within individual genotypes. Furthermore, these three gene pools corresponded to specific geographic regions. This study emphasizes significant genetic

diversity in Kenyan pigeon pea genotypes, essential for adapting to climate changes and future agricultural needs. Consequently, these genotypes offer a valuable resource for breeding programs aiming to develop hybrids with desirable agronomic traits.

Simultaneously, we conducted parallel analyses of physiological responses, including photosynthetic efficiency (Phi2), chlorophyll content (SPAD) and relative water content (RWC), which exhibited correlations and negative correlations with various parameters, reflecting the impact of drought stress on chlorophyll content. Biochemical responses also highlighted changes in total phenolic content, lipid peroxidation (MDA), proline, total protein, total amino acids, free amino acids, and hydrogen peroxide (H_2O_2) content under drought stress. Antioxidant enzyme activity levels, specifically ascorbate peroxidase (APX) and catalase, varied among genotypes and in response to drought severity, offering further insights into adaptive responses to drought stress.

Student Presentation 25   New Insights into processes of Silica scaling during geothermal production: a case of Olkaria Geothermal Field

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The Olkaria volcanic complex is located in the Central segment of the Kenyan Rift System, which is part of the great East African Rift System and is associated with quaternary silicic volcanism. Silica scaling is one of the biggest utilisation problems that affects the generation of electricity from this geothermal resource. The deposition of silica scales has been seen to be a complex process that differs from one well to another within the geothermal field and is mainly guided by pH, temperature, salinity, presence of other chemical elements in solution and enthalpy and characteristics of parent reservoir fluid. To be able to establish the formation mechanisms in Olkaria, we have conducted various sets of sample analysis as well as experiments within the Geothermal field and obtained results that has given us new information about the type of silica scaling in Olkaria. These included polymerization experiments, adsorption experiments, immersion experiments and ion exchange experiments accompanied with high level precision analysis using SEM-EDX, LA-ICP-MS, NMR, XRD and XRF as well as DLS analysis of water samples. The results show that the scaling is not a simple scale formation due to super saturation but is highly influence by other ions in solution, the enthalpy of fluid, pH and the separation pressure. In addition, the scales are not only pure amorphous silica but an amalgamation of various silicate type minerals as well as iron oxides and Sulfides.

TCC Trainings - Scientific Writing and Publishing
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The Training Centre in Communication (TCC Africa, https://www.tcc-africa.org/) is dedicated to enhancing research productivity and visibility by providing a comprehensive training programme. This commitment involves guiding researchers through in-depth training sessions on various research tools, enhancing their writing skills, and improving their publishing abilities.

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Knowledge Unlatched

Knowledge Unlatched is an open access database for books in the Social Sciences, Arts and Humanities field. The key advantage of this database is that it allows all librarians add books from the respective university platforms and it is inclusive of books written in indigenous languages, all at no cost. TCC Africa training is concentrated on harnessing the Open Research Library (ORL), an open-access research discovery solution developed by Knowledge Unlatched whose objective is to boost research discoverability and productivity.

Dimensions

Dimensions is the largest linked research information database in the world. It is a dynamic and user-friendly open- access research tool that has revolutionized the process of discovering, accessing and analyzing research. It encompasses all publications and datasets along with valuable contextual details, all accessible for personal and non-personal commercial use. TCC Africa has introduced various consortiums and institutions to the open-access research tool with the aim of improving research output and visibility. The trainings organized entail interactive sessions offering guidance to the participants from diverse participating institutions on effectively utilization of Dimensions. Dimensions houses over 100 million publications, including scholarly journal articles, books, book chapters, preprints, and conference proceedings. These publications are enriched with linked data sets, funding information, patents, clinical trials, and policy documents, allowing users to explore associated categories, funders, institutions, and researcher profiles.