



**UNIVERSITY OF EMBU**

**3 - 5 November  
Embu**



# **World Forum for Women in Science**

**Kenya 2021**

## **Conference Proceedings**

*“Building a Gender Inclusive Sustainable Future  
Through Science, Technology and Innovation”*



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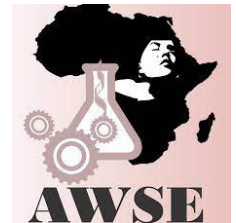
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# FOREWORD



**Prof. Daniel Mugendi Njiru (Ph.D),  
VICE-CHANCELLOR,  
University of Embu**

**T**he 6<sup>th</sup> International Conference for Women in Science Without Borders was held under the theme *“Building a Gender Inclusive Sustainable Future Through Science, Technology and Innovation”*.

The blended conference was held as the world continued to grapple with the COVID-19 pandemic. The fact that this conference was held during the pandemic underscored the need for continued interaction at national and international fora for sharing information and creating networks for innovative research.

The conference brought together international players in Science, Technology, Engineering and Mathematics (STEM), subjects that impart critical thinking skills and instill a passion for research and innovation. This undoubtedly leads to new products and processes that are needed to sustain our economy. The world, especially Africa, has lagged behind in gender equity and especially enrollment in STEM programs in learning institutions. This has translated to few women in research and leadership positions in STEM. The conference was a platform to demystify gender inclusiveness in STEM.

The WISWB conference provided a forum to share ideas, best practices and discussions that advance gender responsive strategies for an increased appreciation of STEM careers and sustainable development.

The conference also provided a platform for capacity building in key areas that provide synergy towards building a prosperous and sustainable future for all through science, technology and innovation. The topics were carefully selected to reflect interests of participants across the board. This training set the stage for the University of Embu to build capacity in the areas of interest beyond the conference.

The deliberations of the conference resolved on the need to enhance the policy frameworks that support the consciousness of social constructs of family and culture in policy creation and implementation. Parents and teachers should be sensitized on the importance of equal

opportunities in order to minimize gender stereotyping. The leaky STEM pipeline can only be addressed by enhancing efforts for gender mainstreaming, and providing a robust monitoring and evaluation framework for gender policy implementation.

The conference presentations were strategic in highlighting the importance of developing national solutions to deal with the challenge of mainstreaming gender in STEM and generation of local solutions to humanitarian challenges. The need for breaking the walls of gender equality through continuous partnership and engagement between institutions for incorporation of best practices is paramount.

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# KEYNOTE SPEAKERS



**TITLE: Building an Equitable Future: Removing Barriers to Achieving Greater Gender Equity in STEM Education**

**Dr. Ann E. Lopez**, is a professor of educational leadership and policy in the Department of Leadership, Higher and Adult Education, Ontario Institute for Studies in Education, University of Toronto. She is the Director of the Center for Leadership and Diversity and Provostial Advisor, Access Programs. Dr. Lopez's research and teaching focuses on antiracist education, school leadership in different contexts, decolonizing and socially just leadership, issues of equity and system change. She has conducted research with school principals in Jamaica, Kenya and the Greater Toronto Area. Dr. Lopez has published several articles and written 5 books including her most recent book entitled Decolonizing Educational Leadership: Alternative Approach to Leading Schools. Professor Lopez has presented her research at international conferences and engaged in various speaking engagements. She is the immediate past President of the National Association for Multicultural Education, the co-Editor-in-Chief of the Journal of School Leadership and co-Series Editor, Studies in Educational Administration. She is the 2020 Award for Distinguished Contributions to Teaching at the Ontario Institute for Studies in Education, University of Toronto



**TITLE: Climate-Smart Agriculture for an inclusive Food Secure Future**

**Dr. Nompumelelo Obokoh** holds a Ph.D in Plant Biotechnology from the Institute of Biotechnology, University of Cambridge, UK. She is currently the Chairperson of the Board of the National Research Foundation (NRF) and a member of the Independent Science for Development Council for the CGIAR, based in Montpellier, France. She has served as a Commissioner in the Presidential Commission on the 4 Industrial Revolution and is managing a private consultancy firm, Langace LTD (PTY), that provides specialised advisory services on gender-responsive climate-smart agricultural practices and Biotechnology. She is also an independent non-executive Director of FruitSA.

With more than 18 years working in agricultural research and innovation systems with a focus on biotechnology, Nompumelelo has worked as the CEO of AfricaBio (an independent non-profit organisation in the biotechnology sector) and as Divisional Head for Innovation Support and Protection of Companies & Intellectual Property Commission (The dtic-CIPC), and with the African Agricultural Technology Foundation (AATF) in Abuja, Nigeria and Nairobi, Kenya. Prior to this, she was a Senior Manager at the Agricultural Research Council in South Africa and a Post-Doctoral Research Associate at the University of Cambridge, UK.

She has also received several awards including the Mandela Cambridge Scholarship, Mandela Magdalene College Scholarship, Fellow of the Cambridge Commonwealth Society, as well as the Rothamstead International - African Research Fellowship.



**TITLE: Balance the STI Equation: Engendering the Future**

**Eng. Catherine Auma Nyambala** holds a BSc. degree in Electrical Engineering and an MBA in Operations Management. She is a Certified Energy Manager, Certified Manager of Organizational Excellence and Certified Lean Six Sigma Green Belt. She is currently the Business Process Improvement Manager at KenGen where she is a member of the Good to Great Innovation Council and the Chairperson of the women development program Pink Energy. Catherine is a member

of the conference committee of the Institution of Engineers of Kenya and a Judge of the Energy Management Award of the Kenya Association of Manufacturers. She is winner of several awards including the Fortune and Goldman Sachs global award: 2012, the Women in Energy Professional Technical and The Business Daily's Top 40 under 40 women. In August 202, Catherine was the overall winner of the KenGen G2G Innovation Seminar 2020. She is an advocate for Women in STEM, EV Infrastructure and Battery Energy Storage Systems.

# TRAINERS



## TOPIC: SCIENCE DIPLOMACY

**Prof. Amal Amin** is a professor for polymers/ nanotechnology at national research center-Egypt. She studied in, worked at and travelled to +30 countries including Germany (Ph.D-DAAD), USA, France, etc. She has distinguished scientific achievements including publications, projects, teaching, awards, etc. She was cofounder and executive committee member of the global and Egyptian young academies (GYA, EYAS).

She was president, co-founder and coordinator of the Egyptian society and Arab network for advanced materials and nanotechnology. She was TWAS young affiliate, TWAS-AAAS science diplomacy alumni and member of TWAS-TYAN and other reputable organizations. She actively participated at meetings of WEF, IAP, TWAS, GYA, WSF, AAAS, UNESCO, INGSA, NASAC, etc. She is a founding chair of women in science without borders' (WISWB) initiative, World forum for women in science series and youth science forum. In December 2020, she cofounded Northern African Research and Innovation Management Association (NARIMA) initiative. Dr Amal is a founder for science diplomacy for the future initiative (2021) and executive committee member of (science in Exile) which is a global initiative to support refugee scientists and at-risk scholars. In 2021, Dr Amal has received outstanding women in tech award of Africa (Africa) and the award of science by women provided by women for Africa foundation (Spain). Recently, in 2021, Dr Amal has been selected in catalyst 2030 global initiative. Dr Amal achievements were featured in women in science-inspiring stories from Africa (NASAC-IAP-2017), SAYAS Success stories of young scientists (2016), scientific African (2019), nature (2020), the next truth (2018, 2020), NASAC book on (Women and sustainable development in Africa-2020), Royal society for chemistry (2020), and others. Dr Amal has several scientific and societal activities on national and international levels. She is especially interested in science communication, simplified science, increasing public awareness/literacy for science, science advice/diplomacy, innovation, science policy AND science education.



### **TOPIC: ENTREPRENEURSHIP AND COMMERCIALIZATION OF INTELLECTUAL PROPERTY AND RESEARCH OUTPUT**

**Dr. George Kosimbei** is a Senior Lecturer in the School of Economics and the Director of Innovation Incubation and University-Industry Linkages at Kenyatta University. He is also an active consultant and researcher with a wide range of experience. He has extensive experience working in health economics, innovation incubation, intellectual property management and technology transfer and commercialization of IP. Prior to his current appointment, Dr. Kosimbei served as the Director of Chandaria Business Innovation and Incubation Center. He is the projected manager of the Kenyatta University - University of Rwanda - Neu-Ulm University of Applied Sciences and DAAD project on Technology Transfer and Commercialization of Intellectual Property. Dr. Kosimbei has received training on IP commercialization and management from the United States Patent and Trademark Office and is an active member of the Association of University Technology Managers (AUTM).



### **TOPIC: SCIENCE COMMUNICATION**

**Dr. Margaret Karembu (MBS)** is the Director of ISAAA-AfriCenter and the principal convener of the Africa Biennial Biosciences Communication symposium (ABBC). A science educator and communication trainer, Margaret has actively been involved in strengthening capacity for science communications and policy outreach for informed choices on modern biosciences in Africa. She is the Editor in Chief of DrumBeat, a monthly e-newsletter on Africa Bioscience Trends and pioneering chair of the Open Forum on Agricultural Biotechnology in Africa (OFAB – Kenya chapter, the African Women for Biosciences and the African Life Science Knowledge hub, all aimed at positioning Africa as an active player in global biosciences' advancements. She is very passionate about science and a strong believer in the power of innovations for transforming African agriculture into efficient and competitive enterprise for women and small-holder families. In 2020, Margaret's efforts were recognized with a conferment by Kenyan President with a State Honour - Moran of the Order of the Burning Spear (MBS) for her contribution to enhancing Science Communication. She holds a Ph.D degree in Environmental Science

Education from Kenyatta University, where she taught for more than 10 years prior to joining ISAAA AfriCenter.



**TOPIC: SCIENCE COMMUNICATION**

**Mrs. Bibiana Iraki-Kipkorir** is a Program Officer at ISAAA AfriCenter, where she handles various communications-related duties. Bibiana has wide experience in science communication, spanning a period of over 8 years. She has trained over 500 African scientists and researchers on how to effectively communicate their work to a non-technical audience and is a strong advocate on the use of credible scientific evidence for informed decision-making. She is a Founder Member of the African Women for Biosciences (AWfB) and currently serves in the network's steering committee. Prior to joining ISAAA, she worked as a Communications Officer at the African Population and Health Research Center and a Communications and Public Relations Officer at the African Biotechnology and Stakeholders Forum. She has also had a stint as an online reporter for Exposure Radio, a University of Glamorgan online radio station. Bibiana is passionate about science communication which she believes is key in transforming Africa's wealth of research knowledge into tangible solutions for development. She holds an MA in Journalism from the University of Wales, Glamorgan, and a BSc (Hons) Biotechnology from Cardiff University

# OPENING REMARKS

## **PROF. EUCHARIA KENYA, CHAIRMAN, CONFERENCE PLANNING COMMITTEE**

- Principal Secretary, State Department for University Education and Research, Amb. Simon Nabukwesi,
- Vice-Chancellor, University of Embu – Prof. Daniel Mugendi Njiru
- Vice-Chancellor, University of Eldoret - Prof. Teresa A. O. Akenga
- University of Embu Management and Senate
- Conference participants
- Invited Guests
- Staff and students
- Ladies and Gentlemen

### **Good Morning,**

I am pleased to welcome you to the World Forum for Women in Science 6<sup>th</sup> International Conference for Women in Science Without Borders, at the University of Embu.

This years' international conference is one of its kind since it is the first blended conference for the WISWB and also the first to be held in Eastern Africa.

### **Ladies and Gentlemen,**

I am grateful to the Management of the University of Embu led by our Vice-Chancellor, Prof. Daniel Mugendi Njiru for providing a conducive for hosting this conference.

I also express my deep gratitude to our sponsors - particularly The National Research Fund, International Plant Biotechnology Outreach, Belgium and the African Women in Agricultural Research and Development, who provided resources towards hosting of the conference; and our partners, our sister Universities and other institutions that supported members of the Planning Committee – University of Eldoret in Kenya, University of Nairobi in Kenya. Kenyatta University in Kenya, Jomo Kenyatta University of Agriculture and Technology, and National Commission for Science, Technology and Innovation.



## Ladies and Gentlemen

The Conference comes at a critical time when the world is still struggling with the COVID-19 pandemic and its' effects on the society. Indeed, we had anticipated to host an in-person conference at the Safari Park Hotel, Nairobi. However, due to the Governments' directive against organization of in-person meetings, regrettably we had to shift to a blended delivery mode. Nevertheless, we envisage to have a wonderful and productive event that will culminate in major resolutions and inform policy formulation globally. The conference has attracted global participation from 18 countries: India, Lithuania, Germany, Spain, Brazil, Pakistan, Malaysia, Sri Lanka, Mauritius, Benin, Zimbabwe, Cote de Voire, South Africa, Burkina Faso, Egypt, Nigeria, Ghana and Kenya.

This conference under the theme **“Building a Gender Inclusive Sustainable Future Through Science, Technology and Innovation”** will run for three days from Wednesday 3rd to Friday 5th November, 2021. Unlike conventional conferences, besides providing a forum for sharing ideas, best practices and discussions that advance gender responsive strategies for sustainable development, this conference also provided a platform for capacity building for participants in key areas that provide synergy towards building a prosperous and sustainable future for all through science, technology and innovation. Participants had an opportunity yesterday to join a training area of their choice out of the three available sessions; **Science Communication, Science Diplomacy, and Entrepreneurship and Commercialization of Intellectual and Research Outputs.**

Thereafter, the second half of today and tomorrow (Friday), participants will share knowledge through diverse thought-provoking 9 sub-thematic areas that include:

1. Gender responsive strategies for school to work transition in STEM
2. Circular economy for a sustainable future
3. Sustainable food systems
4. Post-Covid-19 resilience strategies
5. Innovation and entrepreneurship in STEM
6. Big data and artificial intelligence
7. Automation and robotics
8. Climate change and green energy

9. STEM fields related to SDGs including medicine (*Water, Food, Energy, Health, Environment, Education*)

In addition, there are four plenary session in which world renowned scholars will make keynote presentation on cross-cutting topics emanating from the conference theme. These will no doubt further enrich the discussions during the conference.

**Ladies and Gentlemen,**

Conferences such as this, provide valuable opportunity for research scientists, industry specialists, and decision-makers to share experiences and expand networks.

I am indebted to the many experts who will share their knowledge this week. I equally welcome the representatives of governments, industry associations, and NGOs who have joined us.

As I end my remarks, I wish to sincerely thank and appreciate members of the Conference Planning Committee and the Secretariate, who worked together with an internationally constituted Advisory team to make this conference a reality.

I am sure we will all have fruitful and worthwhile exchanges in the next days and I look forward to learning about your varied experiences and building lasting networks and friendships for the future.

Thank you very much.

God bless you all.

**PROF. AMAL AMIN, HONORARY CHAIR, CONFERENCE PLANNING COMMITTEE**

Dear Ladies and gentlemen

Dear Esteemed guests

Dear All

Good morning

First of all, as a founding Chair, I would like to welcome you all to the World Forum for Women in Science-Kenya

In addition, I would like to thank, recognize and acknowledge Prof Eucharia Kenya specifically and University of Embu, Kenya for hosting and organizing the current edition for World Forum for Women in Science in cooperation with Women in Science Without Borders initiative (WISWB). The conference, with the theme **“Building a Gender Inclusive Sustainable Future through Science, Technology and Innovation”** covers many interesting subthemes.

I would also like to thank all Organizing committee members, guests, participants and the audience.

Thank you all.

Personally, I am really happy as the founder for Women in Science Without Borders initiative (WISWB) to see its extension worldwide as it is now distributed in over 67 countries. Women in Science Without Borders initiative- WISWB, was mainly founded as a gender inclusive initiative with the slogan *“Science for Sustainable Development”*. This was meant to connect people and the world with science across all cultural and gender borders for inclusion of all partners and stakeholders to work together and move forward to attain Sustainable Development Goals including gender equality (SDG 5) for the sake of humanity.

All WISWB activities are multidisciplinary, gathering scientists and stakeholders from industry, media, policy makers, NGOs, the youth and the public, to facilitate global scientific collaboration and projects for the sake of humanity. This creates wider networks for males and females. So, in whole, we convey message that science must be available and accessible for all and science must serve society and community as well. In brief, science must be for peace and for welfare of humanity.

Via WISWB, we confirm the role of science, successful scientific international relations and science diplomacy, in solving critical problems of common and global concern.

The current World Forum for Women in Science in Kenya is the 6<sup>th</sup> one in the series which started in 2017 with the first meeting in Egypt. Other successful meetings were held in Egypt, South Africa and Brazil. In Iraq, a meeting was organized for displaced and refugee scientists under the forum. Our activities now extend to include organizing webinars and events on the critical and emerging topics such as mentorship, the current pandemic (COVID-19), youth science fora and others.

Also, there are future plans to have several other regional specific activities and programs to cover more regions of the world.

WISWB activities from the beginning were supported by international organizations, industry and stakeholders such as International Science Council (ISC), United Nations` bodies (UN), The World Academy of Sciences (UNESCO-TWAS), Inter-Academy Partnership (IAP), Global Young Academy (GYA), media and non-governmental organizations (NGOs) and others.

Our activities always include technical sessions on different scientific topics and other capacity building training sessions to increase the skills and raise the awareness of researchers in different fields such as science diplomacy, international cooperation, innovation, science communication, entrepreneurship and leadership. Finally, for the future, I hope that our initiative would transfer to a complete global and sustainable science-based initiative in order to build real knowledge-based societies and communities which can face future challenges. So, I would like to take this chance to invite all scientists to interact and share knowledge effectively in their societies to really change the world to a better place to live in for the next generations.

Really, I hope that the participants of our network and activities will be ambassadors for that aim and the expected change and I would like to see our initiative everywhere world-wide contributing in building societies with science. In conclusion, scientists are responsible now, more than ever before, for the continuation and development of humanity where the challenges are huge and serious and we should face them bravely and effectively together where no country or no one can or should do it alone. Together we are stronger. On this occasion, I would like to repeat the saying of Stephen Hawking, a great scientist, "*Scientists*

*have become the bearers of the torch of discovery in our quest for knowledge".* Finally, I would like to thank my family, friends, colleagues who always support me and thank you all

**PROF. DANIEL MUGENDI NJIRU, VICE CHANCELLOR, UNIVERSITY OF EMBU**

- Ambassador Simon Nabukwesi, Principal Secretary, State Department for University Education and Research
- Vice-Chancellor, University of Eldoret - Prof. Teresa A. O. Akenga
- University of Embu Management and Senate
- Conference Organizers and Sponsors
- Conference participants
- Invited Guests
- Staff and students
- Ladies and Gentlemen,

**Good Morning**

It is my great pleasure to welcome you to this 6th International Conference for Women in Science Without Borders (WSWB) here at the University of Embu. We are very grateful to the World Forum for Women in Science – Kenya, for choosing the University of Embu to host this important conference. I also thank you for the tremendous effort that each one of you has expended to enable us to host the Conference successfully. Particularly, I would like to appreciate the work done by Prof. Eucharika Kenya, who is the Deputy Vice-Chancellor, (Planning, Administration and Finance) at the University of Embu and her local organizing team for working tirelessly to make this conference a reality.

I thank each and every one of you for being here with us today. I welcome you to the University of Embu. In a special way, I would like to welcome our chief guest, Ambassador Simon Nabukwesi, the Principal Secretary, State Department for University Education and Research. Thank for accepting our invitation to officially open the Conference. We are both pleased and proud to host this Conference here at the University of Embu. I also welcome the participants who are joining this Conference virtually due to the challenges brought about by the COVID-19 pandemic.

First, as we all know, the Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. Sustainable Development Goal Number 4 on **Quality Education**, Sustainable Development Goal Number 5 on **Gender Equality** and Sustainable Development Goal Number 10 on **Reduced Inequality** have been viewed as the most critical in accelerating the achievement of the other SDGs directly or indirectly.

### **Ladies and Gentlemen,**

Secondly, we all recognize the importance of Science, Technology, Engineering and Mathematics (STEM) subjects in the dynamic world that we live in today. Everything is computerized and scientifically engineered that if we do not encourage our students, especially the female students to venture into Science, Technology, Engineering and Mathematics fields, then our future as a nation will be so disadvantaged and left behind. Issues like climate change, global pandemics such as COVID-19, terrorism, threat to species extinction including humans, food security, population growth and societal fragmentation that have caused humanitarian crises globally require that we turn to science and research to help us to address these challenges more than ever before.

STEM imparts critical thinking skills and instills a passion for research and innovation, which undoubtedly leads to new products and processes that are needed to sustain our economy. Thus, STEM is vital in increasing science literacy, creating and nurturing critical thinkers as well as enabling innovation among all people irrespective of gender.

Further, we live in a knowledge based economy. we know the benefits of STEM and marvel at the ability and influence of STEM education in every decision made to understand global challenges. Recently, many Initiatives have been established to increase the enrolment and participation of women and minorities in STEM-related careers. What I am alluding at is that giving both men and women equal opportunities to pursue STEM careers gives them the opportunity to contribute to making the world a better place for us all.

### **Ladies and Gentlemen,**

We need to be more proactive to address gender biases in male-dominated fields. We also need to give women and girls exposure to see opportunities available in STEM careers. Girls

need to see achievements that women make at schools, at work, and in leadership. These successful women will act as role models to be emulated by girls as they choose their subject majors and career paths. In this way girls will gain confidence to compete in STEM subjects and excel. Parents and guardians require constant reminders that girls are as good as boys in intellect and talent hence can contribute to change of attitude towards the participation of girls in STEM.

### **Ladies and Gentlemen,**

In Kenya, like in many developing countries, girls and women are prevented from accessing STEM by the traditions and social norms. This is noticeable at an early age in classroom environment where teachers wield a lot of influence in guiding and mentoring students as they choose career paths. The girls are encouraged to study art subjects while the boys are encouraged to study STEM subjects.

Demystifying STEM should be among top priorities in a bid to increase girls' enrolment into STEM programs. There is need to hold national conversations among African countries about increasing women and girls' enrolment in STEM programmes. There should be a deliberate effort by country leaders to find a lasting solution to the current low number of women and girls enrolling in STEM programmes at primary, secondary, middle level colleges and universities.

This conference therefore, comes at a time when we are in dire need of a direction to save the world and its inhabitants from perishing as a result of a myriad of factors that are both natural and manmade. I am glad that the University of Embu is hosting this particular conference at this historic moment that we are living in.

### **Ladies and Gentlemen,**

Let me wrap up by saying that, as men and women in science, we need to re-examine our role in coming up with local solutions for the problems that afflict our societies. This should be informed by the recent realization, after the Covid-19 Pandemic struck, that relying on other countries to provide solutions is no longer viable, because they have their own challenges to deal with first before helping others.

We need to do more in research, innovation and linking research to real issues and problems that affect our people. We need to reach out to new partners to urgently help us to develop

capacity in researchers and the industrial linkage, so that we can produce solutions for our problems. We will need to re-engage and see how best and how fast we can start making an impact outside the laboratory.

If we can pull together and generate renewed momentum and research in the areas that we have identified in the conference sub-themes, then we can reignite enthusiasm for more participation in STEM fields. This is because everyone will benefit from the fruits accruing from our research and innovation.

With those remarks, I thank you all for coming and I hope that you will enjoy all the sessions and the accompanying debates, as well as opportunities for networking with colleagues and other professionals. I wish you a fruitful engagement during the Conference.

God bless all of you,  
Thank you very much.



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# SPEECH

## **CHIEF GUEST, AMBASSADOR SIMON NABUKWESI, PRINCIPAL SECRETARY, STATE DEPARTMENT FOR UNIVERSITY EDUCATION AND RESEARCH**

- Vice-Chancellor, University of Embu – Prof. Daniel Mugendi
- Vice-Chancellor, University of Eldoret - Prof. Teresa A. O. Akenga
- University of Embu Management and Senate
- Conference participants
- Invited Guests
- Staff and students
- Ladies and Gentlemen

### **Good Morning**

Let me start by thanking the Conference organizers for inviting me to open this important conference. I am happy to note that this international conference is held annually under the auspices of the World Forum for Women in Science (WFWS). The Conference provides an opportunity for us to highlight the role of women in science, in building a prosperous and sustainable future for all through science, technology and innovation.

I am also happy to note that participants are drawn from across Africa and other parts of the World. This will indeed be a great forum to share ideas, best practices and discuss how basic science drives innovation and development in our societies. The discussions will also endeavor to highlight gender equity in Science, Technology, Engineering and Mathematics (STEM) as a driver for sustainable development.

**Ladies and Gentlemen,** the Conference comes at a critical time when the world is grappling with the effects of the COVID-19 pandemic on families, the society and the world economy. Notably, Gender Based Violence incidences have also shot up globally during this pandemic season, with statistics pointing to the fact that women have borne the most brunt of it. This gives us an opportunity, as women in science, to strengthen our efforts and contribution in mobilizing, creating and driving solutions to eradicate COVID-19 from the face of the earth. This is global problem, and it is important for us to come together in forums like this one to contribute to global efforts to find a lasting solution. Women should be at the forefront of a

transformative agenda for recovery from COVID-19.

It is my hope therefore, that this conference will come up with among others, the much needed innovative ideas aimed at starting a new chapter of global action towards recovery from the pandemic.

**Ladies and gentlemen,** the theme of this Conference is “**Building a Gender Inclusive Sustainable Future Through Science, Technology and Innovation**”. This is indeed very relevant and timely because gender inclusivity and sustainable development are two sides of the same coin and none can exist without the other. Kenya has a strong scientific publishing record and a high number of researchers, but only 26% of researchers in Kenya were women according to the UNESCO Institute for Statistics Report, 2015. In the education sector, gender imbalance exists in secondary and tertiary institutions, with female enrolment at secondary level being lower when compared with male enrolment, and at the tertiary level, female enrolment when compared with male enrolment goes even lower, (UNESCO Institute for Statistics, 2015). Overall, women account for a minority of the world’s researchers. In Kenya, Female researchers accounted for 25.7 % of all researchers of total researchers in 2019 (UNESCO Institute for Statistics, 2019 Report). Women’s enrolment in universities and colleges globally increased by 9% from 2011 to 2020 (UNESCO Institute for Statistics (UIS), 2020). Similarly, a study by Education Sub-Saharan Africa (ESSA) on higher education staff and academics in Ghana shows that only 8% of professors at public universities are women. Only 24% of academic staff in tertiary education across sub-Saharan Africa are female (UNESCO, 2019).

The Kenyan Government has taken steps to address gender inequality in society in conformity with the Constitution and the Vision 2030 provisions. We have adopted a strategy to mainstream gender at every level of public service through the performance contracting process in which gender is one of the key crosscutting issues. The Science, Technology and Innovation Act, (2013) recognizes women’s under-representation in leadership positions in academic and research institutions and in scientific and professional associations, and calls for deliberate efforts to achieve a balance in gender representation.

**Ladies and gentlemen,** our universities and research institutions in Kenya are keen on implementing measures to allow meaningful women’s participation in science, technology and innovation as well as leadership positions. For us in the Ministry of Education, we continue to encourage adoption of gender mainstreaming approaches to promote gender equality

and ensure women's participation in all spheres. Key institutions such as the Kenya's National Commission for Science and Technology (NACOSTI) have set aside funds to enable women scientists to conduct research, while the Nairobi-based African Academy of Sciences (AAS) has allocated travel grants to support women scientists to travel to conferences and other fora to present their research findings. Similarly, the proposed establishment of Kenya Association of Women in Science (KAWIS) are important avenues for women scientists to seek professional support and network.

The United Nations **Decade of Action** for the Sustainable Development Goals (SDGs) 2030 has 17 goals for accelerating sustainable solutions to the world's biggest challenges — ranging from poverty and gender, to climate change, inequality and closing the finance gap. The UN Women Report for the Sustainable Development Goals (SDGs) Agenda 2030 states that 'There can be no sustainable development without gender equality'. This statement captures well the essence of women's role in the sustainability of our world – cutting across all sectors and spheres. SDG number 5 which promotes gender equality and empowering of women and girls stresses that any meaningful achievement hoped for in the other Sustainable Development Goals must be hinged on the successful mainstreaming of gender equity and inclusivity in all the other goals.

**Ladies and Gentlemen,** We are all working together towards the attainment of gender equality for all by 2030. We need to think of a global educational system that is able to address the challenges facing women in Science, Technology, Engineering and Mathematics (STEM) subjects. Giving equal opportunities to women in STEM reduces the gender income gap, thus, providing women with economic security. In recent years, much has been done to help inspire women and girls to study and work in technical fields. However, according to the United Nations report (2021), women are continually being excluded from participating fully in science and technical fields. For years, women have been underrepresented in Science, Technology, Engineering and Mathematics (STEM) in University courses and careers as reported by the World Economic Forum of 2020. On average, around 30% of the world's researchers are women; less than a third of female students choose to study higher education courses in subjects like Mathematics and Engineering and women working in STEM fields publish less and often receive less pay. To further elaborate this issue, just 3% of students joining Information and Communication Technology (ICT) courses globally are women. This improves slightly to

5% for Mathematics and Statistics courses and increases to 8% for Engineering, Manufacturing and Construction courses.

Education plays an important role in socio-mobility, leadership, health and generally better quality of life. Advances in Science, Technology, Engineering and Mathematics (STEM) have brought about improvements in many aspects of life, such as health, agriculture, infrastructure and renewable energy. STEM education is also key for preparing students for the world of work, enabling entry into in-demand Science, Technology, Engineering and Mathematics (STEM) careers of tomorrow.

### **Ladies and Gentlemen,**

Closing up the gender gap in science and innovation is not out of reach and we are getting incrementally closer, however slow the pace is, I believe that we shall reach that goal. We need to keep evaluating our progress as a nation and as a society to see where we need to make improvements. Gender parity is not about women, it is a journey for both men and women and we all must work together. Now is the time to take advantage of the ever changing science, technology and innovation space to ensure that no gender is left behind.

In order to ensure the full-fledged participation of women and girls in Science, Technology, Engineering and Mathematics (STEM), we need to start doing more in the education sector through training and mentorship. This will help in shaping the attitudes necessary to pursue leadership positions in science careers by women and girls.

We need to sensitize parents and teachers on the importance of giving equal opportunities to both boys and girls. We need to stop the common stereotypes that say this career is for girls and that is for boys. We need to encourage our daughters to believe in themselves and that they can also make it in all of careers. We also need to provide a work environment that supports work-life balance and particularly allows women to do their work as well as have the flexibility for them to play their reproductive roles effectively. This goes hand in hand with formulating and implementing gender-responsive policy frameworks, such as the provision of childcare facilities at the workplace and career re-entry programmes which encourage women scientists to resume their careers after taking a break to care for family.

In conclusion, I want to wish you all the best in the three-day conference. I look forward to the publication of the Conference proceedings which will have great resolutions that will inform policy formulation in the key conference thematic areas such as:

1. Gender responsive strategies for school to work transition in Science, Technology, Engineering and Mathematics (STEM),
2. Sustainable food systems,
3. Post-Covid-19 resilience strategies,
4. Innovation and entrepreneurship in STEM,
5. Climate change and green energy,
6. Role of STEM fields in the realisation of SDGs goals; **among others.**

I believe that the experts gathered here will be able to actively participate in the nurturing of the next generation of leading female and male scientists who will transform the world into a better place in the face of all the challenges that we find ourselves in.

Lastly, we all need to contribute and also play a role in this debate on building a gender inclusive sustainable future. Let us go out there and be role models and mentors who will foster a sense of belonging among both men and women in Science, Technology, Engineering and Mathematics (STEM) fields. Let us adopt the UN theme of the 2030 Agenda for Sustainable Development Goals of “leave no one behind”. Let us all move together and we will achieve more.

**Ladies and Gentlemen,** with those remarks, it is now my pleasure to declare the 6th International Conference for Women in Science Without Borders officially open.

Thank you

God Bless You all

**Ambassador Simon Nabukwesi,**  
**Principal Secretary, State Department for University Education and Research.**

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# CONFERENCE PRESENTATIONS

## SUB THEME: CIRCULAR ECONOMY FOR A SUSTAINABLE FUTURE

### Using Indigenous Scientific Knowledge to Teach Chemistry Concepts

Charity Esenam Anor, Emmanuel Oppong and Ruby Hanson,  
Department of Chemistry, University of Education Winneba, Ghana. Email:esenamanor@yahoo.com

#### Abstract

This study was designed to assess the impact of the Indigenous Scientific Knowledge Practices involved in the production of cassava dough on the teaching of Chemistry concepts. An ethnographic study [2] of Indigenous Knowledge experts in cassava dough production was conducted and relevant data collected. Consequently, an 'Integrated Indigenous Scientific Knowledge (ISK)-Chemistry lesson' was designed and used on twenty-six students to evaluate its impact on students' learning outcome. The Interrupted Time Series (ITS) design [3] was adopted and used for quantitative data collection on students. The Statistical Package for the Social Sciences (SPSS) was used to analyse the data collected and results interpreted using means and graphs. The paired samples test result for the means of all the Pretests and Posttests gave a significant figure (p-value) of 0.00 which implied that there was significance difference in the average performance of students in the Pretest and Posttest. The analysis also recorded a significant figure of 0.346 when the Posttest scores of females were compared to that of the males. This showed that there was no significant difference in the true average performance of male and female students. Hence, the designed integrated ISK-Chemistry lesson impacted positively on all students and was not gender biased.

#### Introduction

The importance of indigenous scientific knowledge (ISK) practices to the development of economies in the world cannot be over emphasised, hence, should not be ignored when teaching scientific concepts. The integration of Indigenous Scientific Knowledge practices into the teaching of science is an attempt to promote education for sustainable development of the African continent [5]. Indigenous Scientific Knowledge (ISK) refers to knowledge forms



that are passed on from generation to generation, unique to a specific culture and acquired through informal experiments, observation, imitation and experiences [1]. These ISK practices can be meaningfully integrated into the western school science curriculum to improve learning outcome of students. The ability to identify Indigenous Scientific knowledge (ISK) practices that can be used in the teaching of concepts is key in the integration process. One of such identified ISK is the use of the processes involved in Cassava dough production to teach the concept of the Factors Affecting the Rate of Chemical reactions. Indeed, relating a Chemistry concept to this ISK practice will be a delight to learners and hence motivate them to learn Chemistry which is perceived to consist of many abstract concepts.

### Statement of Problem

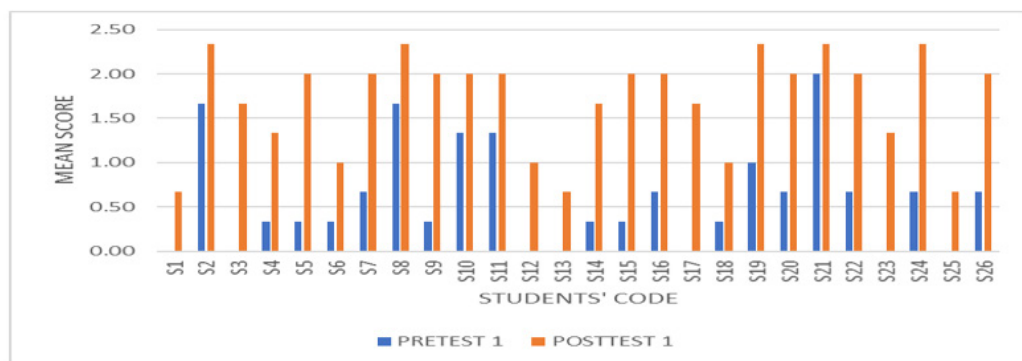
The poor performance of students in Chemistry [4] which is believed to be due to the teaching approach that ignores the use of Indigenous Scientific Knowledge (ISK) and non-illustrative presentations for visualisation and subsequent recall.

Objectives of the Study

1. To evaluate the impact of the use of the 'integrated ISK-Chemistry' lesson on learning outcome of students.
2. To determine the effect of gender on the academic achievement of Chemistry students taught with the 'integrated ISK-Chemistry' lesson.

### Results and Discussions

It was noted from the responses in the posttest that the communication of the concept of the factors affecting the rate of chemical reaction to the students through the use of the processes involved in cassava dough production was effective as depicted in Figure 1



**Figure 1:** A graph of students' performance in pretest and posttest 1

The paired samples test analysis in Table 1 recorded a significant figure of 0.346 which indicated that there was no significant difference in the learning outcome of male and female and male students in the posttest.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MALES POSTTEST1 MEAN - FEMALES POSTTEST1 MEAN	-16.25167	57.13640	16.49386	-52.55440	20.05107	-.985	11	.346

**Table 1:** Paired Samples Test Results for Males and Females Posttest 1 Scores

## Conclusion

The 'integrated Indigenous Scientific Knowledge-Chemistry lesson plan proved effective in communicating the Chemistry concept to learners, as its use resulted in the improvement in students' learning outcome. Again, the designed lesson plan was not gender bias, as the performances of both male and female students improved remarkably during the posttest as evidenced by an insignificance of 0.346 in the paired samples test.

## Recommendations

1. Research in the area of Indigenous Scientific Knowledge should be encouraged by the provision of funding.
2. The design of textbooks to include indigenous knowledge practices for the teaching of science specifically, Chemistry should be encouraged.
3. Teachers and teacher educators should be trained and equipped to design and implement ISK – chemistry teaching strategies.

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## **Functionalization of Jute Fiber via Flame-retardant Finish**

Most. Setara Begum<sup>1\*</sup> and Rimvydas Milašius<sup>2</sup>

<sup>1,2</sup>Faculty of Mechanical Engineering and Design, Kaunas University of Technology, Studentu

Str. 56, LT-51424, Kaunas, Lithuania

Corresponding author: most.setara@ktu.edu

### **Abstract:**

The flammability is considered as one of the important properties of textile materials and the riskiness of flammable fibers have been taken into consideration specifically for industrial consumers. Among the natural fibers, Jute is a biodegradable and eco-friendly fiber with the advantageous properties such as high tenacity, excellent thermal conductivity, moisture regain, ventilation function, etc. [1, 2]. Considering the eco-friendly nature of Jute fiber, this study conducted on the application of Flame-retardant finishes on the fabrics made of 100% Jute and Jutton (80% Jute, 20% Cotton). The concentrations as 40%, 50% and 60% (owf) of Flame-retardant chemical (PYROVATEX CP NEW, Huntsman) were applied by exhaust method.

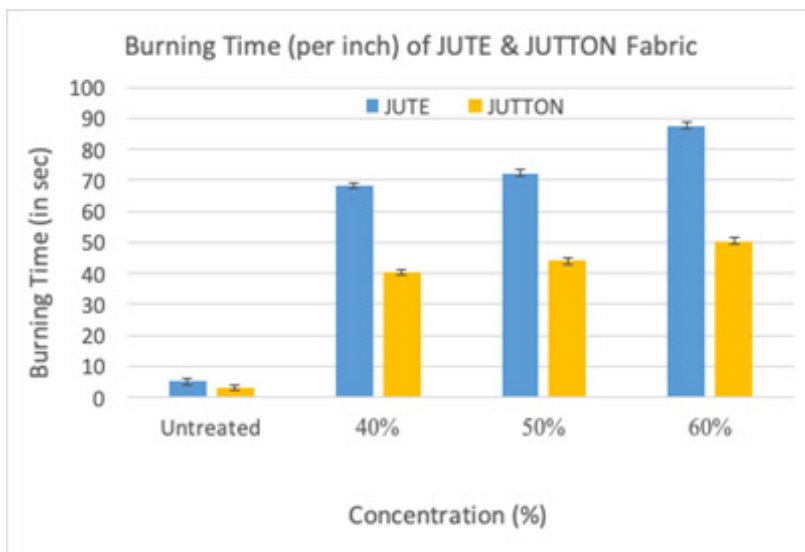
The flammability tests were conducted by the vertical burning test by using Butane burner and observed the changes after exposure. The maximum burning time (burning with flame and with afterglow) was recorded as 88 seconds on the JUTE fabric treated with 60% PYROVATEX CP NEW while 68 seconds was for 40%. On the other hand, JUTTON fabric sustained for 50 seconds and 40 seconds treated for 60% and 40%, respectively. The untreated fabrics sustained for 5 seconds and 3 seconds for JUTE and JUTTON fabrics respectively. An eight (08) minutes time was recorded to burn the whole sample of JUTE fabric and four (04) minutes was counted for the JUTTON fabric.

### **Introduction**

Since protection is mandatory in the high-performance industrial fields, the retrenchment of the flammability of textile fibers is an important concern. According to the statistical records, textiles caused about 50 % of fires globally [3]. Natural cellulosic fibers are prone to fire than the synthetic fibers [4]. Jute and its derivative products are particularly gaining recognition for home textiles such as furnishing, upholstery, temporary and longevity shopping bags, etc. in the local and overseas markets due to its nature of eco-friendliness and bio-degradability. According to the chemical nature, Jute is composed of lignin and cellulose, and physically

coarser fibre. Despite such, Jute has some intrinsic properties such as: flammability, high moisture regains, high tenacity, etc. To improve the performance of jute fabric depending on their purpose of end-uses, several finishing process may apply, for example – flame retardant finish, water repellent finish, crease resistant finish, etc. Durable and non-durable flame-retardant finishes can be applied on cellulosic fibres including jute to make it flame-retardant [5]. For this study, jute fiber is selected depending on its environment friendly characteristics, cheaper and availability.

## Results



**Figure 1:** *Burning time of Jute and Jutton Fabrics*

## Discussion

After applying the Flame-retardant finish, the Jute and Jutton fabrics were exposed to the burning test by using an open flame box set with a butane burner. After the chemical treatment, a remarkable improvement can be observed on both fabrics in comparison of the untreated fabric samples as seen in figure 1. The best results on Jute fabric was recorded with 60% concentration as 88 secs to get burnt of each inch of fabrics. The better results are found on the Jute fabric than the Jutton. An increasing burning time trend has been observed on both fabrics with the increment of the concentration of the flame-retardant chemical. The lesser burning time on Jutton fabric may be caused due to the inherited burning nature of cotton fabric.

## Conclusion and Recommendation

Flammability and the flame-retardancy of the textiles fibers are the major concern for not only the protective textiles but also the home textiles, clothing, childrens' wear, composites, etc. According to the initial results found, the flame-retardant chemical can be functionally increasing the burning time and hence the flame-retardancy of jute fiber. Jute is considered as the sustainable textile fiber and can be treated as one of the alternatives to meet the environmental requirements for functional textile applications and hence to support the sustainability. Further characterization on the treated fabric samples to be accomplished for the full paper preparation.

## Acknowledgment

This research has been conducted as a partial fulfilment of the PhD dissertation under Lithuanian Research Council at Kaunas University of Technology (KTU). Kaunas, Lithuania.

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## **Isolation and identification of the Iron-Reducing Bacteria from iron toxic paddy soil of Burkina Faso**

Otoïdobiga C. H. 1\*, Sawadogo A. 2, Asakawa S. 3, Traoré A. S. 2, Ouattara A.S2 and Dianou D.4

1Research and Training Unit, Sciences and Technology, Norbert ZONGO University, Koudougou, Burkina Faso

2Research and Training Unit, Life and Earth Sciences University Joseph KI-ZERBO, Ouagadougou, Burkina Faso

3Soil Biology and Chemistry, Graduate School of Bioagricultural Sciences, Nagoya University, Nagoya, Japan

4National Center for Sciences and Technology Research, Ouagadougou, Burkina Faso

\*Corresponding author's email: oharmonie@yahoo.fr

### **Abstract**

Iron toxicity is a nutritional disorder that affects rice productivity in West Africa, particularly in Burkina Faso. This edaphic constraint appears in the lowlands when large concentrations of ferrous ions in the soil solution are produced in situ by microbial reduction of ferric ions. The present study was conducted to identify main cultivable Iron Reducing Bacteria (IRB) populations, present in three iron toxic paddy soils in Burkina Faso (*Moussodougou, Tiefora, and Kou Valley*), and to understand their metabolism in rice fields. A culture-dependent approach in soil enrichment culture was used to isolate the cultivable IRB strains. The morphology of the isolates and their ability to use different carbon sources (*glucose, lactose, mannitol, citrate, urea*) were determined. The genetical characterization of five (5) isolates was performed by sequencing of bacterial 16S rRNA. The isolates morphological, biochemical, and genetic characteristics revealed that *Lysinibacillus sphaericus*, *Bacillus subtilis*, and *Bacillus racemilacticus* may be the dominant cultivable IRB species in the studied paddy soils.

### **Introduction**

Iron toxicity is a major nutritional disorder affecting rice production in irrigated and rainfed lowland soils. Iron toxicity occurs when a large concentration of insoluble Fe<sup>3+</sup> is reduced into soluble Fe<sup>2+</sup> throughout microbial processes under both anaerobic and low pH conditions [1]. Iron-Reducing bacteria (IRB) are widely distributed in many environments and are common in flooded soils. In Burkina Faso, iron toxicity affects many rice fields, and many of them were

even abandoned due to iron toxicity. However, reports on the isolation of the IRB from the Burkina Faso paddy soils are limited. A research-based on Fe(III)-reducing functional genes is still limited [2]. Thus, a culture-based study of IRB involving isolation and characterization is necessary to obtain the required physiological information on specific IRB. The present study aimed to identify the main cultivable IRB populations in three iron toxic paddy soils in Burkina Faso (Moussodougou, Tiéfora, and Kou Valley) and to highlight their metabolism.

## **Methodology**

### **Sampling sites**

The soils were collected in irrigated rice fields of Moussodougou, Tiefora and Kou Valley. The samples were stored in the laboratory at +4°C, until analysis.

### **Enrichment**

Soil (10 g) was introduced in 90 ml of sterile Hammann and Ottow [3] and Lovley and Phillips [4] media and incubated at 30°C. The inoculated media of Hammann and Ottow [3] was incubated for 5 days. Lovley and Phillips [4] media, was incubated in anaerobic conditions for 15 days, using nitrogen as gas-phase.

### **Strains isolation**

After three successive transfers in new culture media, the bacterial strains were isolated, using the mineral media supplemented with 15% of agar. The black and brownish colonies obtained were selected and purified.

### **IRB strains characterization**

Gram staining was done using a standard method of coloration. The bacteria morphology was also, determined using phase-contrast microscope. The strains ability to ferment glucose and lactose was tested by using Kliger-Iron-Agar media according to the supplier recommendation. Mannitol Motility Test Agar and Simmons citrate agar media were used to determine the mobility and the ability of the bacteria to use mannitol and citrate as substrates.



## Strains Genetical Characterization

The bacterial DNA was extracted using the « PrepMan Ultra Sample Preparation Reagent » Kit (Applied Biosystems), according to the supplier recommendations. The 16S rDNA was amplified using two pairs of primers (P8F-P535R and 338-1040F, 338-1040R). After electrophoresis, the amplicons were purified and sequenced. The assembled sequences were aligned in the National Center for Biotechnology Information (NCBI) database (<http://blast.ncbi.nlm.nih.gov>), by blasting (Basic Local Alignment Search Tool).

## Results

The isolates morphological and biochemical descriptions are presented in Table 1. The genetical analysis showed that VDK5 and M16 strains are close of *Lysinibacillus sphaericus* with 99 to 100% of the nucleotide sequence homology. VDK12 and Ti13 strains also showed 99 to 100% of nucleotide sequence homology with *Bacillus subtilis*. Moreover, VDK14 strain showed 92 to 98% of nucleotide sequence homology with *Bacillus racemilacticus*. The isolated bacteria are mainly anaerobic and/or facultative anaerobic and have ability to sporulate.

	Strain				
	VDK5	VDK12	Ti13	VDK14	M16
<b>Morphology</b>	Bacilli	Bacilli	Bacilli	Bacilli	Bacilli
<b>Mobility</b>	+	+	+	+	+
<b>Sporulation</b>	+	+	+	+	+/-
<b>Glucose</b>	-	-	-	+	-
<b>Lactose</b>	-	+	+	+	-
<b>Citrate</b>	-	+	+	-	-
<b>Mannitol</b>	-	+	+	+	+/-

+: positive, -: negative

**Table 1:** Morphological and biochemical characteristics of the IRB strains

## Discussion

Several studies showed that *Bacillus subtilis* and *Lysinibacillus sphaericus* (previously named *Bacillus sphaericus*) were involved in the ferric iron reduction process, in submerged soils notably in Senegal, Ivory Coast and West Africa [5]. However, Ouattara et al [5] identified *Clostridium* and *Desulfovibrio* as IRB in Burkina Faso and Senegal lowlands. Thus soil microbiome analysis throughout molecular methods could be essential for an exhaustive study.

## Conclusion

The IRB metabolism and ability to sporulate can explain their survival in the soils during the drought period (oxygenation period) and the occurrence of iron toxicity a few days after soil submersion (anaerobiosis).

## Acknowledgement

The authors would like to express profound gratitude to Early career fellowship program/OWSD, L'Oréal Foundation For Women In Science (FWIS), IFS and AWARD fellowship program for financial and technical supports.

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## Life Cycle Assessment of Drinking Water Treatment in Egypt

Walaa. M. Hassan<sup>1</sup>✉, Dalia. M.M. Yacout<sup>2</sup>, Eslam. M.Hassan<sup>3</sup>, Ahmed M.Kamal<sup>1</sup> and M.

N.Hassouna<sup>4</sup>

<sup>1</sup>Holding Company for Water and Wastewater (HCWW), Egypt, Egypt.

<sup>2</sup> Department of Energy and Technology, Swedish University of Agriculture Sciences (SLU),  
E-750 07 Uppsala Sweden.

<sup>3</sup> Alexandria Petroleum Company (APC), Ministry of Petroleum and Mineral Resources, Egypt

<sup>4</sup> Institute of Graduate Studies & Research, Alexandria University, Egypt.

\*Corresponding author's email: igsr.walaa.amer@alexu.edu.eg

### Abstract

By 2025, Egypt will be ranked among the top ten countries with water shortages due to the rapidly growing population, fast development, and agriculture intensification in Egypt. Evaluating and understanding the potential environmental impacts of drinking water treatment technologies at the national level is a must to improve the efficiency of the different technologies in a sustainable way that meets the local water demand and complies with sustainable development Goals (SDG 13) climate action. This study assessed the environmental impacts of three different drinking water treatment plants in Egypt (conventional, ultrafiltration and desalination), using Life cycle assessment (LCA) as a mean to identify a preferable water management approach. The chosen function unit was 1000 m<sup>3</sup> of water. The modeling was performed with the SimaPro V8.5.2.0, employing Eco-indicator 99 method. The following environmental impacts were considered: Global Warming Potential (GWP) represented by climate change, Carcinogenic Potential (CP), Radiation Potential (RP), Ozone Layer Depletion (OLD), Acidification Potential (AP), Eutrophication Potential (EP), Ecotoxicity Potential (ETP), Land Use (LU), Respiratory Inorganic Formation Potential (RIFP), Respiratory Organic Formation Potential (ROFP), Minerals Depletion (MD), and finally Fossil Fuels Depletion Potential (FFDP).

The results showed that RO desalination technology caused the highest energy consumption, while the conventional treatment was the most favorable technique among the three techniques. Also, Results showed that the energy consumption was found to be the most influential parameter in all technologies. So, the using of wind energy instead of fossil fuels for electricity generation reduced the overall environmental impacts in all three technologies.

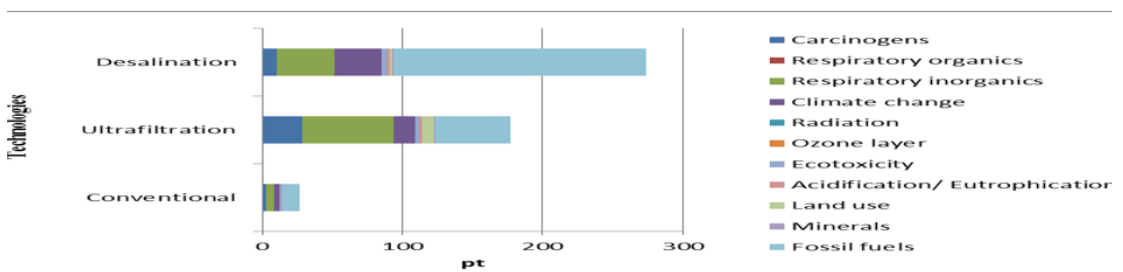
## Introduction

Each of the drinking water treatment technologies have a negative effect on the environment. The conventional drinking water treatment process has two sources of pollution on the environment, which are water treatment sludge (WTS) from the Coagulation-flocculation process and filter backwashing water from filter stage Ahmad et al [1]. Also, Desalination is accompanied by some negative effects on the environment such as energy consumption and brine discharges Zhou et al [2]. Therefore it is important to consider the environment impacts for each technology. Life cycle assessment (LCA) is considered one of the most appropriate tools to assess the environmental impacts of products or services along their life cycle, from the extraction of raw materials until their final disposal (ISO 14040 [3].

The main objective of this study was to assess and compare the environmental impacts of the three different water treatment technologies employed at city level in Egypt “conventional, ultrafiltration, desalination by reverse osmosis” using LCA to choose the preferable sustainable technology with less environmental impacts.

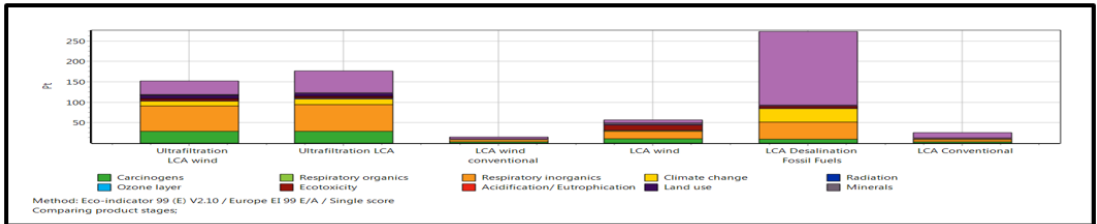
## Results

Results showed that energy consumption was the main factor impacting the environment. Figure 1 showed that the desalination was the highest energy consumer (5050 MJ) followed by ultrafiltration (1490 MJ) then conventional (210 MJ). Results also showed that ultrafiltration has the largest impact (28.48 pt) on carcinogenic potential.



**Figure 1.** Impact assessment of drinking water production by different technologies on the environment per unit process (Single score)

In the sensitivity analysis, the impacts of using wind energy as alternative renewable energy sources for electricity generation were considered as replacements to electricity generation by fossil fuels in all three technologies. Related results are presented in Figure 2.



**Figure 2.** The sensitivity analysis when using wind energy as a source of the renewable energy

## Discussion

This can be attributed to the emitted CO<sub>2</sub> emissions from burning the fossil fuels to generate the required electricity for the treatment processes in the RO technology. Close results were reported by García-Sánchez and Güereca [4] who declared that the energy consumption used for treating potable water had the greatest environmental impacts, which were responsible for 83.9% of the environmental impacts on global warming. The same results also, by Shahabi et al [5].

## Conclusion and Recommendation

By assessing the environmental impacts of the three technologies used for water treatment in Egypt, it was that the heights impacts were from desalination (RO) technology followed by ultrafiltration technology. The energy required for the different technologies was the main cause for the deterioration of the environment. The GHS emissions decreased in all technologies when used wind energy as renewable energy instead of fossil fuels.

## Acknowledgement

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## **SUB THEME: GENDER RESPONSIVE STRATEGIES FOR SCHOOL TO WORK TRANSITION IN STEM**

### **Effect of Gender Responsiveness in Organizational Leadership on Implementation of Strategic Plans in Universities in Mount Kenya Region, Kenya**

Eunice Wangari Mureithi<sup>1</sup> Dr. Jesse Maina Kinyua<sup>2</sup> Dr. Kirema Nkanata Mburugu<sup>3</sup>

Corresponding Author: muriithi.eunice@embuni.ac.ke

<sup>1</sup> School of Business and Economics, University of Embu, Kenya

<sup>2</sup> Lecturer, School of Business and Economics, University of Embu : kinyua.jesse@embuni.ac.ke, Kenya

<sup>3</sup> Lecturer, School of Agriculture, University of Embu: nkanata.mburugu@embuni.ac.ke, Kenya

#### **Abstract**

In this period of globalization when the world is consistently experiencing numerous rapid changes in various fields, the environment in which organizations now operate is never again predictable and stable. This has led to strategic planning to provide an operational framework allowing organizations to cope with changes and gain a competitive edge. Strategic planning in organizations has also looked keenly on having equal rights for women in leadership. Women choose strategies that promote implementing a holistic approach of planning without biasness. Another strategy is to include policies that show representation of women in leadership. Women have been included in leadership and management of the plans up to their implementation. Women have fully been utilized in formulation and execution of strategies. The purpose of this study was to establish the influence of organizational leadership on gender and implementation of Strategic Plans in Universities: A case of universities in Mount Kenya region. A descriptive cross sectional research design was used in this study. A questionnaire with closed ended questions was used to collect data. Data analysis was done using descriptive statistics, inferential statistics as well as content analysis and presented through percentages, and frequencies. The study carried out a correlational analysis in order to ascertain the relationship and strength of associations between organizational leadership and implementation of strategic plans. The study provides stakeholders in universities with a picture of the influence of organizational leadership on gender on implementation of strategic plans in universities.

**Keywords:** Implementation, Strategy, Strategic Plan, Organizational leadership, Communication

## **Introduction**

In this period of globalization when the world is consistently experiencing numerous rapid changes in various fields, the environment in which organizations now operate is never again predictable and stable. Strategic planning then can provide an operational framework allowing organizations to cope with changes and gain a competitive edge (Nickols, 2016). Strategic planning is an essential practice for any organization that aims at assuring that it produces a worthwhile pattern of good results while avoiding an undesirable pattern of bad circumstances. Strategic management refers to the set of managerial decisions and actions that determine the long run performance of a corporation. It includes environmental scanning, strategy formulation, strategy implementation, evaluation and control. More women leaders are being employed to bring in the aspect of equality and inclusivity. Women have participated in scientific leadership as communicators and decision makers. This has led to empowerment because their decisions are crucial in formulating, creating awareness, power and control in strategic management practices. Strategic planning needs a common consensus where decisions articulated on implementation is agreed upon by both men and women. Empowerment of women has also led to inclusivity involving all key stakeholders in planning despite of the gender. Policies have also been introduced that stipulate running of the organization and gender equality and structural inequalities. Women in science have created platforms where planning and policy making does not reinforce any discriminatory practices by benefiting some groups at the expense of others. Strategic planning should be transparent whereby scientific leaders make decisions that are embraced by all regardless of gender. Innovation has been widely accepted by STEM leadership as it involves minimizing unconscious bias among men and women. The steps to reducing bias is: promoting self-awareness, understanding the nature of biasness, have discussions where different viewpoints are listened to by both women and men and lastly promoting bias literacy through training. (Carnes, 2012). While planning for implementation of strategic plans gender action plans must be established that clearly indicate the roles of women.

## **Statement of the problem**

A study by Muraguri (2010) who researched on challenges affecting strategy implementation in private universities found out that the same implementation challenges that is found in the private sector transcends to the private universities. Previous local studies (Obare et al ,2006)



concluded that good strategies have been written but very little has been achieved in their implementation. Therefore, it is important to note that not much attention has been given to the organizational factors influencing implementation of strategic plans in universities in Mount Kenya Region. It is on this basis that this study sought to find out how organizational leadership influences implementation of strategic plans in universities in Mount Kenya Region. Specifically the study aimed to determine the influence of organizational leadership on the implementation of strategic plans among different genders in Universities in Mount Kenya Region.

### **Organizational leadership and gender responsiveness**

Organizational Leadership is a process in which top management can enlist aid and support of others in the accomplishment of a common task. Top managers must communicate their policies and guidelines to their employees (Johnson, 1997). Women are key in formulating and communicating policies that harness gender equality for all, decision making by all and communicating structures that incorporate women while planning. Communication led to development of strategic plans by the government in the Education Sector in 2003. Communication to all despite the gender if done properly helps in successful implementation of the strategic planning process because employees feel part and parcel of the planning. Inclusivity brings about successful implementation of strategies.

### **Results**

Correlation analysis on the effect of Organizational Leadership on Implementation of Strategic Plans in Universities in Mount Kenya Region.

The study conducted correlation analysis in order to ascertain the relationship and the strength of associations between Organizational Leadership and Implementation of Strategic Plans in Universities in Mount Kenya Region. The findings are presented in Table 3. Correlational analysis using Pearson's Product Moment technique was done to determine the relationship between influence of organizational leadership and implementation of strategic plans. It was meant to identify the strength and direction of the association between the influence of organizational leadership and implementation of Strategic plans. Values of correlation coefficient range from -1 and +1. A correlation coefficient of +1 indicates that the two variables are perfectly and positively related in a linear sense, while -1 shows that the two variables are perfectly related

but in a negative linear sense. Correlation coefficient (r) ranging from 0.81 to 1.0 is very strong; from 0.6 to 0.79 is strong; from 0.4 to 0.59 is moderate; from 0.21 to 0.39 is weak; and from 0.00 to 0.19 indicate very weak relationship (Hair et al., 2006).

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		<b>Implementation of Strategic Plans in Universities</b>
<b>Organizational Leadership</b>	Pearson's Correlation	0.4
	Sig. (2-tailed)	0.000
	N	160

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**\*\*.** Correlation is significant at the 0.01 level (2-tailed)

**Table 3:** Correlation analysis on the effect of Organizational Leadership on Implementation of Strategic Plans in Universities in Mount Kenya Region.

The correlation results in Table 3 indicate that there was a positive and significant coefficients between the objective Organizational Leadership and Implementation of Strategic Plans in Universities in Mount Kenya Region ( $r = 0.4$ ,  $p < 0.01$ ). Organizational leadership had a moderate and significant relationship with implementation of strategic plans. These findings are in agreement with a study by Al-Ghamdi (1998) that poor leadership and direction at departmental level are an implementation challenge. The results further agree with Thomson (2008) that it is the responsibility of the managers to explain to their subordinates the need for the strategic plan in a manner that will secure the buy in, enthusiasm and commitment of all the concerned parties in implementation of strategic plans. The study findings imply that there can be no successful implementation of strategic plans without relevant and adequate leadership throughout the implementation process.

### **Conclusion**

The study recommends to the leaders to be inclusive while setting procedures and adhere to policies while formulating strategic goals and objectives. The leaders are also encouraged to

submit to other authorities including stakeholders to enhance ownership of the strategic plan. Women leaders are encouraged to introduce technologies that can empower and mentor other young girls to take up leadership positions for successful implementation of strategic plans. Women leaders are encouraged to participate in decision making to reduce unconscious bias by including all viewpoints in successful planning and implementation. Organizations are recommended to have strong horizontal and vertical communication across the organization. Women in scientific leadership are recommended to create stronger structures since they enhance funding opportunities which hastens the speed towards strategic implementation.

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## **Gender Inclusiveness and Sustainable Development: Any Link?**

Dike, Uzoma Amos<sup>1\*</sup>, Okoh, Johnson Ifeanyi<sup>2</sup>

<sup>1</sup>Department of Religious Studies, National Open University of Nigeria

<sup>2</sup>Department of Financial Studies, National Open University of Nigeria, Abuja.

\*Corresponding author's email: [udike@noun.edu.ng](mailto:udike@noun.edu.ng)

### **Abstract**

Gender inclusiveness is viewed as a concept that encompasses mere equality to collapsing cultural and societal walls that predict male and female labelling with definition of societal roles and expectations. UNwomen report projects that empowering women in the economy and closing gender gaps in the world of work are key elements to achieving the 2030 Agenda for Sustainable Development. Consequently, gender mainstreaming as a strategy is being used internationally for breaking the walls of opposition against women participation. However, religion is one of the ideologies which affects the socio-political practices of a society either positively or negatively. The Christian faith teaches that men and women are to be equal yet many denominations continue to treat each gender differently. The reason is traceable to the interpretations given to the Geneses creation account. The objective of the paper is focused on the study of gender inclusiveness from the perspectives of the creation account in Genesis in the face of emerging realities in managerial studies. The study adopted a multidisciplinary approach, using the tools of exegesis and conceptual review. The study revealed that inclusiveness is the creational language from the Genesis narrative as the Adam is used in reference to humanity created male and female. In conformity with the creation account, the study upholds the creation of humanity – male and female with a gender inclusive agenda from the creator in which both sexes have unique contribution towards the sustainability of the human race.

### **Introduction**

Gender inclusiveness as a concept goes beyond mere equality to the notion that all services, opportunities, and establishments are open to all people such that male and female labelling do not define societal roles and expectations. The European Bank for Reconstruction and Development (EBRD, 2016-2020) has observed that in their regions as well as in many other parts of the world – women still face numerous difficulties in accessing the same economic

opportunities as men. In the same vein, UN women (2018:8) Report projects that empowering women in the economy and closing gender gaps in the world of work are key elements to achieving the 2030 Agenda for Sustainable Development.

### **Statement of Problem**

In the pursuit of the Agenda for Sustainable Development, gender mainstreaming as a veritable strategy in societal development has become a topical issue internationally breaking the walls of opposition against women participation. As such, women have so distinguished themselves in leadership and management sectors of the economy to an extent the trending question is: Are women better leaders than men? (Mamadou, 2019: 2). However, from the perspective of ideology, gender discourse has continued to feature prominently in religious scholarship as religion is one of the ideologies which affects the socio-political practices of a society either positively or negatively. In the Christian faith, men and women are taught to be equal yet many denominations continue to treat each gender differently. The reason is traceable to the interpretations given to the Geneses creation account. Thus need to investigate God's goal for the creation of humanity.

### **Objectives of the Study**

The objective of the paper is focused on the study of gender inclusiveness from the perspectives of the creation account in Genesis in the face of emerging realities in managerial studies. The study reexamined the creation of Adam (humanity) – male and female in Genesis 1:26b-28; 2:20b-24 raising questions such as: Did God create the male to be superior to the female? Are there assigned roles from God to either of the male or female indicating superiority or inferiority? Can either of the two achieve the creation mandate independently?

### **Methodology**

The study adopted a multidisciplinary approach, using the tools of exegesis and conceptual review. Exegesis is useful to the work as it takes readers back to what was said to the original audience back then and there; and draws out meaning of the same word to contemporary readers.

## **Research Findings**

The study revealed that inclusiveness is the creational language from the Genesis narrative as the Adam is used in reference to humanity created male and female. Hence, it is in the realm of inclusiveness that humanity can attain the needed sustainable development. Moreover, God in creating humanity male and female has community-centered goal in which both sexes have unique contribution towards the sustainable development of the world. The text revealed no evidence of any inherent disability in either of the sexes to suggest superiority or inferiority.

## **Conclusion and Recommendation(s)**

The study sets out to reinvestigate the concept of gender inclusiveness from the creation narrative of Genesis in correlation with contemporary managerial realities of both genders. In conformity with the creation account, the study upholds the creation of humanity – male and female with a gender inclusive agenda from the creator in which both sexes have unique contribution towards the sustainability of the human race. The paper maintains that the world and Africa in particular will strive better towards sustainable development goals if the biblical interpretive walls of gender exclusivism are collapsed.

Keywords: Gender Inclusiveness, Gender Equality, Gender Inequality, Sustainable Development

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# **Teacher Trainees' experiences in use of technologies in blended learning: the case of University of Embu and Makerere University**

Josephine Esaete<sup>1</sup> and Speranza Ndege<sup>\*2</sup>

Corresponding author\*

<sup>1</sup>Institute of Open Distance and e-Learning; University of Embu

Email: ndege.speranza@embuni.ac.ke

<sup>2</sup> Department of Science, Technical and Vocational Education; Makerere University

Email: esaete@gmail.com

## **Abstract**

Blended learning is a teaching and learning technique that integrates traditional face-to-face teaching and learning with online teaching. Makerere University and University of Embu have adopted blended learning in teaching and learning for the past one and half years since COVID-19 pandemic. The sudden transition from face to face to online learning brought with it new demands for both students and teachers. For example, instructors were expected to use innovative technologies to engage students with content through asynchronous tools such as discussion boards, chats, collaborative wikis, as well as synchronous E-platforms such as zoom and Web conferencing and others. However, it is presumed that the teacher trainees' experiences might differ due to their exposure levels to technologies, internet connectivity and gender. Therefore, to understand teacher trainee experiences; we will use a non-experimental survey design to gather data of teacher trainee varying experiences in learning online. This paper will share the findings of Bachelor of Education (B.Ed. Arts & B.S.Ed.) male and female teacher trainees' experiences with online learning since adoption of blended learning in 2020. These findings will include the positive and the negative experiences encountered during the online learning.

## **Introduction**

Blended learning is teaching and learning approach that combines online teaching and learning with traditional face-to-face mode of delivery. Students' experiences are enriched by collaborative activities and diversity of online resources provided. However, due to inadequate internet and other infrastructural development, some institutions of higher learning were not able to implement online learning adequately while others implemented as in the case of Makerere University and University of Embu.

Blended learning is driven by technologies such as tablets, smartphones, adaptive learning websites and applications among others with the most common technology being videos/ audios (Dziuban et al., 2018). These technologies aid learners use asynchronous tools such as discussion boards, chats, and collaborative wikis. The synchronous portion of the learning is instructor-led and typically delivered through webinars, allowing online learners to participate via E-platforms such Zoom, Web conferencing among others. The technologies together with instructor's pedagogical strategy determines whether the learners will apply their own ideas and understanding to complete tasks and/or contribute to other learners' experiences.

The quality of the learning experience is enhanced by the student support provided during blended learning. Students require assistance in order to use technology effectively in online learning. As a result, student support is essential in ensuring that students can use a variety of technologies to improve their online learning experiences.

In this mode of study, learning is self-paced because there is flexibility in learning and completing of assignments and this enhances student learning experiences (Poon, 2013). However, self-regulated learning, on the other hand, has some drawbacks, such as learners not devoting enough time to finish activities, bulky attachments such as videos, and a lack of motivation among others (Rasheed, Kamsin and Abdullah, 2020). Another issue is that subject disciplines, such as STEM, internet connection may limit access to virtual laboratories hence denying students the opportunity to see practical demonstrations of ideas in a virtual space (Varlvede et al. 2020), affecting learners experiences.

### **Statement of the Problem**

Both Makerere University and University of Embu offer Bachelor of Education (Arts and Science) degree programs through blended learning mode of delivery. Due to the COVID-19 pandemic, there was a dramatic transition for all students to study online. This significant transition brought with it new demands for both students and teachers. For example, instructors were expected to use innovative technologies to engage the teacher trainees in online learning synchronously and asynchronously. The sudden switch to online learning required use of technologies for effective learning. However, the use of technologies is influenced by many factors such as familiarity and accessibility among others. This study will document the experiences in use of



technologies in online learning by both female and male teacher trainees from University of Embu and Makerere University.

### **Objective**

The objective of this study is to assess female and male teacher trainee's experiences in use of technologies for online learning.

### **Methodology**

The corpus for this study will comprise of second and third year students from the University of Embu and Makerere University. These students have been learning both face to face and online since 2020 hence the right choice for this study. In order to understand the gender similarities and differences in the use of technologies for online learning, the value expectancy theory will be adopted for the study. On the other hand, the experiences of teacher trainees in using technology will be obtained using a non-experimental survey design. The data will be analyzed descriptively.

### **Results**

The paper will present the findings on experiences in the use of technologies in online by the teacher trainees.

### **Discussion**

The findings of the study will be discussed in the context of skills for school-to-work transition.

### **Conclusion and Recommendation**

The conclusions and recommendations will be drawn based on the findings of the study.

### **Acknowledgement**

We will acknowledge the students who will participate in responding to the instrument.

### **Scientific contribution**

This paper will contribute to knowledge on use of technologies by both Bachelor of Education (Arts) and Bachelor of Education (Science) teacher trainees to study on online learning occasioned by COVID-19 pandemic.

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## SUB THEME: POST COVID-19 RESILIENCE STRATEGIES

### **Knowledge, Perception and Practices of Coronavirus Pandemic among Adults in Enugu Urban, Nigeria**

1Afunwa, Ruth A., 2Ezeudu Ngozi, 3Afunwa Emmanuel C., 1Egbuna, Roselyn N., 1Nwakaeze Emmanuel A., 1Okonkwo-Uzor N, 1Ikegbune C and 1Erhirhie Earnest O.

1Department of Pharmaceutical Microbiology and Biotechnology, Faculty of Pharmaceutical Sciences, Chukwuemeka Odumegwu Ojukwu University, Igbariam in Anambra State, Nigeria

1Department of Pharmacology and Toxicology, Faculty of Pharmaceutical Sciences, Chukwuemeka Odumegwu Ojukwu University, Igbariam, Anambra State, Nigeria

2African Thinkers Community of Inquiry College of Education, Enugu State, Nigeria

3Department of Clinical Pharmacy, Faculty of Pharmaceutical Sciences, University of Nigeria, Nsukka, Enugu state, Nigeria.

Presenting Author: missruthus2000@yahoo.com : ra.afunwa@coou.edu.ng

#### **Abstract**

**Background:** COVID-19 is a contagious respiratory illness transmitted through droplets from an infected person when sneezing or coughing or by touching contaminated surfaces.

**Statement of problem:** The communal lifestyle in this area may promote the spread of the virus as most do not observe the precautionary measures.

**Justification:** As a result of the above occurrences, there is the need to evaluate individual awareness and compliance.

**Objectives:** This current study is on adult perception on the spread of the disease; the findings from this study will provide empirical data on the knowledge of the disease and responses in the community.

**Results:** Three hundred and ninety two (98.0%) questionnaires were retrieved with higher male respondents (54.3%). A Likert scale of 1 to 4 was used for all research questions in the survey. Research questions on the perception of COVID-19, awareness level and practice had average values of 3.38, 2.57 and 3.16 respectively while the reliability test for questions on knowledge, perception and practice gave a Cronbach's coefficients of 0.788, 0.568 and 0.609 respectively.

**Discussion:** findings of the study are similar to reports in other African regions where the

knowledge, perception and preparedness among individuals are still very low.

**Conclusion:** The study shows the perception and awareness levels of adults living in Enugu urban with low compliance to the stipulated precautionary measures.

**Recommendation:** There is need for a continuous sensitization among people in the different communities about the coronavirus disease through radio jingles, talk show and documentaries.

## **Introduction**

COVID-19 is a contagious respiratory illness transmitted through droplets from an infected persons or by touching contaminated surfaces, Dong et al [1]. The perception on the spread of Coronavirus disease differ among individuals in this part of the world. It is opined that self-isolation, social distancing and other precautionary measures are un-African due to their communal lifestyle, Serwaa et al [2]. As such, there is the need to evaluate the knowledge and attitude of individuals. This current study is on adult perception on the spread of the disease which will provide empirical data for futuristic reference.

## **Methodology**

### **Research design**

A survey research design was adopted for this study made up of adults randomly selected. The instrument for data collection was a questionnaire arranged on a four point scale of Agree, Strongly agree, Disagree, Strongly disagree.

Four hundred (400) respondents were used in this study made up of adult males and females.

### **Method of data analysis**

Data collected from the research questions were analyzed using ANOVA with Cochran's Test

### **Decision rule**

The decision rule was that any response with a mean of 2.5 and above will be regarded as "Agreed" while any response with the mean below 2.5 will be regarded as "Disagreed".

## Results

S/ N	QUESTIONS	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	$\sum(Q1-Q7)$	F	X	Decisions
1	What is the perception of COVID-19 among adults in Enugu urban?	3.4	3.4	3.41	3.3	3.3	3.3	3.2	---	23.65	7	3.3	Agreed
		3	9		9	7	3	3	--			8	
2	What is the awareness level between male and female adult respondents?	2.0	2.5	3.3	3.14	2.0	2.3	---	---	15.42	6	2.5	Agreed
		1	7	0		7	3					7	
3	What are the precautionary measures used by adult respondents?	3.4	3.41	3.2	3.10	3.01	3.0	3.0	3.1	25.50	8	3.1	Agreed
		6		6			2	9	3			6	

**Key:** Q= question,  $\sum(Q1-Q7)$ = summation of Q1-Q7, F= frequency, X= average mean score

**Table 1:** Summary of Research Questions

A Likert scale of 1 to 4 was used for all research questions in the survey. All the questions under research question 1 had an average values of 3.38, of 2.57 and 3.16 respectively. Since the values are above the decision rule of 2.5, the decision is that all agreed 100%.

## **Discussion**

Respondents agreed to all questions asked under question one. The mean value of all responses was given at 3.38 which is above the decision rule of 2.5. A 100% response rate was received with a Cronbach alpha of 0.768. Olapegba et al. [3], in their study recorded a 94.10% response to the transmission mode of the coronavirus disease among respondents. In the second research question, respondents disagreed on children vulnerability, recovery rates in males and females and the reports on COVID-19 in the community. These findings suggests that the awareness level is still very low. This result is similar to a study by Serwaa et al, [2] on knowledge, perception and preparedness among 350 Ghanaians, where 77.1% of information provided on the pandemic was from the internet. The third research question had a mean average of 3.16. This confirms that respondents had good knowledge about the COVID-19 outbreak and preventive measures but with low compliance in the community.

## **Conclusion and Recommendations**

The findings of this study suggests that there is need for a continuous sensitization among people in the different communities about the coronavirus disease in order to curb the spread. Sharing of palliatives in the different communities to support the indigent within the community will also help. The findings can be extrapolated in other communities and also provide useful data for further studies.

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## **Points of Intervention to Overcome Sex and Gender Inequalities in COVID-19**

Sandra Sánchez-Urtaza<sup>1,2\*</sup>, Cristina Penas Lago<sup>1,2</sup>, Nerea Moreno<sup>1,2</sup> and Lucia Gallego<sup>1,2</sup>

<sup>1</sup>Faculty of Medicine and Nursing, University of the Basque Country, Leioa, Spain.

<sup>2</sup>Foro Emakumeak Medikuntzan / Association for Women in Medicine, Bilbao, Spain.

\*Corresponding author's email: [ssanchez079@ikasle.ehu.eus](mailto:ssanchez079@ikasle.ehu.eus)

### **Abstract**

The COVID-19 pandemic has highlighted that sex and gender differences have implications in human health and well-being. Exposure to the virus and lifestyle can be influenced by biological sex or gender roles. Integrating gender perspective into clinical research on COVID-19 would lead to identify patterns of risk and to develop strategies to effectively address the needs of both sexes. We aimed to analyse if sex and gender differences are considered in clinical research on COVID-19. For this purpose, we carried out a PubMed search with general sex and gender terms to refine our results and we looked up published data from some of the most important international organisations. Our findings showed that 21.2% of the registered studies clearly address sex/gender as a recruitment criterion but only the 4% plan to analyse data by sex or gender. This biased research is not applicable to women, causing wrong diagnosis and treatment failure putting their lives at risk. Many countries have not reported sex-disaggregated data in the last month, and from those countries previously reporting sex-disaggregated case and death data, 30% and 34% are no longer doing so, respectively. Regarding to vaccines, these seem to be less effective and to induce more adverse effects among women. Clinical trials must include the same number of male and female participants, analyse results by sex and all countries must indicate sex-disaggregated epidemiological data. We will not be able to overcome the situation considering only white male population as the standard.

### **Introduction**

The COVID-19 pandemic has turned the spotlight on sex and gender differences with implications in human health and well-being. Evidence to date shows that men are more likely to suffer severe disease than women, whereas women seem more susceptible to long-term COVID-19, and experience negative social and economic impacts. In fact, exposure to the virus and harmful habits can be influenced by biological sex or gender roles. Integrating gender perspective into clinical research epidemiological report on COVID-19 would be a helpful tool to identify patterns of risk and to develop strategies to effectively address the needs of women



and men. Taking into account the growing recognition of the importance of sex and gender in the COVID-19 pandemic, the aim of this analysis was to know if these factors are taken into account in clinical research on COVID-19. For this purpose, we accomplished a systematic review of articles mentioning sex and gender in COVID-19 studies and epidemiological reports through a PubMed search using the following terms: COVID\*, coronavirus, SARS-Cov-2, clinical trial\*, clinical stud\* and vaccin\* in combination with The Texas Tech University Health Sciences Centre Sex and Gender Specific Health (SGSH) PubMed Search Tool; which uses an advanced search string with general sex and gender terms to refine your search. This resulted in 219 articles, of which 129 were published in 2021. For epidemiological data, information was obtained through a search on [globalhealth5050.org](http://globalhealth5050.org); [comitglobal.org](http://comitglobal.org); [clinicaltrials.gov](http://clinicaltrials.gov) and the official websites of the Spanish Agency of Medicines and Medical Devices, the European Centre for Disease Prevention and Control the World Health Organization and the European Medicines Agency.

## Results

Of the 4420 registered studies on ClinicalTrials.gov, just a 21.2% clearly address sex/gender as a recruitment criterion and only a 4% consider sex or gender as a planned analytical variable in accordance with Brady et al 2021 [1]. The male/female ratio is normally over 1 point according to Schiffer et al [5]. Furthermore, studies with only-female recruitment research (2.2%) focused only on pregnancy and COVID-19. Just a 17.8% of the COVID-19 related clinical trials published until December 2020 report or analyse sex-disaggregated data. With respect to epidemiological data, Evagora-Campbell [3] also stated that only 52% of countries reported sex differentiated COVID-19 data on testing, cases, hospitalisations, admissions to ICUs and deaths between mid-April to mid-May 2021. In accordance with the report published in June 2021 by The COVID-19 Sex-disaggregated Data Tracker, most of the Asian and African countries have not reported sex-disaggregated data in the last month. In fact, of those countries previously reporting sex-disaggregated case and death data, 30% and 34% are no longer doing so, respectively. Out of 199 countries, just 16 are reporting sex-disaggregated testing data, 139 report confirmed cases, 27 report hospitalisations, 19 report ICU admissions, 107 report deaths and 42 report vaccinations. Clinical trials suggest that coronavirus vaccines are slightly less effective among women: Pfizer's vaccine showed a 96.4% efficacy in men vs. 93.7% in women; Moderna's vaccine was found to have a 95.4% efficacy rate in men but a 93.1% in women; AstraZeneca

didn't publish sex- disaggregated data; and Sputnik V vaccine was the one with the biggest difference in efficacy between men (94.2%) and women (87.5%). Regarding to vaccine sex-dependant adverse effects data, they are not published in many countries neither on the websites of international institutions such as ECDC, WHO or EMA. The Spanish Agency of Medicines and Medical Devices is one of the institutions which offers sex-disaggregated data. In accordance with their 6th Report of Pharmacosurveillance published in June 2021; 81%, 82%, 74% and 64% of adverse effects were reported in women who were vaccinated with Comirnaty (Pfizer/BioNTech), Spikevax (Moderna), Vaxzevria (Oxford/AstraZeneca) or Janssen (Johnson & Johnson), respectively. Regarding to vaccines and pregnancy/lactation, there is limited data about safety and efficacy on pregnant or lactating women. However, in many countries pregnant women are being vaccinated anyway. On the one hand, 37 countries authorise it for all and 60 only for lactating women; on the other hand, 14 countries do not recommend it with some exceptions, 6 for lactating women.

## **Discussion**

Evidence is showing that the presence of women in clinical trials is insufficient and so, published results are not applicable to women. In addition, there are not enough sex-differentiated epidemiological data available which contributes to a biased landscape of the COVID-19 disease in women. In those countries with a rigorous epidemiological control and sex-disaggregated analysis, for instance Australia, data are showing that women deaths have increased. Data from other countries might be explained by underdiagnosis and treatment failure in women derived by one-sided clinical results. Regarding to vaccines, these have proved to induce more adverse effects and to be less effective in women than in men; probably due to not considering differences in immune responses as females have stronger inflammatory, antiviral and humoral immune responses conforming to Ciarambino et al [2]. However, sex-disaggregated data about adverse effects and efficacy are not reported in many countries as stated by O'Grady [4], which is a clear evidence of economic interests being put above women's health, with a rush for development and commercialization of treatments and vaccines.

## Conclusion and Recommendation

Since the pandemic started, women rights have been relegated and gender inequalities have increased more than ever before. There are clear scientific evidences that sex differences in immune responses affect dramatically COVID-19 interventions and outcomes. A gender-based approach has been shown not only to improve health care, but to avoid further imbalance of existing health inequities in societies. In order to ensure women's health, clinical trials and scientific publications must include the same number of male and female participants; disaggregate results by sex and analyse taking this factor into account; and all countries must indicate epidemiological data differentiated by sex.

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## **Innovations developed from a feminist perspective during the COVID-19 pandemic: case reports in Brazil**

Klena S.M. Silva<sup>1\*</sup>, Alessandra N. Pontes<sup>2,4</sup> and Gesyca P. S. Santos<sup>3,4</sup>

<sup>1</sup>Institute of Science and Technology in Biomodels, Oswaldo Cruz Foundation, Rio de Janeiro, Brasil.

<sup>2</sup>Robotics Nucleus and Technological Innovation Center, Cesmac University Center, Maceió, Brasil.

<sup>3</sup>Postgraduate Student in Intellectual Property and Technology Transfer for Innovation, Maceió, Brasil.

<sup>4</sup>Mulheres Conectadas Startup

\*Corresponding author's email: klena.sarges@fiocruz.br

### **Abstract**

During the COVID-19 pandemic, gender inequalities in Brazil were accentuated, demonstrating the need for emergency affirmative action to support Brazilian women. The work describes three initiatives in innovation from a feminist perspective and carried out in two Brazilian states: Alagoas and Rio de Janeiro. The creation of an inclusive chatbot for primary care in COVID-19 and the creation of the Mulheres Conectadas Seal and the Advisory Council for Women in Technology. The actions strengthened the role of women in science, technology and innovation and provided for the inclusion of poor women, in line with the United Nations (UN) agendas for women.

### **Introduction**

According to the United Nations Brazil [1], in Brazil, women lost progress in equality and gender inequalities related to work, economic participation, health and respect during the recent pandemic. In contrast, Brazilian women have increasingly actively participated in the Brazilian innovation ecosystem. The number of women who undertake and are leading startups in Brazil is expressive and has grown during the pandemic. About 15% of the more than 12,000 businesses created in 2019 were founded by women [2] and more and more innovative products are thought and designed with a female perspective.

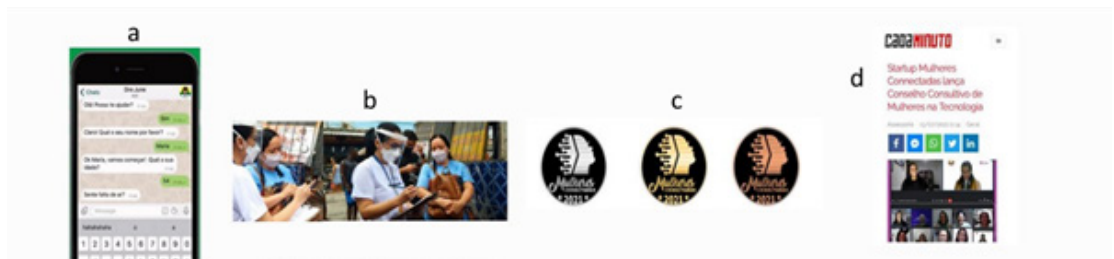
Therefore, it is extremely important to discuss and carry out actions that promote gender equity and, especially, female empowerment. This paper presents innovation initiatives produced

during the pandemic from a feminist perspective at the Innovation Laboratory of the Institute of Science and Technology in Biomodels (ICTB) of the Oswaldo Cruz Foundation (Fiocruz) in Rio de Janeiro (RJ) and at the startup Mulheres Conectadas (Women Connected) in Maceio Alagoas).

## **Results**

In 2020, the ICTB/Fiocruz Innovation Laboratory developed the Dr June chatbot during HackCovid19, a hackaton for the development of technologies to fight the pandemic. The project was created for primary care in COVID19 and health surveillance of the disease, focusing on the need for actions aimed at low-income and excluded citizens. The chatbot's name honors the scientist June Almeida, who discovered the first human coronavirus in 1964, but who, like many other female scientists of her time, did not immediately appreciate her discovery. The chatbot logo reinforces the female image as a producer of knowledge, removing the male stereotype as the facilitator of medical and scientific information. Access to women in vulnerable conditions is facilitated by making free use of the chatbot available. The validation of the chatbot carried out in a favela community in Complexo da Maré (RJ) only heard women (n=10).

In the State of Alagoas, social technology startup Mulheres Conectadas carried out two fundamental actions for the empowerment of women in the entrepreneurship and innovation sector: the creation of the Mulheres Conectadas Seal and the Advisory Council for Women in Technology. The design of the seal and the Council follows the seven Women's Empowerment Principles, presented by UN Women, the UN 2030 agenda, and the UN Global pact. The seal will be awarded to public and private institutions that carry out and undertake to carry out effective actions in favor of gender equality in the universe of work in innovation. While the Advisory Council of Women in Technology aims to encourage the participation of women in the sector by promoting debates, events and other actions that ensure greater inclusion of women in technology and promote gender equality. The Council has partnership with the Association of Brazilian Information Technology Companies of Alagoas-Assespro.



**Figure 1.** *Innovations developed from a feminist perspective during the COVID-19 pandemic:* A Screenshot of chatbot screen Dra June; b. Chatbot validation with test user in favela community - Complexo da Maré (RJ); c. Mulheres Conectadas Seal; d. News posted on Cada Minuto news site about the Advisory Council for Women in Technology.

## Discussion

In Brazil, women who earn up to half the minimum wage and who are responsible for the subsistence of the family correspond to about 40.8% of the people declared to be heads of the family [3]. The pandemic has exponentially increased the unemployment rate for women in Brazil. In 2019, the number of unemployed women was higher (13.1%) than the rate of unemployed men (9.2%) [1]. This information was an important driver in the development of a technological tool with free access, without the need for costs with internet plans on cell phones for access and that would not require a cell phone with robust hardware.

It is a fact that both in Science and in the innovation ecosystem, the greatest prominence is always to the men and a large part of products and processes are prioritized for men's use [4]. Therefore, the importance of strengthening women with actions in these two areas from Startup Mulheres Conectadas, which has a strong mission to contribute to strengthening the purpose of the SDGs 5 (Gender Equality) and 10 (Reduction of Inequalities) that highlight, development and economy in line with the global pact established by the UN on the 2030 agenda.

## Conclusion and Recommendation

Actions such as those presented in this summary strengthen the female presence in the area of science, technology and innovation, as well as act in the field of public policies for the social inclusion of economically disadvantaged women and enhance the participation of women in various sectors of society.

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## **SUB THEME: AUTOMATION AND ROBOTICS**

### **Use of Mobile Phone Applications for Sorghum Seed Varieties Selection**

Susan A. Mbanda<sup>1\*</sup>, Hillary Nyang'anga<sup>2</sup>, Evans L. Chimoita<sup>2</sup>, and Phoebe Fedha<sup>3 1,2</sup> Department of Agricultural Economics, University of Nairobi, P. O. Box 29053-00625, Nairobi, <sup>3</sup>Department of Computer Science, Egerton University, P. O. Box 536-20115, Egerton hilaryteddy@gmail.com; echimoita2011@gmail.com and phoebe.ongalo@egerton.ac.ke Corresponding Author: suembanda@gmail.com

#### **Abstract**

Use of mobile phone applications could be of great help to farmers to abate the many challenges they go through in decision making on sorghum seeds varietal selection. Mobile phone applications have been developed for farmers in Kenya but very few target the local poor sorghum farmers in Homa Bay County. Numerous apps exist to assist farmers in agricultural production though few farmers use them for decision making in sorghum seed variety selection. The lack of mobile app aimed at sorghum farmers contribute to poor sorghum production. However, little is known on how farmers use the existing m-applications to identify the sorghum seeds varieties in their locations. This study aimed at exploring farmers' use of m apps technologies for decision making. Data analysis on descriptive statistics showed that majority 73% owned basic phones while 27% used smartphones and 61% not using m-apps to access information. Majority (60%) made voice calls, 28.7% used SMS, 7.4% used Internet and 4% didn't use any app. 81% were willing to have m-apps geared towards sorghum information while 19% had no idea as to the application. The farmers expressed a strong desire for a new m-app that is sorghum farmer-oriented. It was recommended that the service providers and developers to enhance farmer's awareness on mobile phone applications.

#### **Introduction**

The dynamic growth of mobile phone technology is very relevant for decision making in sorghum production in Kenya. Rural farmers, especially sorghum farmers in Homa Bay County have been faced with information asymmetry challenges due to pitfalls in mobile telephony. M-apps are booming and trending thus experiencing rapid development (Alexova, 2015). However, the development of mobile apps for sorghum compared with other crops is still low.



Most rural areas in the developing countries use low-tech mobile phones (2G) and delivery technologies such as SMS or voice services (Qiang et al., 2012) for M-apps. Farmers practicing sorghum farming still experience periodic low yield (Chepng'etich et al., 2015) thus posing a threat to food and income security. There is need therefore to have interventions to increase sorghum productivity through a decision support system platform for sorghum seed variety selection for the different agro-ecological zones. The mobile phone solution based technology such as calls, Short Message Services (SMS), Unstructured Supplementary Service Data (USSD) and on-line social network applications (WhatsApp, Facebook, Twitter, YouTube and Myspace) have been developed to assist farmers (Myllynmaa, 2016) to make informed decisions. The study uncovered the current status of mobile agricultural apps.

## Results

Table 1 shows the mobile type and ownership by the respondents. Majority 73% owned basic phones while 27% had smartphones (Table 1).

<b>Type</b>	<b>Frequency</b>	<b>Percent</b>
<b>Smartphone</b>	40	27
<b>Basic Phone</b>	110	73

**Table 1:** *Type of mobile phone*

The basic phone popularly known in Kiswahili as “mulika mwizi” was owned by farmers with minority using the Android phone for accessing information. Viewed to be cheap while others noted the poor battery performance, repairs and maintenance on android phones as a reason for not using smartphones. This agrees with Muasa and Matsuda (2019) who also found that the Basic phones were most popular in rural Kenya.

## Conclusion and recommendation

The spread of mobile telephony in the County shows the potential of information delivery through mobile applications. Popular m-apps associated with basic mobile phones are SMS or voice services. In order to increase mobile agricultural app, stakeholders ought to be informed, educated and trained.

## **Acknowledgements**

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## SUB THEME: SUSTAINABLE FOOD SYSTEMS

### **Influence of PGPR isolated from Benin soils in combination with a chitin derivative on greenhouse growth and nutritional status of maize (*Zea mays* L.) plants**

N.A. Agbodjato<sup>1,2</sup>, O.O. Babalola<sup>1\*</sup>, P. A. Noumavo<sup>2</sup>, J. Danbakan<sup>2</sup>, M. Adoko<sup>2</sup>, A. Adjanohoun<sup>3</sup>,  
L. Baba-Moussa<sup>2</sup>

<sup>1</sup>Food Security and Safety Niche, North-West University, PMB X2046, South Africa.

<sup>2</sup> Université d'Abomey-Calavi, 05 BP 1604, Cotonou, Benin.

<sup>3</sup> Institut National des Recherches Agricoles du Bénin, Calavi, Benin

\*Corresponding author's email: olubukola.babalola@nwu.ac.za

#### **Abstract**

To increase crop yields, many farmers use mineral fertilizers, which are indeed considered the most effective weapon but are not without adverse health and environmental consequences. The objective of this study was to evaluate the effects of three rhizobacteria (*Azospirillum lipoferum*, *Pseudomonas fluorescens* and *Pseudomonas putida*) in combination with chitosan on maize greenhouse growth and plant nutritional status. For this purpose, maize seeds were treated with a chitosan solution diluted to 1/10 of its initial concentration (4g//L) and then inoculated with bacterial suspensions of approximately 10<sup>8</sup> CFU/ml. The growth trial lasted 30 days in pots filled with sterile ferralitic soil. The experimental design was a completely block design of eight treatments with four replications. Results showed that maize plants treated with the chitosan-P. fluorescens combination improved height and leaf area of maize plants by 49.66% and 30.64% of the control respectively. The best neck circumference was obtained with the plants treated with the chitosan-A. Lipoferum combination, i.e. an increase of 19.7%. The combination chitosan-P.fluorescens had the highest nitrogen and phosphorus contents, while P. fluorescens alone had the highest potassium content. These results give comfort in the perspective of integrating these bioproducts as biofertilizers in ecologically sound farm management programs.

**Keywords:** sustainable agriculture, chitosan, growth, PGPR, Bioproduct

## Introduction

The use of bioproducts such as Plant Growth Promoting Rhizobacteria (PGPR) and chitosan is one alternative solution that will reduce the overuse of chemical fertilizers and pesticides, causing massive health and environmental problems (Enagbonma and Babalola, 2019). PGPRs are bacteria present in the rhizosphere of plants that secrete substances involved in improving plant growth and health. Chitosan is a bioproduct derived from chitin extracted from crustacean exoskeletons and used in seed treatment to improve plant growth and health.

## Results

- **Effects of PGPR and chitosan on growth parameters at 30 days after sowing (DAS)**

Table 1 shows that maize seeds treated with the combination of chitosan-P. fluorescens improved the height and leaf area of maize plants by 49.66% and 30.64%, respectively, compared to the control. As for the neck circumference, the highest value was obtained on the plants treated with the combination of chitosan and A. Lipoferum, i.e., an increase of 19.7%.

- **Effects of PGPR and chitosan on the nutritional status of maize plants (NPK content)**

Table 2 shows the effect of PGPR and chitosan on the nutritional status of maize plants. We note that the above-ground and below-ground biomass of plants treated with the chitosan-P. fluorescens combination had the highest nitrogen (N) and phosphorus (P) content. On the other hand, plants treated only with P.fluorescens had the highest potassium content.

## Discussion

The effect of PGPR and chitosan used in our study was clearly reflected through the growth parameters of maize plants, with a very highly significant difference ( $p < 0.001$ ) between treatments. The results obtained in our study are superior to those obtained by Agbodjato et al. (2016). The chitosan concentration can explain this difference because the latter used a concentration of 0.5 g/l against 0.4g/l in our study. This increase in growth parameters may also be due to the availability of nutrients stimulated by PGPR and chitosan. PGPRs, by their mechanism of action, improve the growth and yield of crops (Noumavo et al., 2016). Chitosan stimulates plant growth, photosynthesis and nutritional supply (Hernández, 2004).

## Conclusion and Recommendation

This study confirms the promoting effect of PGPR in combination with chitosan on maize growth and plant nutritional status. Therefore, PGPR with chitosan as biofertilizers at the farmer level is consequently highly desired for sustainable agriculture.

## Remerciements

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Treatments	Height (cm)		Circumference (cm)		Leaf area (cm <sup>2</sup> )	
	m	$\sigma$	m	$\sigma$	m	$\sigma$
<b>CTL</b>	29.8	1.99	6.75	0.90	348.64	15.96
<b>Lipo</b>	34.97	6.20	6.75	0.76	398.61	17.04
<b>Fluo</b>	26.875	1.21	6.59	0.78	337.86	16.81
<b>Puti</b>	35.00	1.51	7.85	0.11	429.06	30.79
<b>Chit</b>	31.25	3.53	6.51	1.39	398.07	25.86
<b>Chit-lipo</b>	42.72	3.21	8.08	0.36	449.45	11.13
<b>Chit-fluo</b>	44.60	3.02	7.92	0.55	458.96	19.51
<b>Chit-puti</b>	38.95	7.74	7.14	0.49	417.00	23.95
<b>Probability</b>	0.000		0.000		0.000	

**Table1:** Effects of PGPR and chitosan on growth parameters 30<sup>th</sup> JAS

☒ < 0.001 (very highly significant) m: mean; ☒: standard error. CTL: control (without bacteria and chitosan); lip: only with *A. lipoferum*; flu: only with *P. fluorescens*; put: only with *P. putida*; chit: only with chitosan; Chit-lipo: combination chitosan and *A. lipoferum*; Chit-fluo: combination chitosan and *P. fluorescens*; chit-puti: combination chitosan and *P. putida* .

Treatments	Nitrogen (N)		Phosphorus (P)		Potassium (K)	
	AB	UB	AB	UB	AB	UB
<b>CTL</b>	2.86	1.81	0.57	0.23	5.96	0.95
<b>Lipo</b>	2.28	1.36	0.48	0.24	4.28	1.06
<b>Fluo</b>	2.93	1.61	0.62	0.19	6.73	1.14
<b>Puti</b>	2.97	1.52	0.54	0.18	6.48	0.94
<b>Chit</b>	3.27	1.82	0.35	0.26	6.15	1.92
<b>Chit-lipo</b>	2.66	1.75	0.53	0.33	5.29	1.09
<b>Chit-fluo</b>	3.29	1.83	0.64	0.28	6.31	0.80
<b>Chit-puti</b>	3.15	1.77	0.42	0.28	6.01	1.30

BA: Aerial biomass (leaf and stem); UB: underground biomass (Root)

**Table 2:** *Effects of PGPR and chitosan on NPK content of maize plants*

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## **Fortuitous biological control of tomato leafminer, *Tuta absoluta* in Kenya**

Kinyanjui. G1\* and Kenya. E. U1

1University of Embu, Embu, Kenya.

\*Corresponding author's email: gracekinyanjui11@gmail.com

### **Abstract**

The invasive tomato leafminer, *Tuta absoluta* is a major threat to sustainable production of tomato in Kenya. The commonly used approach to control this pest involves frequent applications of synthetic insecticides, which is unsustainable and accompanied by negative effects on human health and the environment. Biological control is the use of natural enemies and presents a sustainable pest control alternative for *T. absoluta*. Therefore, the objective of the study was to carry out a field survey to identify the indigenous natural enemies that are adapting to *T. absoluta* on tomato crops grown in Kenya. Two predator and nine parasitoid species were recorded. Nevertheless, the overall species abundance and parasitism rates were low to guarantee effective control of the pest. These results are essential in the development of biological control programs for *T. absoluta* that will enable sustainable management of the pest and increase tomato production in Kenya.

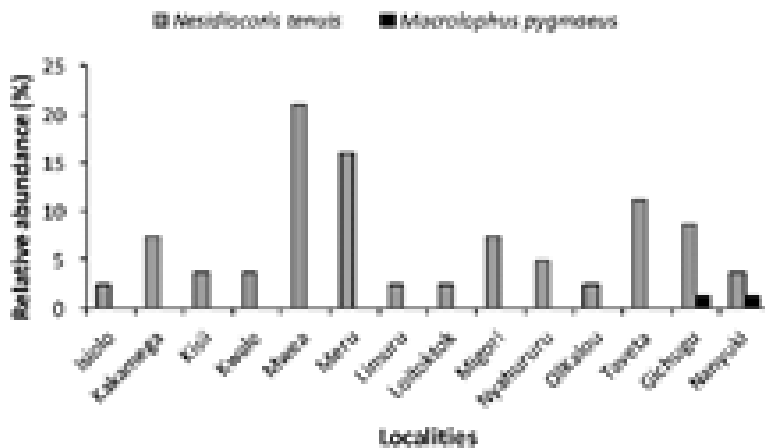
### **Introduction**

Sustainable production of tomato requires the use of sustainable agricultural practices to simultaneously achieve food security, improve livelihoods and conserve the environment. Food security, however, is threatened by low productivity of the crop often associated with, among other biotic factors, infestation of insect pests. The invasive tomato leafminer, *Tuta absoluta* has a devastating effect on global production of tomato. This pest is usually controlled using synthetic insecticides because pest control alternatives are not readily accessible to farmers. Although these insecticides play a significant role in reducing crop damages, their usage levels are unsustainable and their harmful long-term effects on human health and the environment cannot be disregarded. Heavy reliance on chemical control also induce pesticide resistance in *T. absoluta* and further increase the pest's problem. For these reasons, there is need for sustainable pest management strategies for *T. absoluta* to reduce tomato damages, increase production and reduce adverse effects resulting from reliance on synthetic pesticides.

Diverse species of natural enemies of *T. absoluta* have been reported worldwide including predators, parasitoids and pathogens [1, 2]. Among these are several effective species that are currently incorporated in integrated pest management (IPM) strategies for the pest as biological control agents [1]. To attain the goals of biological control in Kenya, natural enemies of *T. absoluta* need to be identified and their efficacy evaluated. Therefore, the objective of this study was to conduct a field survey in tomato growing areas of Kenya to identify the indigenous natural enemies that have adapted to *T. absoluta*. The findings will be useful in developing sustainable pest control alternatives for the pest and improve nationwide production of tomato.

## Results

Two predator species of *T. absoluta* were recorded. *Nesidiocoris tenuis* (Reuter) was the most abundant and was recorded in 14 localities. *Macrolophus pygmaeus* (Rambur) was sampled from two localities as shown in Figure 1.



**Figure 1.** Predators of *Tuta absoluta* in Kenya

Nine parasitoid species of *T. absoluta* were recorded as shown in Table 1. *Hockeria* sp. was the most abundant and recorded the highest parasitism of  $12.88 \pm 1.47\%$ .



<b>Species identity</b>	<b>Sampled localities</b>	<b>Abundance (%)</b>	<b>Parasitism (%)</b>
<i>Hockeria</i> sp.	Kwale, Loitoktok, Taveta	50 (31.25%)	12.88 ± 1.47
<i>Brachymeria</i> sp.	Kwale, Loitoktok, Taveta	34 (21.25%)	9.89 ± 0.90
<i>Bracon</i> sp.	Gichugu, Mwea	7 (4.38%)	6.34 ± 1.12
<i>Diglyphus isaea</i>	Gichugu, Kakamega, Kisii, Meru, Mwea, Nyeri	15 (9.38%)	4.44 ± 1.17
<i>Neochrysocharis formosa</i>	Gichugu, Nyeri	6 (3.75%)	5.35 ± 3.21
<i>Chelonus</i> sp.	Meru	13 (8.13%)	9.02 ± 2.67
<i>Necremnus</i> sp.	Kwale, Loitoktok, Meru, Taveta	19 (11.88%)	4.87 ± 0.80
<i>Goniozus</i> sp.	Bungoma, Meru, Mwea, Nanyuki	13 (8.13%)	5.20 ± 1.11
<i>Stenomesus rufescens</i>	Meru	3 (1.88%)	4.23 ± 0.00

**Table 1.** Parasitoids of *Tuta absoluta* in Kenya

## Discussion

This study showed that indigenous natural enemies in Kenya are adapting to *T. absoluta* and could provide a solid foundation for sustainable management of the pest. These results corresponded with previous research studies in both native and invaded regions of the pest [1, 2]. However, the overall abundance of individual species and levels of parasitism were low to effectively control the population levels of *T. absoluta*. This could be attributed greatly to harmful agricultural practices adopted by farmers [1]. Awareness campaigns, therefore on the need to conserve these natural enemies should be considered, because in addition

to reducing human health risks, fortuitous biological control could significantly reduce *T. absoluta*'s infestations and increase tomato production. Moreover, adoption of sustainable pest management strategies could mitigate environmental damage and increase the diversity of these natural enemies.

### **Conclusion and Recommendation**

Several species of natural enemies have adapted to *T. absoluta* in Kenya. Therefore, there is need to conserve them as a startup of biological control and incorporation in sustainable IPM programs for the pest.

### **Acknowledgement**

The study received financial support from Tuta IPM project-icipc.

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## **Functional properties screening of lactic acid bacteria species from «wômi» in Abidjan (Côte d'Ivoire)**

Toure H., Soro-Yao A.A.\* and Djè K.M.

Food Science and Technology Department, Nangui Abrogoua University, Abidjan, Côte d'Ivoire.

\*Corresponding author's email: amenansoro@yahoo.fr

### **Abstract**

It is now well established that the use of selected strains during fermented products processing could result in a high degree of control over the fermentation process and standardization of the end product. During the screening of the identified species we need to take attention to their technological effectiveness for large-scale production. Probiotics properties are desired technological traits for lactic acid bacteria (LAB) starter cultures. Initial screening for probiotics LAB includes digestive enzymes (e.g. cellulases, amylase, protease, lipase) production in the gastro intestinal tract through in vitro studies.

The ability to use major free sugars of millet and to secrete enzymes of three LAB species isolated from fermented millet dough for «wômi» production in Abidjan (Côte d'Ivoire) were determined. These strains were previously identified and their 16S rDNA sequences are available in the European Nucleotide Archive (ENA, <https://www.ebi.ac.uk/ena>) and the National Center for Biotechnology Information (NCBI, <https://www.ncbi.nlm.nih.gov/nucleotide>) databases with the following accession numbers: UN32 (LT604461), UN47 (LT604462), UN35 (LT604463). The ability to use free sugars was determined in 8 ml MRS broth with sugar (10 g/l) such as glucose, fructose, raffinose, sucrose and lactose as well as chlorophenol red (11 mg/l) as indicator. The ability of the strains to hydrolyze starch, exert proteolytic activity, and hydrolyze cellulosic substrate were performed on MRS agar with 10g/l of starch, skimmed milk and diethyl amino ethyl cellulose (DEAE cellulose), respectively. The strains LT604461 or LT604463 and LT604462 were able to use two and all of the prominent free sugars of millet carbohydrates, respectively.

What does this study conclude ? The strains LT604461 and LT604463 were able to grow either on MRS milk, starch or DEAE cellulose agar without clear zone formation around colonies. The strain LT604462 did not displayed any of the tested activities.

What does this study recommend ? Probiotics potential of LT604461, LT604462 and LT 604463 could not be based on millet free sugars consumption and enzymes (amylase, protease, cellulase) secretion in that assay conditions.

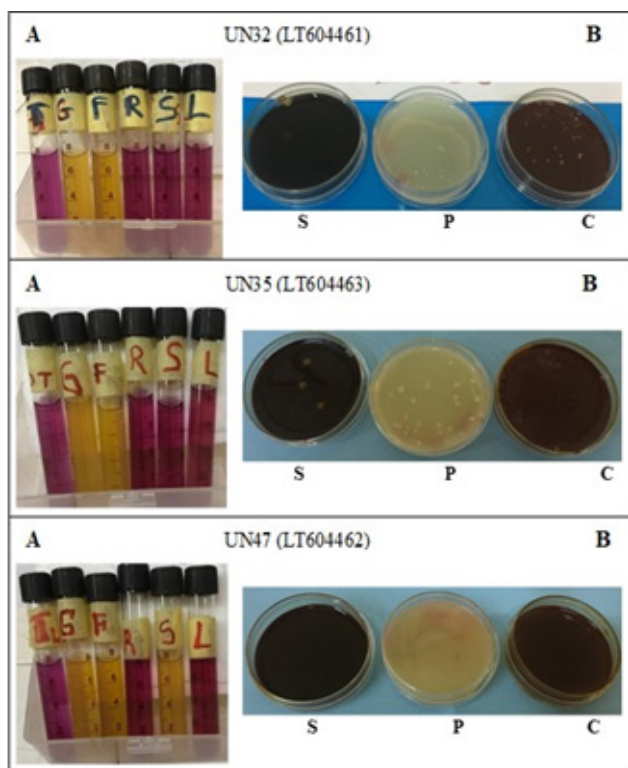
## **Introduction**

Millet (*Pennisetum glaucum*) have a potential for the preparation of healthy foods and are processed into fermented products such as «wômi» in Côte d'Ivoire. Functional food consumption is getting popular as consumers are increasingly becoming aware of the link between nutrition, diet, and health. Health benefits have mainly been reported for lactic acid bacteria (LAB) species called probiotics strains. Probiotics have cell components and secrete functional molecules, such as enzymes, which confer a health benefit to the host. Probiotic-producing enzymes can be evaluated by cultivating candidate strains in culture media supplemented with precursors (e.g., carboxy-methylcellulose, starch, peptone-gelatin, and tributyrin for the activity of cellulases, amylase, protease, and lipase respectively) [1]. Furthermore, the ability of a strain to use prominent free sugars of millet carbohydrates (i.e. glucose, fructose, sucrose) and indigestible sugar such as raffinose could be used for functional property screening of LAB for millet fermentation [2].

Methodology section is missing.

## **Results**

The strains LT604461 or LT604463 and LT604462 were able to use two and all of the prominent free sugars of millet carbohydrates, respectively (Figure 1A). The strains LT604461 and LT604463 were able to grow either on MRS milk, starch or DEAE cellulose agar without clear zone formation around colonies (Figure 1B). The strain LT604462 did not displayed any of the tested activities (Figure 1B).



**Figure 1.** A/Free sugars consumption on MRS broth added with chlorophenol red (T) without sugar, (G) with glucose, (F) with fructose, (R) with raffinose, (S) with sucrose, (L) with lactose and B/enzyme activity on modified MRS agar (S) starch hydrolysis, (P) proteolytic activity (C) DEAE cellulose hydrolysis.

## Discussion

While raffinose and lactose were not fermented by the strains LT604463 and LT604462 in that assay, these sugars were used by the tested strains when API 50 CHL system was used [3,4]. One possible explanation for the absence of raffinose and lactose fermentation by the tested strains could be due to the fact that the activity responsible for the hydrolysis of these sugars is very low to be detected in our assay conditions. In overall, none of the strain displayed starch hydrolysis activity under our assay conditions. These results are in agreement with the previous results reported on starch fermentation when API 50 CHL system was used for the same strains [3].

## **Conclusion and recommendation**

Probiotics potential of LT604461, LT604462 and LT 604463 could not be based on millet free sugars consumption and enzymes (amylase, protease, cellulase) secretion. Tolerance to high acidity and temperature, tolerance to the presence of bile salts, testing of adhesive properties, and production of antimicrobials for pathogen inhibition could be further screened for the characterization of a probiotic candidate.

## **Acknowledgement**

We thank Cherif A. and Koffi K.D. for providing to us data on UN47 and UN32, respectively.

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## **Clarification of Soursop Juice With Cellulase by *Aspergillus niger***

Adesola. A. Ajayi<sup>1</sup>✉, Gbemisola. O. Onipede and Aimalohi, L. Osawemen

<sup>1</sup>Department of Biological Sciences, Augustine University, Ilara-Epe, Lagos State, Nigeria

\*Corresponding author's email: solatutuajayi@gmail.com

### **Abstract**

Food and fruit processing industries use a variety of enzymes to enhance the quality of products as well as reducing the overall production cost. Fresh Soursop fruits were obtained from the Oke Aje local Market in Ijebu Ode, South western, Nigeria. The fruits were peeled, blended and clarified using cellulase. The Cellulase was obtained by a 72h-old-culture of *Aspergillus niger* by submerged fermentation for seven days. Optimum Cellulase activity was obtained at 35oC, pH 4.5 and a substrate concentration of 10mg/ml. The volume of soursop juice from the cellulase-clarified juice was more than that from the control fruits. This research could be very useful for juice processing industries.

### **Introduction**

Soursop is a seasonal and non-durable fruit which is not readily available hence, Soursop has been promoted as an alternative cancer treatment, but clinical studies in humans are lacking (Rady et al., 2018). Soursop is a seasonal fruit which is not always available. The use of enzymes in the clarification of fruit juice clarification because it is a cell wall degrading enzyme. Although there are other microbes capable of synthesizing cellulase but *Aspergillus niger* is one of those can make the freshness of soursop fruit pulp available all year round. *Aspergillus* is a very common mould which has a lot of industrial applications in biotechnology. This is because it has the ability to produce a good number of enzymes. Cellulase is one of such enzyme. It has a lot of uses especially in the juice industries for juice microbes which are generally regarded as safe (GRAS) in the food industries. There is an increase in use of microbial enzymes in industries because they are environmental friendly. The study was therefore carried out to use cellulase by *Aspergillus niger* to clarify Soursop juice.

### **Results**

The crude cellulase by *A.niger* (Plate 1) gave the highest enzyme activity on the fifth day of incubation. Hence, the cellulase produced on day 5 was used for the clarification of soursop juice (Fig. 1 & 2) and characterization of the cellulase. The volume of juice obtained from the

cellulase clarified soursop juice was more than that of water for all the clarification parameters used.

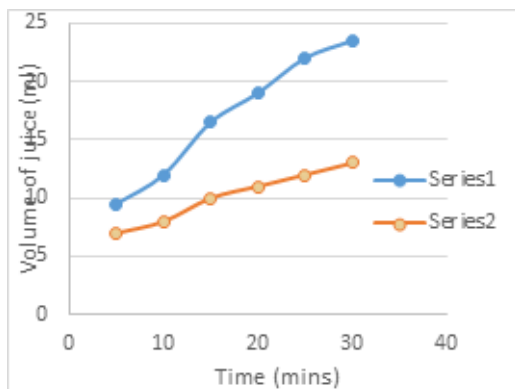


**Plate 1:** *Pure Culture of Aspergillus niger*



**Figure 1:** *Soursop*

Source: <https://hort.purdue.edu/newcrop/morton/soursop.html>



**Figure 2:** *Effect of Incubation Time (25min) on Soursop juice clarification with cellulase by Aspergillus niger*

Series 1 – Cellulase ; Series 2 - Water



## **Discussion**

The results of this investigation revealed optimum cellulase production on the fifth day of incubation under submerged fermentation by *Aspergillus niger*. Umbrin et al. (2012) reported maximum cellulase activity after four days in the solid state fermentation by *A. niger*.

## **Conclusion and Recommendation**

This study established the production of cellulase by *Aspergillus niger* for clarification of soursop juice. Optimal conditions for the cellulase were at a temperature of 35°C, pH 4.5 and substrate concentration of 10mg/ml.

## **Acknowledgement**

The authors of this study acknowledge the efforts of Mrs. K. Adepoju, the laboratory Technologist in the Microbiology Laboratory of the Department of Biological Sciences, Augustine University, Ilara Epe Lagos State, Nigeria.

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## **Analysis of gender knowledge communication in the banana and plantain value chain in Murang'a, Kirinyaga and Embu Counties, Kenya**

Alice Wambura Kaguongo<sup>1\*</sup>, Grace Wamue- Ngare<sup>2</sup> and Mary Mwangi<sup>3</sup>

<sup>1</sup>Kenyatta University, Sociology, Gender and Development Studies Department, Nairobi, Kenya.

<sup>2</sup>Kenyatta University, Sociology, Gender and Development Studies Department, Nairobi, Kenya.

<sup>3</sup>Kenyatta University, Biochemistry and Biotechnology Department, Nairobi, Kenya.

\*Corresponding author's email: wamburakaguongo@gmail.com

### **Abstract**

This study sought to establish the uptake and utilization of gender knowledge in the adoption of new tissue culture banana varieties among men and women stakeholders in Murang'a, Kirinyaga and Embu Counties in Kenya. Plant breeders produce superior crop varieties that promise higher yields, income, resistance to pests and diseases as well as climate change tolerance. However, gender dynamics within value chains quite often lead to a backlash in optimizing benefits from new varieties. The study further sought to establish pathways to gender knowledge communication as well as effective strategies to enhance efficacy of gender knowledge implementation and sharing within the value chains under the "*Climate Smart Banana Project*". This project utilizes a gender responsive participatory approach in introduction of new varieties which are resilient to climate change. The study applied a mixed methods design. Participants sampled included men and women farmers, traders, processors and County Government officials. The preliminary results have revealed that while policy makers and implementers have higher levels of gender knowledge, male and female farmers' knowledge is limited. This dearth is visible especially among men despite the presence of extension officers constantly giving the information. Observably, a breakdown in communication regarding gender knowledge from extension officers to the farmers was found wanting. The study thus recommends a structured, participatory and multi- sectoral approach at county level to offer gender trainings to all stakeholders in the cooking banana and plantain value chains.

### **Introduction**

Bananas are an important source of income for rural, resource poor, smallholder male and female farmers and a staple for urban consumers (Tushemereirwe (1). Their potential to alleviate poverty among rural households has not effectively been exploited. In addition,

production continues to decline due to climate fluctuations, diseases and pests. Tissue Culture cultivars have been introduced to respond to this. Despite their resilience, adoption rates remain low. Specifically, gender blind and biased approaches, rigid local cultures, behavioral factors, and gender norms influence uptake. Plant breeders must therefore engage men and women farmers, social scientists and other users to understand the often invisible factors, needs and preferences in order to enhance uptake of new cultivars (Marimo et al (2)).

## **Methodology**

This was a mixed methods study with respondents being purposively selected. Data was collected through survey, Focus Groups Discussions, observation and Key Informant Interviews.

## **Results**

Gender knowledge levels were found relatively low among men and women banana farmers in the study. Only 26% (12% male; 14% female) of all participants have any gender knowledge. 66% of these have fair levels with 22% being male and 44% female. Observably, County Government officials were found to have higher levels of gender knowledge obtained from trainings from donor- funded projects. It was also noted that there is no gender –specific training within the agricultural value chains targeting County officials or any other. As noted, 55% of the farmers, mostly men, who had any minimal gender knowledge had obtained it from extension officers, hence its scarcity.

It was also noted that men and women implement and share knowledge acquired from agricultural trainings only if it is aimed at increasing production and cutting costs. Such knowledge is freely shared within the family, friends and other farmers irrespective of gender. Observably, while such knowledge is perceived to purposively improve yields, knowledge that seemingly contravenes social norms, in particular gender knowledge is reluctantly shared or not shared at all. While women claimed futility of sharing or even implementing any knowledge that challenges gender norms, men were more hesitant to share similar information especially if it demands full disclosure on specific issues like family budget.

## **Discussion**

Considering that gender relations, determine roles, responsibilities, rights and power dynamics within a household and community, it is important to consider gender central. This is critical

since gender dynamics determine how knowledge is shared between and among men and women. This affects what men and women learn, how they learn, utilize and share gender knowledge. Therefore, there must be deep considerations of local contexts on gender and social differences in order to understand gaps between awareness and utilization of new knowledge. Extension officers, and social networks are considered the major sources of agricultural knowledge Fidelugwuowo (3); Lwoga et al (4). This study however reveals that these have not been efficient in gender knowledge sharing.

### **Conclusion and Recommendation**

In conclusion, communicating gender knowledge is central to adoption of new cultivars. There is therefore need to incorporate it throughout the entire value chain. Gender responsive approaches should be incorporated to bridge the gap between scientific innovations and social factors that deter adoption.

### **Acknowledgement**

This project was supported by the LEAP- Agri, CLISMABAN banana project.

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## **Hours of priming in mature coconut water and seed weight improved juvenile growth phase in soursop**

1Okoli, Nneka Angela, and 2Okocha, Kalu Sunday

1Department of Crop Science and Horticulture

2Department of Food Science

1,2Nnamdi Azikwe University, Awka, Nigeria

Email of corresponding author: na.okoli@unizik.edu.ng

### **Abstract**

Poor seedling emergence and poor juvenile growth phase are major constraints in soursop production. Two hundred and ten (210) observational stands of soursop seedlings were gotten from five (5) seeds of 0.6 - 0.8 g and 0.3 - 0.5 g weights which were primed in mature coconut water at 0, 12, 24, 36, 48, 60 and 72 hours and replicated three times. Juvenile growth phase showed a linear increase as the hours of priming in coconut water increased, peaked at 60 hours of priming and dropped at 72 hours of priming. Dry matter content of heavy seed primed at 60 hours (4.20 g) was higher than dry matter content of light seed primed at 72 hours (1.55 g). These results showed that hours of priming in coconut water and seed weight played crucial roles in juvenile growth phase of soursop in the nursery.

### **Introduction**

Soursop (*Annona muricata*) is a fruit of the Annonaceae family. Soursop is commonly propagated by seeds. Seeds of soursop contain thick black coat which impose dormancy and hinders germination and emergence (Okoli et al., 2020). Seed priming breaks dormancy, promotes early germination, seedling growth and crop yield (Najorda and Rosales, 2019). Coconut water contains growth regulators and has been established as a better alternative for gibberellins and indole acetic acid and encourages vigorous growth and development in plants (Yong et al., 2009). Dada et al., (2019) reported high percentage emergence of *Annona muricata* seeds with increase in the time of soaking in coconut water. Seed weight plays a crucial role in the germination and juvenile growth of soursop because of food reserve content (Okoli et al., 2020). Poor Juvenile growth impairs flowering phase in soursop and subsequently yield (Okoli et al., 2020). Therefore, the objective of the study is to determine the effect of hours of priming in mature coconut water and seed weight on the juvenile growth phase of coconut water.

## Results

### Dry matter content (g)

The result of soursop dry matter content at 9 months after planting (MAP) is presented in figure 1. Soursop dry matter content was significantly ( $P < 0.05$ ) affected by hours of priming, seed weight and interaction of hours of priming and seed weight. Heavy seed primed at 60 hours produced highest dry matter (4.20 g) while light seed primed at 72 hours produced least dry matter (1.55 g).

### Relationship between leaf width, leaf length and root length with soursop dry matter content at 9 MAP

There was a significant ( $p < 0.05$ ) positive correlation between dry matter content and leaf length, leaf width and root length (Table 1). Consequently, increase in dry matter content of soursop seedling could be associated with increase in root length, leaf length and leaf width.

	Root length	Leaf length	Leaf width	Number of leaves
Dry matter	0.90**	0.77*	0.78*	0.64 <sup>ns</sup>

**Table 1:** Simple linear correlation between dry matter content and root length, leaf length and leaf width.

\*Significant at 5% probability level, \*\*Significant at 1% probability level, ns = non significant

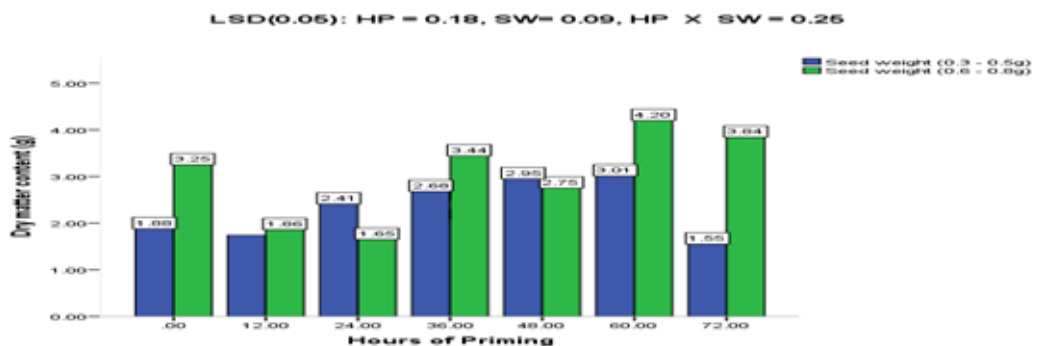


Fig 1: Effect of hours of priming in coconut water and seed weight on dry matter content of soursop seedling

HP = Hours of priming, SW = Seed weight, HP x SW = interaction of hours of priming and seed weight

## **Discussion**

Seed primed in coconut water had overall improved growth and consequently dry matter content. Priming of seeds in growth hormones improved soursop seedling dry weight (Najorda and Rosales, 2019). Higher dry matter content in heavy seeds is related to higher food reserves in the seeds which produced seedlings with thicker stems than those raised from light seeds (Okoli et al., 2020). The significant positive correlation between dry matter content and leaf length, leaf width, and root length could be attributed to the increase in the leaf size and root length. Roots absorb nutrients and water from the soil which are used by the leaves to produce photosynthates that are translocated to the stems, roots and the leaves in the juvenile growth phase (Mbah and Eke-Okoro, 2015).

## **Conclusion and recommendation**

In the study, we highlighted the roles of hours of priming in coconut water and seed weight as a pre sowing treatment and important agronomic factor respectively. Our results revealed that hours of priming in coconut water and seed weight can regulate seedling emergence and juvenile growth in soursop because coconut water contains growth hormone and heavy seed weight contains higher food reserve. Therefore, we recommend that for vigorous juvenile growth phase of soursop, farmers should prime soursop seeds of 0.6 - 0.8 g at 60 hours in mature coconut water.

## **Acknowledgement**

Nnamdi Azikiwe University, Awka, Nigeria is acknowledged for her support of this research work

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## **Coffee Production Enhancement Through Direct Somatic Embryogenesis**

Mayoli, R.N.1,2, Isutsa, D.K.2,3, Nyende, A.B.4 and Mweu, C.M.4

1KALRO-Coffee Research Institute, P. O. Box 4-00232, Ruiru, Kenya

2Chuka University, P. O. Box 109-60400, Chuka, Kenya,

3Egerton University, P. O. Box 536-29115Egerton, Kenya

4Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya

Email: profdorcaski@gmail.com, rosemayoli@yahoo.com

### **Abstract**

Regeneration of plantlets via somatic embryogenesis (SE) is considered pivotal for application of cell culture methods. This research evaluated the response of 'Ruiru 11' Sibs to plantlet regeneration protocol. Experiments were set up at Coffee Research Institute (CRI), Kenya in 2016 and 2017. Explants from field-grown mother plants were harvested, sterilized, cultured, germinated and rooted in culture media containing MS basal salts. Results showed that explants were effectively sterilized using 30% sodium hypochlorite for 20 minutes. Sib 71 best responded to SE and should be used in future for mass propagation of 'Ruiru 11'.

Keywords: Coffee, Ruiru 11 sibs, Somatic embryos, Regeneration

### **Introduction**

Atehnkeng et al [1] reported that not all cultivars are amenable to SE regeneration and/or transformation. This may be due to factors which influence their growth, development and performance in culture. Ruiru 11 is a composite of 66 sibs each derived from a cross between a specific female and male population. The objective of the study was to evaluate responses of selected Sibs to a plantlet regeneration protocol in vitro.

### **Materials and Methods**

The research was done in the CRI laboratories and greenhouses. Eleven sibs used in the study were: sibs 11, 41, 52, 71, 91, 93, 100, 121, 131, 137 and 142. Explants from field-grown mother plants were harvested, cultured, germinated and rooted in culture media containing MS basal salts various hormones as described by Mayoli [2].

## Results

There was significant effect of sodium hypochlorite concentration and time on the number of clean explants (Table 1). Significant differences resulted on the different regeneration parameters tested (Table 2).

## Discussion

Field-grown explants exhibited high contamination attributed to the presence of microbes. Sib 71 best responded to SE and this reinforced the hypothesis by Molina et al [3] that SE is dependent on genotype.

## Conclusion

Field-grown explants were effectively sterilized using 30% sodium hypochlorite for 20 minutes. Sib 71 best responded to SE and should be used for mass propagation of 'Ruiru 11'.

	Sodium hypochlorite concentration		
	20%	25%	30%
Time (minutes)	Clean explants (%)		
20	35.0b*	20b	64.3 a
25	20.7c	11c	36.3b
30	55.3a	30a	14.3c
CV (%)	16.3	16.1	12.1
LSD (0.05)	12.0	6.5	9.3

**Table1.** Sterilization of field-grown Ruiru 11

Sib	Total embryos	Embryogenic cultures (%)	Embryos / explant	Shoot length (cm)	Shoot formation (%)	Root length (cm)	Root formation (%)	Survival (%)
11	3.67f*	11.67g	1.56d	0e	0e	0d	0f	0e
41	4.33ef	13.33g	1.67d	0e	0e	0d	0f	0e
52	0f	0h	0e	0e	0e	0d	0f	0e
71	29c	42.5d	3.44b	1.7a	73.33b	2bc	94.33a	91a
91	0f	0h	0e	0e	0e	0d	0f	0e
93	14d	33.33e	2.44c	1.14c	65c	2.5a	93de	78.3b
121	10.67de	25f	2.24cd	1.25bc	80ab	1.6c	56.33cd	50d
100	25c	50c	2.42c	0.7d	46.67d	1.7c	41.67e	46.7d
131	0f	0h	0e	0e	0e	0d	0f	0e
137	46.33b	63.33b	3.67b	1.32bc	84.25a	2.2ab	63.63c	80b
142	0f	0h	0e	0e	0e	0d	0f	0e
Control	75.33a	73.33a	6.89a	1.37b	85.26a	2.4ab	79.21b	61c
CV (%)	18.7	14.2	21.8	17.5	12.5	24.3	22.3	6.8
LSD (0.05)	8.5	6.23	0.75	0.1842	7.6223	0.42	12.08	3.91

**Table 2:** Induction and regeneration of Ruiru 11 sibs

### Acknowledgement

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## **The contribution of underutilized crops to achieving the Sustainable development Goals (SDGs): A case of Bambara Groundnut (*Vigna Subterranea* (L.) Verdc).**

Onai R. S. Mtengwa<sup>1\*</sup>, Ethel E. Phiri<sup>1</sup>, Pertrus J. Pieterse<sup>1</sup> and Eastonce T. Gwata<sup>2</sup>

<sup>1</sup>Stellenbosch University, Cape Town, South Africa.

<sup>2</sup>University of Venda, Thohoyandou, South Africa.

\*Corresponding author's email: orsmtengwa@gmail.com or 18909507@sun.ac.za

### **Abstract**

Future food and nutrition security requires a paradigm shift especially in the wake of climate change which is expected to increase. Neglected and underutilised crops (NUS) can help to develop more sustainable, diverse and nutritionally sound food systems. Bambara groundnut (BGN) (*Vigna subterranea* (L.) Verdc) is an underutilised legume which is grown at low levels in marginal farming systems throughout sub-Saharan Africa. However, despite emerging research interest due to its positive attributes, it continues to occupy the sidelines of agricultural research and development. Consolidating potentials and recommending a clear strategy for transforming crops such as BGN into conventional agriculture is relevant. With BGN being called an exemplar underutilised legume for resilience under climate change, understanding current production will assess potential and pose a challenge for policymakers, researchers and other stakeholders. Smallholder farmers are estimated to produce four-fifths of the developing world's food and this warrants reviews to evaluate current production practices. Along with the unearthing of indigenous knowledge (IK), a survey conducted in the Limpopo Province, South Africa also suggested that the inclusion of this crop in cropping systems will contribute to the achievement of the Sustainable Development Goals (SDGs).

### **Introduction**

BGN is a source of vital nutrients, and has been termed a 'complete food' [1]. It is climate-smart owing to its ability to fix nitrogen, and to grow under harsh conditions such as poor soils and drought [2]. Despite its remarkable nutritional and agro-ecological qualities, the potential of BGN in improving food systems is still not fully embraced. The utilisation limitations of BGN include the knowledge gap in improved seed system, agronomic practices, processing and utilization [3]. However, for improvement to be facilitated it is important to assess current production practices. Investigating farmers' existing production practices is instrumental in influencing government policies, researchers, breeders, agriculture organisations and

communities in decision making concerning the production of BGN as a future crop for food and nutrition security.

## **Methodology**

A survey was conducted in the Limpopo Province, South Africa in June 2019. One hundred and forty (140) farmers from all five districts of the Limpopo Province of South Africa were interviewed. A mixed-methods approach was used to integrate both qualitative and quantitative data in this study. For quantitative evaluation, a questionnaire was used to understand the regularities in production and utilisation of BGN, while qualitative evaluation explored the in- depth individual perceptions about BGN.

## **Results**

Survey revealed promoters for production of BGN and these form a good basis for development of BGN as a future crop.

## **Discussion**

The farmers' indigenous knowledge of the growth and utilisation of BGN could be used to design effective strategies for food and nutrition security and livelihood improvement.

## **Conclusion and recommendation**

NUS crops like BGN offer potential in the achievement of SDGs addressing social, economic and environmental issues, particularly those of no poverty (SDG1), zero hunger (SDG2), good health and well-being (SDG3), gender equality (SDG5), decent work and economic growth (SDG8), responsible consumption and production (SDG12), climate action (SDG13) and life on land (SDG15).

## **Acknowledgements**

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## **SUB THEME: STEM FIELDS RELATED TO SDGS**

Bacteriology of post-operative wounds and surface swabs from wards and theatre  
Johnstone Amulioto1\*, Margaret W. Muturi1, Scholastica Mathenge1, and Gideon M. Mutua2

1School of Medicine, Kenyatta University, Nairobi, Kenya.

2Mama Lucy Kibaki Hospital, Nairobi, Kenya.

\*Corresponding author's email: jamulioto@gmail.com

### **Abstract**

Despite surgical site infection being a problem in Kenya, little is known about the implicated pathogens and their antibiotic susceptibility profiles. This study sought to determine the prevalence and antibiotic susceptibility patterns of bacteria isolated from the wards, operating room, and post-operative wound infections at Mama Lucy Hospital. This was a cross-sectional descriptive study for 6 months. A total of 126 samples were collected. Of these, 58 came from surgical wound infections, and 68 were obtained from predefined areas of the wards and operating room of the facility. The samples were processed through Gram reaction, culture, biochemical tests, and antibiotic susceptibility tests. Statistical work was through a statistical package for the social sciences version 20. A total of 137 bacteria were isolated, 78 of these came from the wounds while 59 were recovered from the hospital surface swabs. The preponderant wound bacteria was *Staphylococcus aureus* 28.2% followed by *E.coli* 15.4%. The main contaminant for the wards and operating room was *Staphylococcus aureus*. The wound isolates were sensitive to Chloramphenicol 69.2%. Whereas the environmental bacteria had 93.2% sensitivity to Chloramphenicol. The most prevalent wound bacteria was *Staphylococcus aureus*, while Chloramphenicol was seen as the best drug for treating SSI at the hospital. The facility, therefore, needs to identify the most frequent bacteria associated with SSI. In addition, they need to monitor the bacteria that frequently contaminate the wards and operating room. Keywords: surgical site infections, hospital environment, susceptibility, bacteria

### **Introduction**

Despite surgical site infection being a problem in Kenya, little is known about the implicated pathogens and their antibiotic susceptibility profiles. Also, limited literature on pathogens residing in our healthcare environments exists.

## Methods

The sample size was determined using Fischer et al (1998) formula and later reduced using the finite population correction formula for proportions. Where  $N/n$  = sample size,  $n_0$  (original sample size),  $P = 50\%$ ,  $d =$  precision (5%), and  $Z = 1.96$ . Taking into account the number of surgical wound infections seen prior (68). The reduced sample size ( $n$ ) was 58 and in addition to 68 predefined surface swabs taking the number to 126 samples.

$$N = (Z^2 P(1-P)) / d^2$$

$$n = n_0 / (1 + ((n_0 - 1) / N))$$

$$384 / (1 + ((384 - 1) / 68))$$

## Results

The majority of the wound isolates were Gram-negative rods (Table 1). For environmental isolates, Staphylococcus and Bacillus species were predominant across the areas evaluated.

Bacterial Groups	Female 39(67.2%)	Male 19(32.8%)	Total 58 (100%)	P-value (0.136)
Gram-positive bacteria	27 (34.6%)	6 (7.7%)	33 (42.3%)	
Gram-negative bacteria	30 (38.5%)	15 (19.2%)	45 (57.7%)	
<b>Total</b>	<b>57 (73.1%)</b>	<b>21 (26.9%)</b>	<b>78(100%)</b>	

**Table 1.** Prevalence of bacteria within gender

Bacterial groups Female 39(67.2%)

Male 19(32.8%)

Total 58 (100%) P-value (0.136)

Gram-positive bacteria 27 (34.6%) 6 (7.7%) 33 (42.3%)

Gram-negative bacteria 30 (38.5%) 15 (19.2%) 45 (57.7%)

Total 57 (73.1%) 21 (26.9%) 78(100%)



## Discussion

In the present work, *Staphylococcus aureus* was seen as the prevalent wound isolate. These results were in harmony with those of Bastola et al [1]. However, the work of Nwankwo et al [2] found *E.coli* as the main surgical wound bacteria. The isolated bacteria are mostly skin or enteric bacteria, as a result, the difference can be ascribed to the type of surgical procedure.

## Conclusion and Recommendation

The most prevalent SSI bacteria was *Staphylococcus aureus*, while Chloramphenicol was seen as the best drug for treating SSI at the hospital.

The facility, therefore, needs to identify the most frequent bacteria associated with SSI. In addition, they need to monitor the bacteria that frequently contaminate the wards and operating room.

## Acknowledgment

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Cutaneous Leishmaniasis in Sri Lanka: Analysis of Epidemiological Profiles

BHAGYA DEEPACHANDI<sup>1\*</sup>, SUDATH WEERASINGHE<sup>1</sup>, KALMI SIRIDEWA<sup>1</sup>, SHREENIKA DE S. WELIANGE<sup>2</sup> AND YAMUNA SIRIWARDANA<sup>1</sup>

[1] Department of Parasitology, Faculty of Medicine, University of Colombo, Colombo 00800, Sri Lanka.

[2] Department of Community Medicine, Faculty of Medicine, University of Colombo, Colombo 00800, Sri Lanka.

\*Corresponding author's email: [deepachandi@gmail.com](mailto:deepachandi@gmail.com)

## **Abstract**

Cutaneous leishmaniasis (CL) is the major clinical presentation of human leishmaniasis in Sri Lanka and caused by a genetically distinct parasite of visceralizing *Leishmania donovani*. CL caused by dermatotropic *L. donovani* has been reported from few other endemic settings also, e.g., Asia, Africa and some Mediterranean countries (e.g., Turkey, Tunisia). Sri Lanka reports a large epidemic among them. Different socio-demographic characteristics, micro-changes within the disease profile and biannual seasonal variations were reported in recent studies. Here we further analyzed clinico-epidemiological patterns over different regions of the country. Confirmed CL patients were selected (n=600) to represent different disease foci in the country, i.e., Northern, Southern, North-Western, Central and Western foci. Clinico-epidemiological features of CL were analyzed in relevant to likely place of disease acquired or residence of each case. Statistical analysis was carried out using SPSS package. A set of 14 clinico-epidemiological markers were identified and they are further useful for field screening with high predictions power. Those markers included age, sex, lesion onset, lesion number, lesion duration, lesion size, lesion site, lesion type, lesion color, lesion edge, lesion margin, surface scaling in nodules, dry/moist ulcers and surrounding skin. Analysis revealed two major, different disease transmission profiles in Northern and Southern regions of the country. Those were independent and long existed. Findings further indicated a parasitic etiology and further in-depth genetic characterizations are required to identify existence of different sub-species/sub-strains within the country. All these findings are important for clinical screening, clinical management and disease control activities in Sri Lanka.

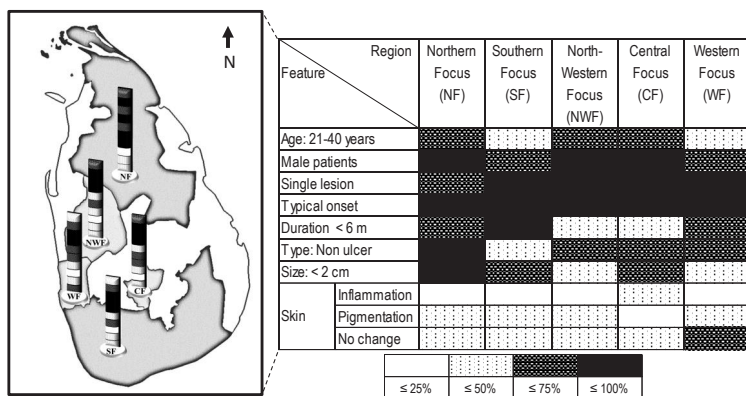
## **Introduction**

Human leishmaniasis is a globally important disease and has been recently categorized as a neglected tropical disease (NTD) by World Health Organization (WHO). The disease is found in parts of the tropical and subtropical region in the world and Southern Europe. It is especially common in low-income populations in developing regions of Africa, Asia and America. Human leishmaniasis is a vector-borne parasitic disease with major clinical forms of cutaneous (CL), muco-cutaneous (MCL) and fatal visceral (VL) infections. Majority of local cases represents CL caused by visceralizing *Leishmania donovani* (Siriwardana et al [1]). Recent clinico-epidemiological analyses of CL patients presented over 1.3 decades in the country revealed novel information (Siriwardana et al [2]). Different socio-demographic characteristics,

micro-changes within the disease profile and biannual seasonal variations were reported (Siriwardana et al [2]). Also, major disease reporting areas still remain confined to Northern and Southern disease foci (Siriwardana et al [2]). Early case detection and treatment are highly recommended for *L. donovani* control due to absence of animal reservoirs in *L. donovani* transmission. In depth information on clinico-epidemiological profiles facilitates clinical screening, clinical management and disease control activities within the country. This study described the clinico-epidemiological patterns over different regions of Sri Lanka.

## Results

Figure 1 demonstrates preliminary analysis of variation of selected clinico-epidemiological features over different disease foci within the country. In depth analysis of data indicated two major patterns of clinico-epidemiological profiles within the country which were independent, long existed and propagated within Northern and Southern regions over the time. Also majority of patients in Northern region presented with slow progressing and non-ulcerative lesions, while majority in Southern region presented with rapid progressing and less non-ulcerative lesions. Among the different clinico-epidemiological characteristics associated with CL, 14 major clinical markers were identified which are useful for field case detection with high prediction power. Those included age, sex, lesion onset, lesion number, lesion duration, lesion size, lesion site, lesion type, lesion color, lesion edge, lesion margin, surface scaling in nodules, dry/moist ulcers and surrounding skin. Further analysis indicated that North-Western and Central foci were more similar to Northern focus while Western focus showed mixed characteristics of both Northern and Southern foci.



**Figure 1:** Preliminary analysis of variation of selected clinico-epidemiological features in Sri Lanka.

## **Discussion**

Consideration of different socio-demographic and clinical characteristics revealed evidence for presence of two major disease transmission foci in Sri Lanka. Region based differences further provide clues for presence of different sub-species/sub-strains within the country. Further genetic characterization of local parasite will be useful to confirm those possibilities. Although Western foci is considered as a non-endemic region for the disease and having less prevalence of leishmaniasis, presence of similar characteristics highlighted that disease is spreading within the country.

## **Conclusion and recommendation**

This study provided insight into region based differences in the epidemiological profiles of CL in Northern and Southern Sri Lanka. Differences observed in the regions may be useful in clinical screening and management of patients. Further studies are recommended to identify the underlying reasons.

## **Acknowledgement**

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## **Drinking Groundwater Quality Index Evaluation In Nakuru Town**

Margaret Mwikali Keli<sup>1</sup> , Dr. Thomas Mutuku Munyao<sup>2</sup> , Prof. Eng. Emmanuel C. Kipkorir<sup>2</sup>

1. University of Eldoret, P. O. Box 1125 – 30100, Eldoret, Kenya, mwikalimaingi@gmail.com.

2. University of Eldoret, P. O. Box 1125 – 30100, Eldoret, Kenya, munyaothomas@gmail.com.

2. Moi University, P. O. Box 3900 – 30100, Eldoret, Kenya, ekipkorir@mu.ac.ke

\*Corresponding author's email: mwikalimaingi@gmail.com - 0721288237

### **Abstract**

In water quality monitoring practices, limitations associated with the conventional methods hinders' development of a robust database that can represent quality status of a drinking water supply system in a reliable way. The study aimed at determining the quality status of groundwater for drinking uses in Nakuru Municipality and exploring the applicability of CCME-WQI (Canadian Council of Ministers of the Environment Water Quality Index technology in analysis and interpretation of the water quality data. Analytical values of electrical conductivity, pH, selenium, cadmium, chloride and fluoride were used in calculation of the index values based on the CCME-WQI framework. The sampling sites composed of 23 boreholes. Water samples were collected for three hydrological/seasons (transition, short rain and dry period) (June, 2014 to March, 2015) and analyzed using standard procedures, CCME-WQI and descriptive statistical methods. Examined borehole water of the area was found to be fresh in pH, chloride and electrical conductivity but contaminated in selenium, cadmium and fluoride in line to WHO, 2011 and NEMA, 2006 standards for drinking water. Based on the CCME-WQI, index values for drinking water quality of groundwater samples were calculated in a range of 29.83 to 37.71 with an average value of 33.77 and ranked as poor in regard to drinking uses. Selenium, cadmium and fluoride were taken as important parameters impacting water quality as their concentrations were elevated. The study concludes that borehole water quality is poor, not potable and need proper treatment before use.

**Keywords:** Drinking water quality, CCME-WQI, statistical methods, Nakuru Municipality

### **Introduction**

Ensuring the safety of drinking water is a growing problem. The issue necessitates application of appropriate methods that can create a data base on overall quality of drinking water over a range of spatiotemporal scales and changing environmental pressures for safe drinking

water supply operation and management (Akter, 2016). However, traditionally, water quality monitoring and analysis are limited to conventional methods that do not provide robust historical datasets for further exploration to extract useful information on overall status of drinking water quality and its time-space dimensions (Cude, 2001). Given this limitations, there is need to explore possible solutions using existing technologies like WQI to provide viable alternatives in drinking water quality data evaluation. Around the world, the importance of the water quality index has emerged through providing acceptable information on water quality conditions of water bodies. The CCME-WQI model is a widely used and globally accepted model for assessing water quality. For the study area, published work on application of CCME-WQI technologies in evaluating suitability of groundwater for drinking uses does not exist. The CCME-WQI model has been adopted in this study as an alternative method to evaluate and classify the areas drinking water quality status from selected sources based on selected parameters and three seasons.

## Results

To evaluate the average water quality for drinking, analysis was based on determining the integrated influence of the observed parameters and integration of the three index periods (transition period, short rain period and the dry period).

$$\text{Equation: CCME-WQI} = 100 - \frac{(\sqrt{(\sum 12 + \sum 22 + \sum 32)} + 1.732)}{\quad} \quad (\text{CCME, 2001}).$$

For the 23 sampled boreholes, index values by CCME-WQI method were calculated and ranged from 29.83 to 37.71 with an average value of 31.05 and ranked poor in regard to drinking uses.

## Discussion

The results showed that generally the quality of water from the examined boreholes is poor as per the standards of drinking water (WHO, 2011; CCME, 2001). The levels of chloride, pH and electrical conductivity remained within the required guideline value while fluoride, selenium and cadmium had elevated levels. Based on the combined influence on the overall water quality parameters, selenium, cadmium and fluoride were taken as important parameters in rating of the water quality as their concentrations exceeded the objective (permissible limits for drinking water as per WHO, 2011).

## **Conclusion**

Overall, the results of the calculated WQI values based on the observed water quality parameters indicate that borehole water from the examined sites are not potable and need proper treatment before use.

## **Acknowledgement**

The study was not funded.

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## **Cardioprotective Potentials of Diet Supplemented with Parkia Biglobosa Roasted Seeds on Isoproterenol-induced Cardiotoxicity in Wistar Rats**

Adetoun E. Morakinyo<sup>1</sup>✉, Samuel C. Nzekwe<sup>2</sup> and Temitope. A. Oyedepo<sup>3</sup>

<sup>1</sup>Department of Biochemistry, Adeleke University, Ede, Nigeria.

<sup>2</sup> Department of Biochemistry, Adeleke University, Ede, Nigeria.

<sup>3</sup> Department of Biochemistry, Adeleke University, Ede, Nigeria.

\*Corresponding author's email: adetounadejumobi05@gmail.com

### **Abstract**

The incidence and prevalence of metabolic diseases which include cardiovascular diseases (CVDs) have increased worldwide in the last three decade. Recently, attention has been focused on phytochemicals derived from different plant species as potential therapeutic agents in the prevention and management of CVDs. The purpose of this study was to investigate the cardioprotective potentials of diet supplemented with *P. biglobosa* roasted seeds on isoproterenol-induced cardiotoxicity in Wistar rats. The findings of the study revealed that the seed extract of *P. biglobosa* contained an appreciable quantities of phytochemicals. There was no significant difference in the activities of creatinine kinase myocardial band (CK-MB), lactate dehydrogenase (LDH) and the concentration of high density lipoprotein cholesterol (HDL-c) in the group pre-treated with *P. biglobosa* supplemented feed when compared cardiac control group. However, a significant decrease was observed in the activity of (aspartate aminotransferase) AST and the concentration of total triglycerides (TG) and total cholesterol (TC) in the group pre-treated with *P. biglobosa* supplemented feed when compared with the cardiac control (cardio-toxic group). The study suggested that *P. biglobosa* could be capable of reducing hyperlipidemia which is a risk factor for CVDs. Further study is required to identify the bioactive compounds in the plant.

**Keywords:** Cardioprotective, cardiotoxicity, *Parkia biglobosa*

### **Introduction**

CVDs are the number one cause of death globally. An estimated 17.9 million people died from CVDs in 2016, representing 31% of all global deaths WHO [1]. According to the World Health Organization (WHO), more than 80% of the world population uses traditional medicine to cope with health problems WHO [2]. Hence this study was carried out.



## Results

Phytochemicals	Composition
Tanin (%)	0.998
Cardiac glycoside (%)	1.195
Saponin (%)	4.87
Alkaloids (%)	14.892
Flavonoid (QE/g)	175.5 ± 1.50
Total Phenolics (TAE/g)	328.5 ± 2.50

**Tables 1.** Phytochemical composition of seed extract of *P. biglobossa*

Group	CK-MB (U/L)	LDH (U/L)	AST (U/L)	TRIG (mg/dl)	CHOL (mg/dl)	HDL (mg/dl)
Control	4.337 ± 0.613	16.40 ± 7.521	131.20 ± 0.924	85.05 ± 3.911	78.70 ± 1.443	0.166 ± 0.001
Cardiac control	4.083 ± 0.783	16.64 ± 1.459	183.8 ± 8.737 <sup>a</sup>	155.7 ± 2.813 <sup>a</sup>	113.8 ± 1.135 <sup>a</sup>	1.215 ± 0.003 <sup>a</sup>
ISO + Propanalol	4.400 ± 0.550	15.93 ± 2.009	83.77 ± 16.28 <sup>ab</sup>	114.40 ± 2.91 <sup>ab</sup>	100.80 ± 5.531	1.105 ± 0.009 <sup>ab</sup>
ISO + <i>P. biglobossa</i> <i>a</i>	5.500 ± 0.550	14.81 ± 0.053	108.30 ± 9.726 <sup>ab</sup>	129.9 ± 8.163 <sup>ab</sup>	84.86 ± 2.534 <sup>c</sup>	0.203 ± 0.027 <sup>ab</sup>

**Table 2:** Effect of diet supplemented with *P. biglobossa* roasted seeds on cardiac biomarkers and lipid profile of isoproterenol-induced cardiotoxicity in wistar rats

Each value represented Mean ± SEM (n=5). Value of p <0.05 was considered significant. The values across column with superscript (a) implied significant difference from control while (b) implied significant difference from cardiac control.

## Discussion

The cardiac biomarkers: CK-MB, LDH and AST are fundamental parameters for detecting cardiotoxicity. The activities of these biomarkers were elevated in the plasma of isoproterenol-induced cardiotoxicity group. This is due to leakage of the enzymes from the heart into the blood as a result of membrane degradation and disruption of cardiac muscle cells. The ability of the diet supplemented with *P. biglobossa* (25 %) to significantly reduce the activity of AST may be attributed to the active principles including polyphenols, tannins, saponins, alkaloids

contained in the plant which probably help to maintain membrane integrity, thereby limiting the leakage of these enzymes. The elevation of total cholesterol and triglycerides plasma levels in the cardiac control group indicate isoproterenol may be interfering with biosynthesis or metabolism of lipids. The lipid-lowering effect of this plant may be due to the secondary metabolite that can bind with bile acids to increase their excretion, inhibit hepatic cholesterol biosynthesis and inducing lipoprotein lipase. This result is in agreement with the findings of Tesfaye et al [3] and Epure et al [4].

### **Conclusion and Recommendation**

The administration of diet supplemented with *P. biglobosa* seed to ISO-induced cardiotoxicity in rats caused a significant decrease in AST level and ameliorated lipid profile perturbation in the Isoproterenol- induced cardiotoxicity in rats. This may be attributed to the presence of phytochemicals present in the seed. However, further study is recommended to identify the bioactive compounds in the seed.

### **Acknowledgement**

We acknowledged the teaching and research Laboratory, Adeleke University, Ede, Nigeria for providing facility for this study.

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## **Sero-prevalence of Leishmaniasis in Sri Lanka: A Method Comparison Study**

Bhagya Deepachandi<sup>1\*</sup>, Kalmi Siridewa<sup>1</sup>, Sarfaraz Ejazi<sup>2</sup>, Anirban, Bhattacharyya<sup>2</sup>, Nahid Ali<sup>2</sup>,  
Preethi Soysa<sup>3</sup> and Yamuna Siriwardana<sup>1</sup>

<sup>1</sup>Department of Parasitology, Faculty of Medicine, University of Colombo, Colombo 08, Sri Lanka.

<sup>2</sup>CSIR-Indian Institute of Chemical Biology, Kolkata, India.

<sup>3</sup>Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Colombo, Colombo 08, Sri Lanka.

\*Corresponding author's email: deepachandi@gmail.com

### **Abstract**

We recently developed and validated a crude parasite antigen based enzyme linked immunosorbent (ELISA) assay for detection of cutaneous leishmaniasis (CL) caused by *Leishmania donovani* in Sri Lanka. In current study, we further compared in-house ELISA with other established serological tools of leishmaniasis in the world which was important to identify better diagnostic tools for field case detection and identify antigen variation of closely related species of the *Leishmania* genus. Sero-positivity of confirmed CL cases (n=100) was analyzed. Sero-positivity observed by In-house ELISA was further compared with direct agglutination test (DAT/ Institute of Tropical Medicine, Belgium), Indian dipstick test (Indian Institute of Chemical Biology, India) and rK39 strip test (InBios, USA). Performance of each test was assessed using specific parameters, sensitivity and specificity. Agreement between performances of each test was further evaluated using Kappa index value according to standard methods. Statistical analysis was carried out using SPSS v25.0. In-house ELISA showed a high sero-positivity of 81.0% (n=81/100) compared to other three tests. DAT, Indian dipstick test and rK39 showed sero-positivity of 57.5%, 22.0% and 15.0% respectively. According to Kappa index value, there was no perfect agreement between tests and only a slight agreement was observed. Less sero-positivity observed with established tools highlighted the importance of developing local parasite based assays. This study also highlighted possible antigenic variations between closely related *Leishmania* strains used for producing the described tests which should be confirmed using further in-depth studies.

## Introduction

Sri Lanka is an atypical focus of cutaneous leishmaniasis in Indian subcontinent and reports the world's largest outbreak of leishmaniasis caused by a genetically distinct, dermatotropic strain of *Leishmania donovani*. It is usually a visceralizing parasite and caused fatal VL in other endemic settings. Therefore, sero-prevalence studies are important to understand the immunogenic nature of the local causative agent. High sero-prevalence associated with *L. donovani* induced cutaneous leishmaniasis (CL) was recently reported by us for the first time in the world (Deepachandi et al [1]). However, visceralizing potential of local parasite is yet to be confirmed by further in-depth studies. Based on the findings, we further developed and validated an in-house ELISA for detection of local CL (Deepachandi et al [1]). Also detection of asymptomatic cases is important as highlighted by leishmaniasis elimination programs. They may contribute to spread the disease in endemic settings. Identification of a better tool for field case screening is required in such a situation. Therefore, we further compared locally developed in-house ELISA with other established serological tools used in other leishmaniasis endemic settings in the world. Those were direct agglutination test (DAT) developed by Institute of Tropical Medicine, Antwerp, Belgium, Indian dipstick test developed by Indian institute of Chemical Biology and rK39 strip test which is commercially available from InBios International, Inc., USA. Further, DAT is prepared based on Sudanese *L. donovani* 1S strain, Indian dipstick test is prepared based on Indian *L. donovani* AG83 strain and rK39 test is prepared based on *L. chagasi* strain (Sundar et al [2], Jacquet et al [3], Saha et al [4]). Therefore, current study further allowed identification of possible existence of antigenic variations between closely related *Leishmania* species.

## Results

A high sero-positivity was observed with in-house ELISA (81.0%, n=81/100) compared to other three tests. Among other tests, DAT showed a high sero-positivity of 57.5% compared to sero-positivity observed in Indian dipstick test (22.0%) and rK39 strip test (15.0%). Also among sero-negative cases by in-house ELISA, DAT showed a high sero-positivity of 44.4% compared to other two tests. Established tests showed only a slight agreement with in-house ELISA. Clinical characteristics of patients positive by each test were different. Majority of ELISA positive group were from Southern part of the country and presented with late, single, large and ulcerative lesions. DAT showed high sero-positivity in patients with single and large lesions while Indian dipstick test showed high sero-positivity in late lesions. Patients presented from Northern

part of the country with large and multiple lesions showed high sero-positivity with rK39 test. According to further comparisons of test cost per patient, DAT was about 5.5 USD while Indian dipstick test, rK39 test or in-house ELISA each were about 3.0 USD.

## **Discussion**

Study provided evidence for applicability of in-house ELISA for local case detection due to high sero-positivity rates observed with local assay. Less sero-positivity observed by other established tests may be due to antigenic heterogeneity of *Leishmania* parasites, variability of antigenicity in different populations, combination of environmental and genetic factors or other specific situations, e.g., asymptomatic or immunosuppressed cases as described in other leishmaniasis endemic settings in the world (Zijlstra et al [5]). According to sero-positivity obtained by each test, DAT can be considered as an alternative test when in-house ELISA is negative or not available. However, further analysis with a large number of samples is required to confirm this possibility.

## **Conclusion and Recommendation**

Due to possible geographical differences of *Leishmania* parasite species, identification of local parasite based serological tests is important to increase diagnostic accuracy. Further in depth method comparison studies using a large number of samples are recommended. Also, further analysis of antigens of local parasite using immuno-proteomic approaches will enhance performance of local assay.

## **Acknowledgement**

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## **Polymorphism in the LDL-receptor gene and its association with lipid levels in an African population**

Taona Emmah Mudhluli<sup>1</sup>, Danai Tavonga Zhou<sup>2</sup>, Hilda Matarira<sup>1</sup>

<sup>1</sup> Department of Laboratory Diagnostic and Investigative Sciences, Chemical Pathology Unit,  
University of Zimbabwe

<sup>2</sup> Department of Laboratory Diagnostic and Investigative Sciences, Medical Laboratory Unit,  
University of Zimbabwe

Corresponding Author's email Address: taonaemmah@gmail.com

### **Abstract**

Background: Antiretroviral therapy (ART) has made HIV a chronic manageable disease, though inter-individual differences brought by genes need investigations.

Statement of the problem: The low density lipoprotein receptor (LDL-R) gene has been associated with differences of serum levels in individuals, few studies have looked into the single nucleotide polymorphism (SNP) of the LDL-R Ava II.

Justification: To reduce the risk of coronary heart disease (CHD) in HIV patients it is necessary to examine the several different SNP of the LDL-R in this study it's the Ava II.

Objective: The objective of the study was to demonstrate if there is an association between, Ava II SNP of the LDL-R gene and dyslipidemia in Zimbabwe HIV patients.

Results: Both genotypes were associated with significantly high levels of total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) in ART experienced patients.

Discussion: Studies have shown that individuals with the mutant allele exhibit plasma cholesterol concentrations that are elevated twofold or more above normal concentrations, this was not true for this study

**Conclusion and Recommendations:** There was no association between, Ava II SNP of the LDL-R gene and dyslipidemia in Zimbabwe HIV patients, hence there is no need to monitor the SNP.

## **Introduction**

Several SNPs of the LDL-R gene have been associated with inter-individual differences in serum cholesterol levels. The objective of the study was to investigate if there is an association between, Ava II SNP of the LDL-R gene and dyslipidemia in Zimbabwe HIV patients.

## **Method and Materials**

A total of 150 HIV infected patients, 105(70%) female and 45(30%) males were recruited in the study. Fifteen(10%) were ART-naïve patients, 117(78%) were on efavirenz based ART for 6-120 months and 18(12%) were on efavirenz based ART for 121-240 months. Lipid profiles were measured using an enzymatic assay. The Ava II SNP of the LDL-R gene was amplified using polymerase chain reaction and genotyped using restriction fragment length polymorphism combined with gel electrophoresis.

## **Results**

According to this study, the thiamine/thiamine (T/T) genotype was the most common genotype in Zimbabwe with 117 (78 %) of the study population, whilst the cytosine/cytosine (C/C) was least common with 7(5%) the remaining 26(17%) being heterozygous with both thiamine/cytosine (T/C) genotypes. The allelic frequency of Ava II SNP of the LDL-R was 82% (T) and 18% (C) respectively. Both genotypes were associated with significantly high levels of TC and LDL-C in ART experienced patients.

## **Discussion**

Studies have proven that the Ava II genotype is highly diverse in different populations, a South African study reported the C allelic frequency of 17% Zyl et al, [1] hence. Furthermore, it is said individuals with this mutation exhibit plasma cholesterol concentrations that are elevated twofold or more above normal concentrations, this was not true for this study. Those taking ART for 121-240 months, despite their genotypes, had very high TC levels compared to other groups, this was in agreement with earlier studies that reported increases in levels TC and LDL-C with ART.



## **Conclusion and Recommendation**

A positive correlation between ART duration and, TC was reported in this study in patients with both the wild type and mutant allele of the LDL-R Ava II gene. Hence, there is no association between, Ava II SNP of the LDL-R gene and dyslipidemia in Zimbabwe HIV patients

## **Acknowledgements**

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## **Diarrheagenic *Escherichia coli* isolated from fecal baboon samples**

Jael Obiero<sup>1\*</sup>, Ronald Ngetich and Kenneth Kariuki Waititu

<sup>1</sup>Department of Reproductive Health and Biology. Institute of Primate Research, Karen, Nairobi, Kenya

<sup>2</sup>Center for Microbiology Research, Kenya Medical Research Institute. Nairobi, Kenya

<sup>3</sup>Animal Sciences Department. Institute of Primate Research, Karen, Nairobi, Kenya

Corresponding author's email: jaelobiero@gmail.com

### **Abstract**

*Escherichia coli* is a normal inhabitant of the mammalian gut, but it also exists in a number of pathogenic forms. Diarrheagenic *E. coli* constitute pathotypes that are responsible for fatal infections in humans. Increasing contact between humans and non-human primates provides an opportunity for the transfer of potential pathogens between host species. This study aimed to isolate and characterize diarrheagenic *E. coli* pathotypes from captive and free ranging olive baboon faecal samples. Four *E. coli* pathotypes including Enterotoxigenic, Enteropathogenic, Enterohaemorrhagic and Enteroinvasive were detected from baboon faecal samples. Olive baboons harbour *E. coli* pathotypes and could be a potential source of zoonoses. Pathotype proliferation in the non-human primates is a potential threat to human health. An enhanced understanding of existence of pathotypes in these animals is critical not only to maximize and maintain human health but also to shape the understanding of disease and to foster new preventive and therapeutic approaches.

### **Introduction**

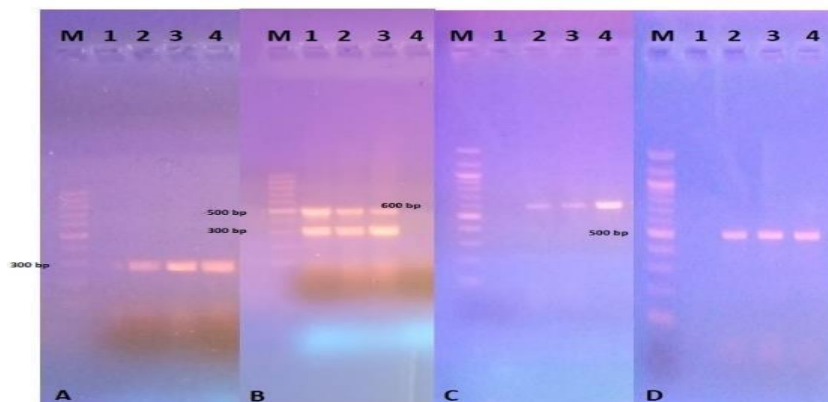
*Escherichia coli* is a normal inhabitant of the mammalian gut, but it also exists in a number of pathogenic forms. Diarrheagenic *E. coli* (DEC) constitute pathotypes that are responsible for fatal infections in humans. Six strains associated with DEC include: enterotoxigenic *E. coli* (ETEC), enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC), enterohaemorrhagic *E. coli* (EHEC), enteroaggregative *E. coli* (EAEC) and diffusely adherent *E. coli* (DAEC) have been characterized based on pathognomic virulence factors they produce [1]. Increasing contact between humans and non-human primates (NHPs) provides an opportunity for the transfer of potential pathogens between host species. This study aimed to characterize DEC pathotypes isolated from fecal samples of captive and free ranging baboons.

## Results

Four *E. coli* pathotypes including ETEC, EPEC, EHEC EIEC were detected from baboon faecal samples. The most prevalent pathotypes were enterotoxigenic (14.5%) and atypical enteropathogenic (14.5%) in the captive and the free- ranging respectively. However, the observed differences in the pathotype detection were not significant ( $p>0.05$ ). Enteroaggregative and diffusely adherent *E. coli* were not detected from any of the study samples (Table 1). Virulence genes representing the four DEC pathotypes detected in this study included *elt* for ETEC (Figure 1A), *eae* and *bfp* genes for EPEC (Figure 1B), *ipaH* for EIEC (Figure 1C), and *stx1&2* (VTcom) for EHEC (Figure 1D).

Pathotype	Number (%) of pathotype isolated	
	Captive (n*=62)	Free ranging (n*=62)
Enterotoxigenic <i>E. coli</i>	9 (14.5%)	1 (1.6%)
Typical Enteropathogenic <i>E. coli</i>	1 (1.6%)	5 (8.1%)
Atypical Enteropathogenic <i>E. coli</i>	2 (3.2%)	9 (14.5%)
Enterohaemorrhagic <i>E. coli</i>	2 (3.2%)	0
Enteroinvasive <i>E. coli</i>	1 (1.6%)	3 (4.8%)
Enteroaggregative <i>E. coli</i>	0	0
Diffusely adherent <i>E. coli</i>	0	0

**Table 1:** *E. coli* pathotypes isolated from captive and wild olive baboon fecal samples



**Figure 1.** Agarose gel electrophoresis showing virulence genes detected

## Discussion

Some strains of *E. coli* have evolved by acquisition of virulence encoding genes through

horizontal gene transfer resulting in highly pathogenic forms of this bacteria capable of causing diverse intestinal and extra intestinal infections.<sup>5</sup>

DECs as enteric pathogens are responsible for fatal infections in humans, and have been isolated from different NHPs

except baboons [2]. Considering that there is increased contact between humans and NHPs due to different anthropogenic activities like farming, fragmentation and logging presence of DECs in these hosts poses a high risk of zoonotic transmission that could result in escalated morbidity and mortality.

### **Conclusion and Recommendation**

Olive baboons harbour diarrheagenic *E. coli* pathotypes hence could be an important source of DEC infection to humans who come into contact with their fecal materials by virtue of occupation or anthropogenic activities. Wildlife such as NHPs should be handled with care to reduce potential risk zoonoses. Strategies to limit transmission of pathogens between human and NHPs would benefit both human and primate conservation

### **Acknowledgement**

We acknowledge the Institute of Primate Research for supporting this study.

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## **A Sensitive Tool for Molecular Detection of Leishmania Parasites**

Bhagya Deepachandi<sup>1\*</sup>, Sudath Weerasinghe<sup>1</sup>, Kalmi Siridewa<sup>1</sup>, Preethi Soysa<sup>2</sup> and Yamuna Siriwardana<sup>1\*</sup>

<sup>1</sup>Department of Parasitology, Faculty of Medicine, University of Colombo, Colombo 00800, Sri Lanka.

<sup>2</sup>Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Colombo, Colombo 00800, Sri Lanka.

\*Corresponding author's email: deepachandi@gmail.com

### **Abstract**

Sri Lanka is a recent focus of human leishmaniasis in Indian Subcontinent and reports a large outbreak of cutaneous leishmaniasis (CL) caused by *Leishmania donovani*. Few cases of other forms of leishmaniasis, i.e., muco-cutaneous (MCL) and visceral (VL) leishmaniasis have also been reported within the country. Early case detection and management are important for disease control. However light microscopy (LM), the widely used parasitological diagnostic method has only about 70% sensitivity. Different atypical conditions, post-treatment cases or other chronic conditions of leishmaniasis show poor positivity with LM. In this study we developed a modified nested PCR assay with increased accuracy for diagnosis of leishmaniasis. Inner primers used in this assay allowed amplification of DNA only from genus *Leishmania* and avoid amplification of other kinetoplastid parasites such as *Crithidia* and *Leptomonas*. Patient samples collected from confirmed leishmaniasis cases including both CL and VL (n=40) and samples collected from controls (n=30) were used for the study. Diagnostic accuracy of the assay was further compared with routine diagnostic methods, LM and parasite culturing. The new assay reported 100% sensitivity and specificity. However only 87.5% were positive by other routine methods. This assay reduces the risk of contaminations compared to other conventional nested PCR since whole procedure of PCR reaction set up is carried out in same PCR tube. This modified nested PCR assay is useful for accurate case detection of human leishmaniasis and for detection of cases that are undetected by other parasitological techniques.

### **Introduction**

Human leishmaniasis is a vector-borne parasitic disease caused by *Leishmania* parasites. Leishmaniasis is associated with high morbidity while few clinical forms of leishmaniasis,

i.e., muco-cutaneous leishmaniasis (MCL) and visceral leishmaniasis (VL) are associated with high mortality. It is a globally important disease spread in parts of tropical and subtropical countries and Southern Europe. The first autochthonous case of cutaneous leishmaniasis (CL) was identified in several decades ago in Sri Lanka. Cases are being continuously reported and leishmaniasis is an established parasitic disease in Sri Lanka nowadays. Majority of local cases represent the cutaneous form of the disease while few other forms of MCL and VL were reported recently (Siriwardana et al [1]). Currently, parasitological tools are widely used for detection of local cases, i.e., light microscopy (LM) and parasite culturing. Although LM is cost-effective, easy to handle and less complex, accuracy may be varied and depends on the experience of the technical person and parasite load of the samples. Also, cultures are prone to contaminations and involved complex methods. Few molecular techniques are also currently used for diagnosis of local leishmaniasis including conventional PCR and nested PCR assays (Lachaud et al [2]). However accuracy of those tests is limited. This highlighted the need of developing more accurate tools for disease diagnosis. In this study we modified and developed a highly sensitive nested PCR assay which was previously described by several research groups and evaluated its applicability for local case detection (da Silva et al [3]).

## **Results**

Amplified gene size of the described assay was 358 bp which was the product size of inner primers (Cruz et al [4]). The described method was 100.0% sensitive, specific and accurate for detection of leishmaniasis. Control group used for the study consisted patients with other skin diseases and other systemic diseases which mimic leishmaniasis and healthy individuals from disease endemic and non-endemic regions of the country. All of them turned negative by the described assay. According to tested concentrations, the lowest detection limit of the described assay was about 1 fg of DNA. When compared to routine diagnostic methods, combined results of LM and parasite culturing reported only about 87.5% which was less than the positivity obtained by new method. In further method validation procedures, assay showed 100.0% repeatability for laboratory diagnosis.

## **Discussion**

Major advantage of the described method is high accuracy for detection of leishmaniasis. It can detect all clinical forms including atypical and rare forms with fewer parasites which are difficult to detect through routine parasitological laboratory techniques. Also this method is

100% specific to amplify only *Leishmania* genus-specific genes and avoid amplification of other Kinetoplastida (Cruz et al [4]). For an instance, two other species in Kinetoplastida group, i.e., *Leptomonas* and *Crithidia* usually co-exist with *Leishmania* parasites within the human body as reported from other endemic settings in the world. Although those species are not pathogenic to humans (Ahuja et al [5]), false positive PCR results may lead to reduce quality of diagnosis. Careful exclusion of those species is important. Also this same technique was successfully used for detection of other pathogenic microorganisms in different settings in the world. Those included *Leishmania chagasi*, *Mycobacterium tuberculosis*, *Vibrio cholera*, dengue virus serotypes, *Plasmodium falciparum* and etc.

### **Conclusion and Recommendation**

Early case detection of leishmaniasis is important for disease control activities. Also in local situation, the cutaneous form of disease is caused by *Leishmania donovani*, a virulent species in the genus. However, visceralizing potential of local parasite is still unknown. Therefore accurate detection of clinical cases is required. Although different parasitological and molecular diagnostic methods are already established in local setting, sensitivity of those tests is still limited. Therefore the described method can be applied as a second line assay for detection of leishmaniasis. Further improvements are recommended for increasing detection limit of the assay.

### **Acknowledgement**

The research reported here was supported by University of Colombo research grants (AP/3/2/2014/RG/13).

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## **Influence of social support and advocacy on performance of child health programmes**

R.W. Ibrahim<sup>1</sup>, P.N. Keiyoro<sup>2</sup> and J.W. Ngunjiri<sup>3</sup>

1 Embu County, Embu, Kenya.

2 University of Nairobi, Nairobi, Kenya.

3 University of Embu, Embu, Kenya.

\*Corresponding author's email: rehema209@gmail.com

### **Abstract**

Millions of children under five die annually due to amenable deaths which can be prevented. At this age, children are fully dependent on their mother or caregiver for all needs. It is also a delicate phase in growth and development which shapes the latter years of the individual in terms of physical and cognitive development. Community Health Workers are the ones mainly in touch with the households and play an important role in health care service delivery. The objective of this study was thus, to establish the influence of Social Support Services and Advocacy on implementation process of child health care Programmes. The study adopted Cross-sectional survey design and targeted a populations of 346 households that had children aged 5 years and below and being served by 32 community health workers and 4 Community Health Extension Workers. Considering that the population size for Community Health Workers and Community Health Extension Workers was small, a census was carried out while sample size of households was determined using statistical formulae provided by Yamane for calculating sample sizes at 95% confidence level and  $e = 0.05$ , the final sample size consisted of 186 households (with children aged 5 years and below), 32 Community Health Workers and 4 Community Health Extension Workers hence this gave a total of 222 respondents. Questionnaires, observation schedules and interview were adopted as main primary data collection sources. Data was examined for completeness, consistence and reliability. The second stage involved data coding with the help of Statistical Package for Social Sciences. Thereafter, results were analyses using descriptive statistics. The findings showed that CHW provided sufficient referral services to mothers with new born hence high implementation process of child health services programmes. The study also found out that mothers in Mbeere South are well informed and advised on child health care and maternal healthcare by Community Health Workers and this could lead to low rates of mortality cases for new born babies in the area. Community Health Workers had delivered their best when advocating for community leadership support and initiative towards sensitizing the people on the importance of safe pregnancy and motherhood.

**Keywords:** Support services, community Health Workers, child, health care, programs

## **Introduction**

Causes of death differ substantially from one country to another; however, pneumonia and diarrhea remain the illnesses that are most often associated with child deaths. The lives of an estimated million children could be saved each year if proven interventions such as antibiotics for pneumonia and oral rehydration therapy for diarrhoea were universally available in the 42 countries responsible for 90% of child deaths (Black et.al. 2003). According to World Health Organization (2007) utilization of community members to render certain basic health services to their communities is a concept that is scaling up across the globe.

## **Results**

### **Implementation process of child health care Programmes**

Table 1 show child care programs implementation started with antenatal during pregnancy in which majority were able to access 129 (71%). The follow up visits after delivery were also carried out and the newborn babies' health was checked to ensure it was at its peak. The newborns for checkup were very good at 169(90%). The Community Health Workers also offered support during home visits after delivery at 105 (58%).

### **Responsibilities of CHWs in providing child health care services.**

Results showed that 28 (93%) of Community Health Workers make home visits, provide health talks and distribute mineral supplements to households in the area while 3(7%) said that they did not.25(83%) said that they do make referrals in serious cases that they encounter during their visits whereas the remaining 5(17%) said that they did not make referrals. 29(97%) accompanied pregnant mothers to hospitals, made a follow up on the condition of pregnant women while 1 (3%) did not.26(87%) of the Community Health Workers ensured the provision of Family planning commodity and also follow up for counseling for the HIV positive mothers.29(97%) conducted routine medical checks like blood pressure, urinalysis and referral for PMTC.

## Discussion

The health care programs are important in reducing inequalities in healthcare access. This is in agreement with Ballester, (2005) who said community health workers are an essential component of the health care delivery system. They provide the critical link between the health care and human service system and their communities. Therefore, Community health workers (Community Health Workers) improve access to and increase utilization of primary health care, reduce costs of care, improve quality of care, and reduce health disparities. The support services provided by Community Health Workers are important. This is in line with Perry and Zulliger (2012) assertions that Community Health Workers are effective at promoting immunization utilization, identifying children who have need immunizations, expanding immunization coverage, and providing immunizations

## Conclusion and Recommendations

This study indicates that the CHWs have a good relation with the community members and provide support in child health care programs. Therefore, the health care system in developing country can integrated CHWs services in the mainstream of the health delivery system to increase the impact.

## Acknowledgement

No funding was received for this study.

Frequency (F) and Percentage (%)	Always		Rarely		Never	
	F	%	F	%	F	%
Attendance of antenatal during pregnancy	129	71	40	22	11	7
Attendance of health facility with your new born for check ups	162	90	15	8	3	2
Community Health Workers visit to my home 24 hours after delivery of my youngest child	105	58	60	33	15	9

**Table1:** *Implementation process of child health care Programmes*

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## **Who Is Feeding Our Children? A Study of Ghana school-feeding service.**

Jolene Azagba-Nyako 1,2, Gloria K. Folson<sup>3</sup> and I.Tewfik<sup>1</sup>

1. Faculty of Science and Technology, University of Westminster, London, UK
2. Noguchi Memorial Institute of Medical Research, University of Ghana Legon
3. Food Research Institute -Council for scientific and Industrial Research Ghana

\*Corresponding Author Email: jolenenyako@yahoo.co.uk

### **Abstract**

Almost half a million school children depend on meals offered under the Ghana School Feeding Programme (GSFP) as their main stable food for the day. However, there exist little plausible evidence of the nutritional benefits of the programme, and very few studies focusing on effect of the nutritional environment on the impact of feeding programme. This study sought to evaluate the nutritional environment of the GSFP programme in the Lower Manya-Krobo Municipality (LMK) of Ghana and enhancing its effectiveness through policy recommendation. The study employed field observations, cross sectional survey and focus group discussions for data collection. In all, 18 schools, 49 school staff and 18 caterers from GSFP beneficiary schools were purposively selected for each phase. The study found that the nutritional environment within the beneficiary schools were very weak and thus hindered the extent to which the beneficiaries are able to access nutritious food and nutrition information. The findings showed that caterers' limited knowledge of nutrition ranked top, as to access nutritious food; access to clean drinking water sources; and lack of permanent dwelling structures within the schools were the main hindrances to operating an effective GSFP in the area. In all the schools surveyed, it was evident that the retailed non-indigenous food stuffs contribute to most of the cost in running the SFPs, with very little being drawn from the local agricultural communities. The results obtained showed the need to prioritize capacity building of stakeholders to improve the nutrition environment at school level. The study recommends the adaptation of a bottom-up approach to nutrition education and advocacy especially among school level stakeholders such as teachers and caterers to improve the nutritional outcomes of beneficiaries of the GSFP in LMK.

### **Introduction**

Though the primary responsibility of schools is to promoting academic achievement, schools in low-income countries have however; become one of the focal points for assessing public

health campaigns and nutritional inventions (school feeding programmes) to promote optimal health during childhood. Traditionally, nutritional assessment of GSFP focus on obtaining valid and reliable quantitative information about individuals' or groups of children' food or nutrient intakes and improvements to physical parameter with limited focus to individuals' or groups nutritional/dietary environment. Nutritional environment embodies all activities, structures and stakeholders that seek to explain the role of nutrition in health promotion and work toward directing school children towards making healthy food choices and developing healthy physical activity habits in and outside the school. The current study forms part of the larger intervention (S-COOL meal intervention) to enhance the GSFP in the Lower Manya Krobo Municipality, Eastern Region of Ghana. The aim of the current study was to assess the nutritional environment of the GSFP participating school in LMK, identified shortfalls and provide solutions to create a supportive school nutrition environment increase impact in beneficiary schools.

## **Methodology**

The study was design to consist of three phases a situational analysis (field observation), a cross sectional survey and focus group discussion. The nutritional environment was assessed in 18 schools in Ghana from peri-urban region of the Lower Manya-Krobo Municipality. The field observation was done using adaptation of Nutrition Environment Measures Survey in Stores questionnaire (NEMS-S) and photo journal to assess the physical environmental aspects of the GSFP. The cross-sectional survey assessed the perceptions about GSFP. Focus group discussions was conducted using Indigenous Caterers Association of Ghana (ICAG) assessment tool kit. Descriptive statistics derived from using MS Office Excel 2011 for Mac with Statplus were used to describe the population for each survey as well as field observation data. Qualitative Data was analysed and interpretation were drawn using the framework as described by Taylor-Powell, E., & Renner 2003(1).

## Results

Questions	Response	
	YES n (%)	NO n (%)
Trained teacher with speciality in nutrition on school staff?	11(22.45)	38 (77.55)
Do you have a role in the school-feeding programme?	18(36.73)	31(63.27)
Are nutrition-oriented pictures and educational material in your school?	10 (20.41)	39(79.59)
Are there nutrition discussions with your staff on the school-feeding programme?	37(75.51)	12(24.49)
Are there discussions with parents on the school-feeding programme?	9 (18.37)	40(81.63)
Are there discussions with Caterers/cooks on the school-feeding programme?	3(23.07)	10 (76.92)

**Table 1:** Teachers response to parameters of nutritional environment

Nutrient	DRV*	WFP **	Mean	%DRV	Pvalue
Energy kcal	1445	433.5	362.34	25.07%	0.0082
Carbohydrate g	130	39	168.70	129.10%	0.026
Protein g	19	5.7	4.63	21.05%	0.096
Fats g	35	11	14.56	41.60%	0.065
Calcium mg	550	165	140	25.45%	0.782
Iron mg	8.7	2.61	3.06	35.17%	0.340
Zinc mg	5	1.5	0.87	17%	0.00

\*Dietary Reference Values (DRVs) comprise a series of estimates of the amount of energy and nutrients needed by children 5-8years \*\*WFP recommend school lunch average requirement usually 30% of DRV

**Table 2:** Nutrient adequacy of GSFP meals (% DRV)

\*Dietary Reference Values (DRVs) comprise a series of estimates of the amount of energy and nutrients needed by children 5-8years \*\*WFP recommend school lunch average requirement usually 30% of DRV

The data presented here was taken between April 2015 to Jun 2017, few of the relevant results are reported here.

## **Discussion**

With respect to logistics and inputs to sustain the nutrition environment across the GSFP schools studied, there were no guidelines for food procurement, meal composition, processing and preparation of school meals. Considering school level stakeholder capacity in terms of nutritional knowledge, the trend in the results in Table indicated that stakeholder had fairly limited knowledge of nutrition. Caterers as well as teachers did not have any specialty knowledge or training on child nutrition. and concepts that integrate traditional food systems with the science of nutrition. In terms the greater access to quality and the availability of healthier local foods, the findings indicated that Meals were predominantly rice-based meals (11 out 15 observations) and did not adequately incorporate local agriculture produce. The average energy 362.34KCal (25.07% DRV  $p=0.0082$ ) as shown in Table 2. a similar observation was made by Hauwere 2010 (2) and Danquah et al, 2012 (3), with the latter reported that rice which was not indigenous to Ghana was the predominantly preferred starchy staple and its price significantly affected the quantities of protein used in the preparation of the sauce. The nutrition environment of school is of particular importance because school meals comprise the major staple food for most beneficiary children in LMK. This indicates that a large number school children are dependent on GSFP for nourishment hence, the need to optimize the environment within which GSFP is delivered is all the more important. These datasets are of importance because they challenge a commonly accepted belief that the efficacy of nutrition intervention rests solely on the supply of healthier foods. The findings highlight an opportunity to consider school environment as an efficient point of intervention improvement. Increased availability of information on healthier food, incorporation of acceptable quality local food into school. menus, training for teachers, parents school children and food serves providers. This study has limitations, including the food environments described may not be generalisable to other rural areas or more urban locations. These findings are consistent with previously published



literature on food environments of rural communities. However, unique characteristics of each community limit our ability to make inferences about other communities from these data.

### **Conclusion and Recommendation**

Increasing attention is being given to the need for school-based interventions to promote healthier eating in children in an effort to reduce nutrition-related morbidity and mortality. The present study suggests that school nutrition environment could be strategic points of intervention to improve the nutrition impact of the GSFP. Future research should examine how the school level stakeholders can be incorporate in the design, implementation and monitoring of school feeding programme. Co-creation and co-design with school level stakeholder present a more sustainable way to ensure the nutrition environment can promote healthier dietary behaviours among GSFP beneficiaries.

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## **Value for money analysis of funds spent on disease interventions**

Winnie. Chacha<sup>1</sup>✉, Jane. Aduda<sup>2</sup> and Samuel. Mwalili<sup>3</sup>  
1,2,3JKUAT, Nairobi, Kenya. \*winniemchacha@gmail.com

### **Abstract**

Governments, health providers, policy makers and development partners fund different health interventions to address the health challenges and needs of their population. These interventions attempt to achieve better health at a reduced cost. Limited budgets due to scarcity of resources and political pressure have made governments and donors towards health care interventions to increasingly demand for transparency and proper management of resources. Funders want to know the value for their money and efficiency in the use of their investments holistically. Value for money involves assessing the health and social impact of a dollar spent on an intervention to improve health of citizens. This research seeks to ascertain the value for money by assessing the impact of an amount spent on an individual receiving an intervention to improve their health using utility adjusted Quality of life years (QALYs). QALYs values are simulated by applying survival analysis and the beta distribution. To determine the individual's perceived benefit and their health seeking behavior, the Von Neumann Morgenstern utility functions are compared. The logarithmic utility function is found to be the best. In addition, the hidden social impact is assessed using the bayesian hidden markov model. Findings suggest that the HMM is an effective way of modelling for the hidden impact.

### **Introduction**

Scarcity of resources has resulted to underfunded health systems making access to decent health care a challenge. This necessitates the optimal use of resources allocated to health interventions. The Kenyan government is determined to improve the quality and access to healthcare in line with Vision 2030 and Millenium Development Goals. The proportion of Kenya's revenue allocated to health budget increased by 10.3% to 114 billion Ksh in the 2020/2021 with 19.2 billion Ksh set aside to address healthcare interventions.

Despite increased budgetary allocations towards health interventions, for many developing countries, little progress has been made towards providing affordable and timely information regarding the cost and impact of a particular intervention for both health and non-health outcomes. There is need to measure the impact of an intervention on individuals in terms of improvement in the quality of life and the true impact on the society as a whole.

## Methodology

QALYs is used to measure the change in quality of life after receiving an intervention. It is a product of the morbidity and mortality. The negative exponential, power and logarithm utility functions are compared as functions of QALYs. The HMM is modelled on the QALYs as the observed variable.

## Results

The log utility of health(QALYs) (Q) and expenditure(C) is given by:

$$U(Q,C) = Q \cdot \log(aC) \quad (1)$$

If  $x$  denotes the maximal proportion of expenditure that an individual is willing to give up in order to be cured then:

$$Q \log(aC) = 1 \cdot \log(aC(1-x)) \quad (2)$$

$$\log(aC) \cdot x^Q = aC(1-x)$$

Utility Function	Residual Sum of Squares	AIC
Log	$2.15 \cdot 10^{-3}$	-23.3
Negative Exponential	$1.07 \cdot 10^{-3}$	-20.2
Power	$3.12 \cdot 10^{-2}$	-13.2

**Table 1:** *Utility Function*

## Discussion

logarithmic utility has the least AIC thus the best model to measure perceived benefit and health seeking behavior of individuals.

## Conclusion and recommendation

Bayesian HMM is suitable for the hidden social impact of an intervention. Real life data can be applied to model.

## Acknowledgement

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# **Bayesian Structural Equation Modelling for Count Time Series Combined with Unobserved variables (Latent Variables)**

Walter Yodah<sup>1</sup>, George Orwa<sup>2</sup> and Rumanus Odhiambo<sup>3</sup>

JKUAT.Nairobi ,Kenya

Bomet University. Bomet Kenya

Meru university. Meru, Kenya

Corresponding author's email: walter.yodah@jkuat.ac.ke

## **Abstract**

The fact that real life data contains numerous problems for instance, in eld such as; education, psychology, sociology, economics, demography, political sciences and other areas in social sciences, some constructs such as; intelligence, trust, self-esteem, motivation, success, ambition, prejudice, conservatism among others, cannot be directly observed. The construct may also be coupled with instances where count time series exist as the response variable. The question arises on whether the construct or the unobserved variables directly affect some observed time count series or not (response variable). To establish whether the relationship exist between count time series and latent variables techniques no known model can be used. In this study, the proposed model is Bayesian structural equation model (BSEM) technique for modelling count time series being influenced with unobserved variables (latent variables) as the main objective the study. BSEM techniques is the proposed model for the study that incorporates Bayesian techniques and SEM in modeling data sets involving count time series and latent variables using Poisson regression. The SEM component considered in this case is the measurement equation part. Besides that, other specific objectives to be achieved include: - Estimation of parameters based on Bayesian structural Equation modeling (BSEM Technique) to combined count time series as the response variable and Latent variables as the covariate variables, to investigate the asymptotic properties of the estimators estimated for both count time series and latent variables and lastly to apply the BSEM approach in modeling various count time series combined with latent variable.

## **Background Information**

Many organizations highly depend on making key decision in order to achieve certain objectives designed mainly to realize specific vision and mission of the organization. For instance, the government may be interested knowing how to allocate a given limited resource

to its population. To make proper decision there is need to analyse the available data before deciding on how the resource will be allocated. With regards to this, it is clear that the process of making decision highly depends on the availability of data, from which information can be extracted. However, in most cases real data which is commonly available normally encounter several challenges which may include: missingness, in accurate information, unreliability of the information, the astructure/arrangement of the data to be analyzed among many others. Analyzing real life data with already existing techniques sometimes may prove to be very difficult subject to the nature of data being handled. Because of these problems encountered while handling real life data, it is extremely important and necessary to understand the nature/type of data being handled so as to identify challenges and make modification if need arises or develop new statistical procedure that could aid in finding the solutions to different types of problems.

In this study the main focus will be based on how latent variables affect count series data. There are many instances where count time series exist for example, the number of student being admitted at the university yearly, monthly the number of vehicles using a given highway, annual number of patients being admitted in the hospital. yearly number of deaths recorded in a region due to Ebola attacks, weekly number of corruption cases led in court in a given country and many more. In some cases, counts time series may be observed together with some explanatory variables (covariate data) which may have a significant effect on the outcome of the count time series. The covariate data usually may take any form for instance those that may be observed directly or indirectly. In circumstances where both explanatory and response variables are observed directly, the usual count time series modelling techniques are applied. The most common modelling of count series data involves the use of Poisson regression techniques. On the other hand, in situation where both the dependent variable and explanatory variable are not observed directly, the commonly applied modelling technique involve formulation and estimation of SEMs. In this study, the interest will be to model count time series involving both observed count time series being treated as dependent variable and unobserved independent variable.

### **Statement of the Problem:**

Modelling real life data at times may be very challenging since real life data contains numerous problems for instance, in fields such as; education, psychology, sociology, economics, demography, political sciences and other areas in social sciences, some constructs such as; intelligence, trust, self-esteem, motivation, success, ambition, prejudice, conservatism among others may not be measured directly. In such cases, it is not easy to obtain correct estimates of how the variables relate to each other since the constructs cannot be directly be measured or observed. In literature, there are many modelling algorithms that can be considered or be employed depending on the type of data under consideration. The commonly used algorithms for data sets which are not observed directly mainly involve the use of structural equation models (SEM) which is a system of several linear relationships among latent variables. Application of SEM models at a time may be very challenging especially in social research where various types of data sets are considered at the same time. In such circumstances application of complex SEM models through Bayesian approach coupled with data augmentation via MCMC algorithms may be necessary. In addition to that, modern technology and use of Gibbs sampler have also made it easier in obtaining samples of any arbitrary size originating from the posterior analysis for the parameters to be estimated in SEM given covariance data and a prior information. Other estimates such as standard deviations, point estimates, and confidence interval estimates of the parameters can be calculated easily from the samples.

As an illustration, Bayesian approach to SEM can be used widely to analyze variety of data sets which include; ordered categorical variables/ dichotomous variables, data that belongs to exponential family of distributions which is a family of distribution mainly applicable in circumstances where there is serious violation of some assumptions, missing observations among others. In solving some of these problems MCEM and MCMC approaches have been applied widely for complex models due to their flexibility. Despite all this development, unobserved data (construct) coupled with count time series (response variable) exist. To establish the relationship of how constructs or the unobserved variables directly affect observed count time series (response variable) remains a challenge. As a result, estimation of how unobserved variables affect the dependent variable (count data) is extremely difficult thus leading to inaccurate/unreliable findings or biased inferences in some cases. In particular measuring the extent to which some construct of unobserved data (latent variable) affect count time series remains a challenge.

## **Objective of the Study**

The main objective of the study was to model observed count time series being influenced with unobserved variables (latent variables) using Bayesian structural equation model (BSEM) model.

## **Specific objectives**

To develop Bayesian structural equation model for count time series data involving latent variables as the main covariates using Poisson Generalised autoregressive moving averages (poisson GARMA).

To estimate parameters based on Bayesian structural Equation model (BSEM Technique) for data sets involving count time series as the response variable and Latent variables as the covariate variables.

## **Justification and Significance of the study**

It is known that that real life data contains numerous problems for instance in the field of social sciences, education, engineering, stock market data, economic data, experimental data amongst others, count data usually exist and in many cases they may be influenced with latent variable (unobserved variables). In such circumstances, establishing how unobserved variables affect the dependent variable (count data) is extremely difficult thus leading to inaccurate findings which eventually may result to biased inferences. The other underlying fact is that it is difficult to combine both count series and latent variables at ago because of the complexity in the model bayesian approach will be considered. Because of this challenge, there is need for a study to be conducted on the best approach that may be used to model count time series being influenced with unobserved variables. The study is also meant to determine the most reliable technique which can be used to model count data being influenced with latent variable (unobserved variables). Furthermore, new insights will be provided regarding the most appropriate modeling techniques for the above mentioned challenge as far count data is concerned. s models for observed data.



## Methodology

### Basic SEM Models

In this section, we now considered the basic Structural Equation Models which can be listed as follows; Exploratory factor analysis (EFA) models, confirmatory factor analysis (CFA) which was first developed by Joreskog (1969) then extended to factor model of second-order by the same Joreskog (1970). The second order model was later generalized to factor models of higher-order. The model was also extended to higher-order moment structures by Bentler (1976, 1983). The other basic Structural Equation Models (SEMs) considered are factor analysis models, Linear Structural Relation model (LISREL models) and Bentler's models developed by Bentler (1983)

### Confirmatory Factor Analysis

Basically confirmatory factor analysis (CFA) model is an extension of the EFA model and it is defined mathematically by an expression which similar to that of Exploratory factor analysis (EFA) that is:

$$X = \Lambda \xi + \epsilon \quad (1)$$

with  $X, \Lambda, \xi$  and  $\epsilon$  having similar distribution assumptions as in the case of EFA model. In a CFA model, the unobserved variables are allowed to be related with each other such that  $\xi$  is distributed as  $N[0, \Phi]$  with a positive definite covariance matrix. In addition to that covariance matrix of based on confirmatory factor analysis model can be expressed as:

$$\Sigma = \Lambda \Phi \Lambda^T + \Psi \quad (2)$$

It is clear that from the above model, all the parameter which are not known are found within the covariance matrix  $\Sigma$ . Therefore, the statistical theory as far as the estimation of parameters is developed on the basis of covariance structure analysis framework. Besides estimation of the structural parameters based on the covariance matrix, the fundamental interest is to estimate the random vector  $\xi$  of latent factor scores. Also in this case the regression equation follows the joint distributions  $X$  and  $\xi$  with mean vector zero and covariance matrix  $\Sigma$  that is  $N[0, \Sigma]$  where

$$\Sigma = \begin{bmatrix} \Lambda \Phi \Lambda^T + \Psi & \Lambda \Phi \Lambda^T \\ \Lambda \Phi \Lambda^T & \Lambda \end{bmatrix}$$

The regression equation between  $\xi$  and  $X$  therefore becomes

$$\xi = \Phi \Lambda^T (\Lambda \Lambda^T + \Psi)^{-1} X = \Phi \Lambda^T \Sigma^{-1} X \quad (3)$$

In the case of EFA,  $\Phi$  in equation 4 above is treated as identity matrix. For both EFA and CFE models.

$$\xi = (\Lambda^T \Psi \Lambda)^{-1} \Lambda^T \Psi^{-1} X \quad (4)$$

According to yum silk (2007), the methods of estimation  $\xi$  based on equation 4 and 5 are not commonly used due to the following facts. First the sampling error are always not taken into consideration in their estimation. Secondly,  $\xi$  have very complicated distribution since the function associated with it is anon linear. However, Bayesian method can be used to overcome this challenges.

### Count time series models

In this section, we now consider the count time series models which constitute observation driven models. to achieve this we first consider the Generalized linear models and time series.

### The generalised linear model

The generalised linear model can be described as non linear models and are widely applied in many arears. In this case a lot of emphasis will be laid to count time series which follows generalized linear models. On that note, count data regression models can be illustrated and presented using the Generalized linear models which is basically platform for analyzing count time series as was developed by Nelder and Wedderburn (1972). GLMs gives details of the relationship between the dependent variable on a vector of explanatory or predictor. If we consider  $X_t$  to be the time series of interest as the dependent variable, and with an aim of prediction given some p-dimensional vector of past independent/predictor variables or covariates and also if we let  $\mu_t$  to be the conditional mean or expectation of the outcome or response given the past then the challenge is how to establish the relationship between the conditional mean  $\mu_t$  with the explanatory variables. The assumptions in linear models is that conditional mean of the response given the past of the process is a linear function of the covariates. However, in circumstances where the data are not normally distributed, the results can be meaningless. Data which follows Poisson or Gamma distribution data with expected value of response variable  $\mu_t$ , the linear regression equation between  $\mu_t$  and the explanatory

variables or the covariates may result to mean estimates which are negative. To overcome this challenge, generalized linear models have been recommended for instances where the observed data follows an exponential family of distribution. It is worth noting that, the unifying concept underlying generalized linear models is that it belongs to exponential families of distributions. Members of this family of distribution have probability density function or probability mass function expressed as:

$$f(x_t; \theta, \Phi) = \exp\left\{\frac{y_t \theta_t - a(\theta_t)}{\alpha_t(\Phi)} + b(y_t; \Phi)\right\} \quad (5)$$

where  $\mu_t$  is a field generated and  $\eta_t$ , and  $\alpha_t$  are parametric functions with canonical location parameter while  $\alpha_t$  is the dispersion parameter. According to Benjamin Kadem (2010). Time series which follows generalized linear models (GLM) can be illustrated by considering random and systematic components. For random component given the past data belongs to a family of exponential distribution, the conditional distribution of the output (response) given the past belongs to the exponential family of distributions in natural or canonical form. That is for  $t = 1, 2, 3, \dots, N-1, N$  and it is expressed as:

$$h(\mu_t) = \sum_{j=1}^p \beta_j S_{t-1} = S'_{t-1} \beta \quad (6)$$

The function  $h(\cdot)$  which can be given as  $\eta_t$  is a linear predictor of the model. Suppose one-dimensional response process  $\{Y_t\}$  is given and covariate process  $\{X_t\}$  is also given, then the general,  $S_{t-1} \beta$  is given as follows:

$$S_{t-1} \beta = \sum_{j=1}^p \alpha_j F_i(Y_{t-i}) + \sum_{i=1}^q \theta_j G_i(\mu_{t-1}) + X'_t \psi \quad (6)$$

$F(\cdot)$  and  $G(\cdot)$  are the functions which are known for all  $i$ . It can be noticed that equation (7), is special case of equation (6) with  $S_{t-1}$  being defined as:

$$S_{t-1} = \{X_t F_1(X_{t-1}), \dots, F_p(X_{t-p}), G_t(\mu_{t-1}), \dots, G_q(\mu_{t-q})\}$$

while

$$\beta = (\varphi' \alpha_1 \alpha_2, \dots, \alpha_q \theta_1 \theta_2, \dots, \theta_p)$$

Now the inference of partial likelihood is applied to model (7), the resulting model somehow related to model (7) obtained is given as:

$$S_{t-1}\beta = \sum_{j=1}^p \alpha_j \{g(y_{t-j}) - X'_{t-j}\psi\} + \sum_{i=1}^q \alpha_i \varepsilon_{t-j} + X'_t \psi \quad (8)$$

The model obtained in equation 8 is referred to as Generalized Linear Autoregressive Moving Average of order GLARMA (p,q) or simply GARMA (p,q) because it has both autoregressive (AR) and moving average(MA) parts with

$$\varepsilon_{t-1} = g y_{t-1} - \eta_{t-1}$$

If the conditional distribution given in equation (5) is specific, for instance if the conditional distribution in equation 5 is Poisson, then the Generalized Linear Autoregressive Moving Average of order (p,q) obtained is also Poisson. That is equation 23 becomes Poisson GARMA (p,q).

### Poisson GARMA(p,q) Model

Having considered the general GLARMA<sub>p,q</sub> model expressed in equation 23 we now consider the Poisson GARMA(p,q) Model which can be described as follows:

For the case of count time series {Y<sub>t</sub>} with t = 1,2,3,...,N , the conditional distribution is Poisson with mean λ<sub>t</sub> and can be expressed as:

$$f(Y_t, \theta_t, \Phi) / H_t - 1 = \exp\{Y_t \log \lambda_t - \lambda_t - \log Y_t!\} \quad (9)$$

which implies that:

$$E(Y_t / H_t - 1) = \lambda_t, b(\theta_t) = \lambda_t = \exp(\theta_t), \text{var}(\lambda_t) = \lambda_t, \Phi = 1, \text{and } \omega_t = 1$$

The link function which is fundamentally derived from poisson distribution is expressed as:

$$h(.) = \theta_t(\lambda_t) = \log(\lambda_t) = \eta_t = S'_{t-1}\beta$$

which yield

$$\log \lambda_t = \sum_{j=1}^p \alpha_j \{g(y_{t-j}) - X'_{t-j}\psi\} + \sum_{i=1}^q \alpha_i \varepsilon_{t-j} + X'_t \psi \quad (10)$$

or simply

$$\lambda_t(\beta) = \exp(S'_{t-1}\beta) \quad \text{where } t = 1, 2, 3, \dots, N \quad (11)$$

with  $Y_t = \max(Y_t - 1, c)$ ,  $0 < c < 1$  The above empirical adjustment may influence the regression coefficients. Besides specifying the first moment in (5), it is assumed that the conditional variance of the response is given by which is the general log linear model for Poisson distribution for count time series. Equation 9, 10 and 11 can be considered to Poisson GARMA model.

### Binomial GARMA(p,q) Model

using the same argument as applied in Poisson GARMA model, the conditional distribution  $f(Y_t, \theta_t, \Phi) / H_{t-1}$  may be following binomial distribution with mean

$$f(Y_t, \theta_t, \Phi) / H_{t-1} = \exp Y_t \log \left( \frac{\mu_t}{r - \mu_t} \right) + r \log \left( \frac{r - \mu_t}{r} \right) + \log \left( \frac{\Gamma(r + 1)}{\Gamma(Y_t + 1) \Gamma(r - Y_t + 1)} \right) \quad (1)$$

$\mu_t$ , such that with the canonical link function being expressed as;

$$\log \left( \frac{\mu_t}{r - \mu_t} \right) = \sum_{j=1}^p \alpha_j \{g(Y_{t-j}) - \mathbf{X}'_{t-j}\psi\} + \sum_{i=1}^q \alpha_i \varepsilon_{t-j} + \mathbf{X}'_t \psi \quad (13)$$

### Negative Binomial GARMA(p,q) Model

Assuming that the conditional distribution follows negative Binomial distribution with parameter  $k, \mu_t$ , then the distribution can be written as;

$$f(Y_t, \theta_t, \Phi) / H_{t-1} = \exp k \log \left( \frac{k}{\mu_t + k} \right) + Y_t \log \left( \frac{\mu_t}{\mu_t + k} \right) + \log \left( \frac{\Gamma(k + Y_t)}{\Gamma(Y_t + 1) \Gamma(k)} \right) \quad (14)$$

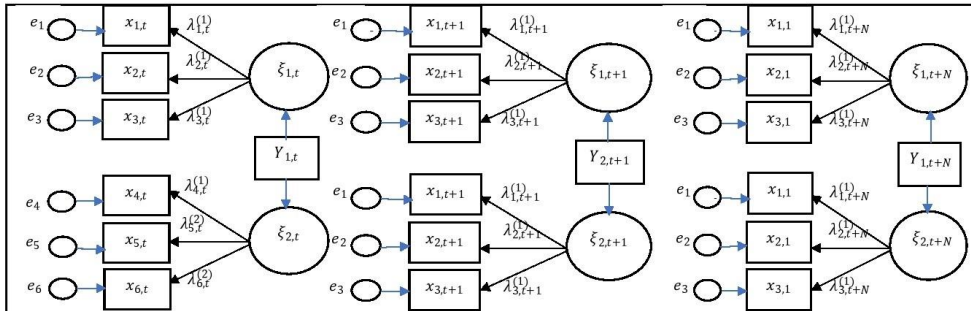
the canonical link function remains the same as in the case poisson and binomial that is,

$$\log \left( \frac{\mu_t}{\mu_t + k} \right) = \sum_{j=1}^p \alpha_j \{g(Y_{t-j}) - \mathbf{X}'_{t-j} \psi\} + \sum_{i=1}^q \alpha_i \varepsilon_{t-j} + \mathbf{X}'_t \psi \quad (15)$$

and  $Y_t = \max(Y_t - 1, c), 0 < c < 1$

### BSEM Model

Having considered both sem models and count time series model, the central focus is how to model count time series being influenced by latent variables based on confirmatory factor analysis (CFA) also known the measurement equation which forms part of the structural equation model (SEM) where observed variables manifest into some few unobserved variables known as latent variables. The latent variables are then treated as the covariates or the explanatory to count time series data. Figure 1 shows the underlying structure of the the latent variables under consideration



**Figure 1:**

To develop the model, we first consider the covariance structure of the CFA model given equation 1 and 4 according to Lee (2007) equation. Assuming the latent variable was observed with time, we can express  $\xi$  as  $\xi_{k,t}$  where  $t = 1, 2, 3, \dots, N$ .

$$\xi_{k,t} = (\Lambda_t^T \Psi_t^{-1} \Lambda_t)^{-1} \Lambda_t^T \Psi_t^{-1} X_t \quad (16)$$

with

$$\xi_{k,t} = \begin{bmatrix} \xi_{1,1} \\ \xi_{2,1} \\ \vdots \\ \xi_{k,1} \end{bmatrix}, \xi_{k,t+1} = \begin{bmatrix} \xi_{1,2} \\ \xi_{2,2} \\ \vdots \\ \xi_{k,2} \end{bmatrix}, \dots, \xi_{k,t+N-1} = \begin{bmatrix} \xi_{1,N-1} \\ \xi_{2,N-1} \\ \vdots \\ \xi_{k,N-1} \end{bmatrix}, \xi_{k,t+N} = \begin{bmatrix} \xi_{1,N} \\ \xi_{2,N} \\ \vdots \\ \xi_{k,N} \end{bmatrix}$$

or simply

$$\xi_{k,t} = \{\xi_{k,t+1}, \xi_{k,t+2}, \xi_{k,t+3}, \dots, \xi_{k,t+N-2}, \xi_{k,t+N-1}, \xi_{k,t+N}\}$$

now if we let  $Y_t$  to be count time series data following Poisson GARMAp,q model described in equation 6,7 and 8 and at the same time being influenced by covariant latent variable  $\xi_t$  observed at time  $t$  then the poisson GARMA (p,q) can be expressed as:

$$f(Y_t, \theta_t, \Phi)/H_{t-1} = \exp\{Y_t(\sum_{j=1}^p \alpha_j \{g(Y_{t-j}) - \mathbf{X}'_{t-j}\psi\} + \sum_{i=1}^q \alpha_i \varepsilon_{t-j} + \mathbf{X}'_t \psi) - \lambda_t - \log Y_t!\} \quad (17)$$

now substituting  $X_t$  with  $\xi_t$  we get the following

$$f(Y_t, \theta_t, \Phi)/H_{t-1} = \exp\{Y_t(\sum_{j=1}^p \alpha_j \{g(Y_{t-j}) - \xi'_{t-j}\psi\} + \sum_{i=1}^q \alpha_i \varepsilon_{t-j} + \xi'_t \psi) - \lambda_t - \log Y_t!\} \quad (18)$$

In equation 18 above, if we substitute  $\xi_t$  with the expression  $(\Lambda_t^T \Psi_t^{-1} \Lambda_t)^{-1} \Lambda_t^T \Psi_t^{-1} X_t$  the model becomes:

$$f(Y_t, \theta_t, \Phi)/H_{t-1} = \exp\{Y_t(\sum_{j=1}^p \alpha_j \{g(Y_{t-j}) - ((\Lambda_{t-j}^T \Psi_{t-j}^{-1} \Lambda_{t-j})^{-1} \Lambda_{t-j}^T \Psi_{t-j}^{-1} X_{t-j})\psi\} + \sum_{i=1}^q \alpha_i \varepsilon_{t-j} + (\Lambda_t^T \Psi_t^{-1} \Lambda_t)^{-1} \Lambda_t^T \Psi_t^{-1} X_t)\psi - \lambda_t - \log Y_t!\} \quad (19)$$

To estimate the parameter in the model, two approaches can be applied namely: Application of bayesian to the CFA component of the model to obtain  $\xi$  values and then incorporate the values in the model. secondly, apply Bayesian approach to the whole model after expressing latent variables in terms of observed variable. Considering the first approach, the CFA model in equation 2 can be written as

$$X_{kt} = \Lambda_{kt} \xi_{kt} + \epsilon_{kt} \quad (20)$$

where:  $X_{kt}$  is  $(p \times 1)$  observed random vector at time  $t$ ,  $\Lambda_{kt}$  is  $(p \times q)$  factor loadings matrix at time  $t$ ,  $\xi_{kt}$  are  $(p \times 1)$  factor scores (latent scores) and are  $N(0, \Phi_{kt})$ ,  $\epsilon_{kt}$  is  $(p \times 1)$  random vector of error measurements and  $N(0, \Psi_{et})$ .

If we let  $X_{kt} = (x_{1t}, \dots, x_{pt})$  be the observed data,  $\Xi_{kt} = (\xi_{1t}, \xi_{2t}, \dots)$  be the factor scores and  $\theta_{kt} = \{\Psi, \Lambda, \Phi\}$  be the structural parameters. We obtain factor scores in  $\Xi_{kt}$  by treating them as missing values and augment the factor scores with the observed data set  $X_{kt}$ . Based on Gibbs sampling algorithm a large sample  $(\theta_{kt}, \Xi_{kt})$  from joint posterior distribution of  $(\theta_{kt}, \Xi_{kt} | X_{kt})$  given  $X_{kt}$  is generated as follows: for  $(j + 1)$ th iteration, with current values of

$$\begin{aligned} & \text{Generate } \Xi_{kt(j+1)} \text{ from } P(X_{ikt} | \Phi_{kt}^{(j)}, \Lambda_{kt}^{(j)}, \Psi_{kt}^{(j)}, X_{kt}) \\ & \text{Generate } \Psi_{kt(j+1)} \text{ from } P(\Psi_{kt} | \Xi_{kt}^{(j+1)}, \Phi_{kt}^{(j)}, \Lambda_{kt}^{(j)}, X_{kt}) \\ & \text{Generate } \Lambda_{kt(j+1)} \text{ from } P(\Lambda_{kt} | \Xi_{kt}^{(j+1)}, \Phi_{kt}^{(j)}, \Psi_{kt}^{(j)}, X_{kt}) \\ & \text{Generate } \Phi_{kt(j+1)} \text{ from } P(\Phi_{kt} | \Xi_{kt}^{(j+1)}, \Lambda_{kt}^{(j)}, \Psi_{kt}^{(j)}, X_{kt}) \end{aligned}$$

For the parameters to be estimated, using Gibbs sampling algorithm, the conditional distributions  $p(\Xi | \Lambda_{kt}, \Psi_{\epsilon}, \Phi, X_{kt}) = p(\Xi | \vartheta_{kt}, X_{kt})$  was required. To derive the conditional distribution of  $p(\Xi | \Lambda, \Psi_{\epsilon}, \Phi, X)$ , it was important to note that  $\xi_i$  and  $x_i$  for  $i = 1, 2, \dots, n$  are mutually independent. From the conditional distributions, conjugate priors of the parameters in the model can also be obtained which in this case were gamma distribution, inverted gamma distribution, both wishart and inverted wishart distribution as described by Lee and Yum (2007) that is;

$$\begin{aligned} \psi_{ert}^{-1} & \stackrel{D}{=} \Gamma[\mathbf{a}_{0\epsilon kit}, \mathbf{b}_{0ert}] \\ [\Lambda_{irt} | \psi_{ert}] & \stackrel{D}{=} N[\Lambda_{irt}, \psi_{ert} \mathbf{H}_{0\epsilon kt}], \text{ and } \Phi_{it}^{-1} \stackrel{D}{=} W_q[\mathbf{R}_0, \rho_0], \end{aligned} \tag{21}$$

On the other hand, the posterior parameter estimate was given by:

$$\begin{aligned} \vartheta_{kt} & = \{\Psi, \Lambda, \Phi\}, t = 1, \dots, T \\ \hat{\theta} & = \frac{1}{T} \sum_{i=1}^T \hat{\theta} \end{aligned}$$

and

$$\text{var}(\hat{\theta}) = \frac{1}{T} \sum_{i=1}^{T-1} (\theta^t - \hat{\theta})(\theta^t - \hat{\theta})^t$$



The estimated parameters above are then used to estimate the  $\xi_{k,t}$  values based on the expression

$$\xi_{k,t} = ((\Lambda_{m,t}^k)^T \Psi_{k,t}^{-1} \Lambda_{m,t}^k)^{-1} (\Lambda_{m,t}^k)^T \Psi_{k,t}^{-1} X_{m,t}$$

where

$$\xi_{k,t} = \begin{bmatrix} \xi_{1,t} \\ \xi_{2,t} \\ \vdots \\ \xi_{k,t} \end{bmatrix}, \Lambda_{m,t}^k = \begin{bmatrix} \lambda_{1,t}^{(1)} & \lambda_{1,t}^{(2)} & \cdots & \lambda_{1,t}^{(k)} \\ \lambda_{2,t}^{(1)} & \lambda_{2,t}^{(2)} & \cdots & \lambda_{2,t}^{(k)} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{m,t}^{(1)} & \lambda_{m,t}^{(2)} & \cdots & \lambda_{m,t}^{(k)} \end{bmatrix}, \Psi_{k,t}^{-1} = \begin{bmatrix} \frac{1}{\Psi_{e,1}} & 0 & \cdots & 0 \\ 0 & \frac{1}{\Psi_{e,2}} & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \cdots & \frac{1}{\Psi_{e,n}} \end{bmatrix}$$

$$(\Lambda_{m,t}^k)^T = \begin{bmatrix} \lambda_{1,t}^{(1)} & \lambda_{2,t}^{(1)} & \lambda_{3,t}^{(1)} & \cdots & \lambda_{m,t}^{(1)} \\ \lambda_{1,t}^{(2)} & \lambda_{2,t}^{(2)} & \lambda_{3,t}^{(2)} & \cdots & \lambda_{m,t}^{(2)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \lambda_{1,t}^{(k)} & \lambda_{2,t}^{(k)} & \lambda_{3,t}^{(k)} & \cdots & \lambda_{m,t}^{(k)} \end{bmatrix}, \text{ and } X_{m,t} = \begin{bmatrix} x_{1,t} \\ x_{2,t} \\ \vdots \\ x_{m,t} \end{bmatrix}$$

with the above information on the parameters, we can still express the above equation as follows:

$$\xi_{k,t} = \left( \begin{bmatrix} \lambda_{1,t}^{(1)} & \lambda_{1,t}^{(2)} & \cdots & \lambda_{1,t}^{(k)} \\ \lambda_{2,t}^{(1)} & \lambda_{2,t}^{(2)} & \cdots & \lambda_{2,t}^{(k)} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{m,t}^{(1)} & \lambda_{m,t}^{(2)} & \cdots & \lambda_{m,t}^{(k)} \end{bmatrix} \begin{bmatrix} \frac{1}{\Psi_{e,1}} & 0 & \cdots & 0 \\ 0 & \frac{1}{\Psi_{e,2}} & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \cdots & \frac{1}{\Psi_{e,m}} \end{bmatrix} \begin{bmatrix} \lambda_{1,t}^{(1)} & \lambda_{2,t}^{(1)} & \cdots & \lambda_{m,t}^{(1)} \\ \lambda_{1,t}^{(2)} & \lambda_{2,t}^{(2)} & \cdots & \lambda_{m,t}^{(2)} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{1,t}^{(k)} & \lambda_{2,t}^{(k)} & \cdots & \lambda_{m,t}^{(k)} \end{bmatrix} \right)^{-1}$$

$$\begin{bmatrix} \lambda_{1,t}^{(1)} & \lambda_{2,t}^{(1)} & \lambda_{3,t}^{(1)} & \cdots & \lambda_{m,t}^{(1)} \\ \lambda_{1,t}^{(2)} & \lambda_{2,t}^{(2)} & \lambda_{3,t}^{(2)} & \cdots & \lambda_{m,t}^{(2)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \lambda_{1,t}^{(k)} & \lambda_{2,t}^{(k)} & \lambda_{3,t}^{(k)} & \cdots & \lambda_{m,t}^{(k)} \end{bmatrix} \begin{bmatrix} \frac{1}{\Psi_{e,1}} & 0 & \cdots & 0 \\ 0 & \frac{1}{\Psi_{e,2}} & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \cdots & \frac{1}{\Psi_{e,m}} \end{bmatrix} \begin{bmatrix} x_{1,t} \\ x_{2,t} \\ \vdots \\ x_{m,t} \end{bmatrix},$$

$$= \begin{bmatrix} a_{1,1}x_{1,t} + a_{1,2}x_{2,t} + \cdots + a_{1,m}x_{m,t} \\ a_{2,1}x_{1,t} + a_{2,2}x_{2,t} + \cdots + a_{2,m}x_{m,t} \\ \vdots \\ a_{k,1}x_{1,t} + a_{k,2}x_{2,t} + \cdots + a_{k,m}x_{m,t} \end{bmatrix}$$

From these values we can now establish the extent to which every  $\xi_{k,t}$  affects  $Y_t$  (count data) based on GARMA models. Alternatively by multiplying  $\xi_{k,t}$  and the constant  $\psi$  in equation 3.30, we get

$$= [a_{1,1}x_{1,t} + a_{1,2}x_{2,t} + \dots + a_{1,n}x_{n,t}, \dots, a_{k,1}x_{1,t} + a_{k,2}x_{2,t} + \dots + a_{k,n}x_{n,t}] \begin{bmatrix} \psi_1 \\ \psi_2 \\ \vdots \\ \psi_k \end{bmatrix}$$

which yields

$$= [\psi_1 a_{1,1} x_{1,t} + \psi_1 a_{1,2} x_{2,t} + \dots + a_{1,n} x_{n,t}, \dots, \psi_k a_{k,1} x_{1,t} + \psi_k a_{k,2} x_{2,t} + \dots + \psi_k a_{k,n} x_{n,t}] \quad (22)$$

hence we write the above equation as:

$$= \underbrace{(\psi_1 a_{1,1} + \psi_2 a_{2,1} + \dots + \psi_k a_{k,1})}_{\psi_1^*} x_{1,t} + \underbrace{(\psi_1 a_{1,2} + \psi_2 a_{2,2} + \dots + \psi_k a_{k,2})}_{\psi_2^*} x_{2,t} + \dots + \underbrace{(\psi_1 a_{1,n} + \psi_2 a_{2,n} + \dots + \psi_k a_{k,n})}_{\psi_k^*} x_{n,t} \quad (23)$$

hence we write the above equation as:

$$\psi_1^* x_{1,t} + \psi_2^* x_{2,t} + \dots + \psi_k^* x_{n,t} \quad (23)$$

which simply imply that  $\xi_{k,t}^T \psi = X_{k,t}^T \psi$  and  $\xi_{k,t}^T \psi = X_{k,t}^T \psi$  in equation 3.28 and 3.29. However using equation 23 we can only be able to establish the relationship between observed variables and the dependent variable and it will be difficult to establish how each the latent variable affect  $Y_t$  count data.

Having obtained  $\xi_{k,t}^T$ , we consider Bayesian prediction of the entire model and this can be done by defining prior densities of the proposed model. Using logarithmic link function for the parameters, the corresponding multivariate Gaussian priors for each parameter will be as follows:

$$\psi^* = [\psi_1^*, \psi_2^*, \dots, \psi_k^*] \text{ where } \psi^* \sim N(\mu_0, \sigma_0^2 \mathbf{I}_0),$$

$$\alpha = [\alpha_1, \alpha_2, \dots, \alpha_q] \text{ where } \alpha \sim N(\mu_1, \sigma_1^2 \mathbf{I}_1)$$

$$\phi = [\phi_1, \phi_2, \dots, \phi_q] \text{ where } \phi \sim N(\mu_2, \sigma_2^2 \mathbf{I}_2)$$

with  $\mathbf{I}_0, \mathbf{I}_1, \mathbf{I}_2$ , are identity matrices of order  $k \times k, p \times p, q \times q$  respectively

$\mu_0, \mu_1, \mu_2$  are mean vectors of length  $k, p$  and  $q$  also  $\sigma_0, \sigma_1, \sigma_2$  are prior variance. the likelihood function for the proposed model can be presented as follows:

$$L(\psi^*, \alpha, \phi) \propto \prod_{t=r+1}^n f(y_t | H_{t-1}) \quad (24)$$

which can be expanded to yield the following:

which can be expanded to yield the following:

$$\begin{aligned}
L(\beta^*, \alpha, \phi | Y_t) &\propto \prod_{t=r+1}^n f(y_t | H_{t-1}) \\
&\propto \prod_{t=r+1}^n f(Y_t, \psi^*, \alpha, \phi / H_{t-1}) \\
&\propto \prod_{t=r+1}^n \exp\{Y_t \log \mu_t - \mu_t - \log Y_t!\} \\
&\propto \prod_{t=r+1}^n \exp\{Y_t (\sum_{j=1}^p \alpha_j \{g(Y_{t-j}) - ((\Lambda_{t-j}^T \Psi_{t-j}^{-1} \Lambda_{t-j})^{-1} \Lambda_{t-j} \Psi_{t-j}^T X_{t-j}) \psi\} \\
&\quad + \sum_{i=1}^q \phi_i \varepsilon_{t-j} + (\Lambda_t^T \Psi_t^{-1} \Lambda_t)^{-1} \Lambda_t \Psi_t^T X_t) \psi - \lambda_t - \log Y_t!\}
\end{aligned}$$

in this case it is clear that the link function as described in equation 5.2 becomes:

$$\begin{aligned}
\log \mu_t &= \left( \sum_{j=1}^p \alpha_j \{g(Y_{t-j}) - ((\Lambda_{t-j}^T \Psi_{t-j}^{-1} \Lambda_{t-j})^{-1} \Lambda_{t-j} \Psi_{t-j}^T X_{t-j}) \psi\} \right. \\
&\quad \left. + \sum_{i=1}^q \phi_i \varepsilon_{t-j} + (\Lambda_t^T \Psi_t^{-1} \Lambda_t)^{-1} \Lambda_t \Psi_t^T X_t \right) \psi
\end{aligned} \tag{25}$$

Note that in the likelihood function  $\psi^* = \psi((\Lambda_t^T \Psi_t^{-1} \Lambda_t)^{-1} \Lambda_t \Psi_t^T)$

since  $f(y_t | H_{t-1})$  can also be denoted by  $f(Y_t, \psi^*, \alpha, \phi / H_{t-1})$  as described in the likelihood function, its conditional density function can be written as:

$$f(y_t | \beta^*, \alpha, \phi, H_t) = \exp\{Y_t \log \mu_t - \mu_t - \log Y_t!\} \tag{26}$$

where  $H_t$  denotes a set of all information up to time  $t$ . The conditional mean and variance for  $y_t$ , given  $H_t$ , are:  $E(y_t | H_t) = \mu_t$  and  $var(y_t | H_t) = \mu_t$ , respectively. Similarly, from the likelihood function, the posterior distribution can be presented as

$$p(\psi^*, \alpha, \phi | Y) \propto L(\psi^*, \alpha, \phi | Y) P(\psi^*, \alpha, \phi) \tag{27}$$

Now using equation 18 and 19 the density of  $y_t$  can be expressed as:

$$p(Y_t | \hat{H}_t) = \int_{\{\psi^*, \alpha, \phi\}} f(Y_t | \psi^*, \alpha, \phi, \hat{H}_t) p(\psi^*, \alpha, \phi) d\psi, d\alpha, d\phi \tag{28}$$

Now applying MCMC algorithm, we can obtain the probability of  $Y_t$  given  $H_t$

$$p(Y_t | \hat{H}_t) = \frac{1}{D} \sum_{j=1}^D f(Y_t | \psi^{*(j)}, \alpha^{(j)}, \phi^{(j)}, \hat{H}_t) \tag{29}$$

Evaluating the expected value of  $Y_t$  given  $H^t$  we get that

$$E(Y_t|\hat{H}_t) = \int_{Y_t} Y_t p(Y_t|\hat{H}_t) dY_t = \hat{Y}_t \quad (30)$$

combining equation 20 and 22 we get the following:

$$E(Y_t|H_t) = \int_{Y_t} Y_t \left[ \int_{\{\psi^*, \alpha, \phi\}} f(Y_t|\psi^*, \alpha, \phi, \hat{H}_t) p(\psi^*, \alpha, \phi) d\psi^*, d\alpha, d\phi \right] dY_t \quad (31)$$

which leads to

$$E(Y_t|\hat{H}_t) = \int_{\{\psi^*, \alpha, \phi\}} \left[ E(Y_t|\psi^*, \alpha, \phi, \hat{H}_t) \right] p(\psi^*, \alpha, \phi) d\psi^*, d\alpha, d\phi. \quad (32)$$

if we let  $E(Y_t|\psi^*, \alpha, \phi, H^t) = \mu_t$  for the parameters  $\psi^*, \alpha, \phi, H^t$  then by applying MCMC output vector  $(\psi^*(j), \alpha_j, \phi_j), j = 1, 2, \dots, D$  it follows that  $E(Y_t|H^t)$  can be obtained by the expression

$$\hat{Y}_t = \frac{1}{D} \sum_{j=1}^D \mu_t(\psi^{*(k)}, \alpha^{(k)}, \phi^{(k)}, \hat{H}_t) \quad (33)$$

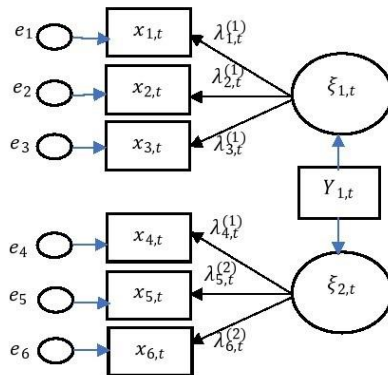
The interval of the  $Y^t$  based on  $100(1 - \alpha)$  quantiles of MCMC sample  $\mu_t$  can be obtained Highest posterior Density approach as described by Chen and Shao(1998)

## Results

The findings based on simulated data, considered CFA model with two latent variables observed at time  $t$  and using the bayesian approach to estimate the parameter in the model we get the estimates shown in Table 1

$$X_{kt} = \Lambda_{kt} \xi_{kt} + \epsilon_{kt}$$

Figure 2



Parameters	Bayes Est	Std Er	Paramete	rsBayes Est	Std E
$\lambda_{1,t}^{(1)}$	0.861	0.241	$\psi_{e,1}$	0.671	0.127
$\lambda_{2,t}^{(1)}$	0.714	0.156	$\psi_{e,2}$	0.948	0.188
$\lambda_{3,t}^{(1)}$	0.527	0.142	$\psi_{e,3}$	1.086	0.176
$\lambda_{4,t}^{(2)}$	0.682	0.195	$\psi_{e,4}$	1.062	0.142
$\lambda_{5,t}^{(2)}$	0.611	0.132	$\psi_{e,5}$	1.053	0.081
$\lambda_{6,t}^{(2)}$	0.543	0.161	$\psi_{e,6}$	0.872	0.193
$\Phi_{11}$	0.723	0.161	$\Phi_{12}$	1.072	0.981

from the above estimator we estimate  $\xi_{k,t}$  (latent score) values using the equation

$$\xi_{k,t} = ((\Lambda_{m,t}^k)^T \Psi_{k,t}^{-1} \Lambda_{m,t}^k)^{-1} (\Lambda_{m,t}^k)^T \Psi_{k,t}^{-1} X_{m,t}$$

$$\xi_{k,t} = \begin{bmatrix} \xi_{1,t} \\ \xi_{2,t} \end{bmatrix} =$$

$$\begin{bmatrix} a_{1,1}x_{1,t} + a_{1,2}x_{2,t} + a_{1,3}x_{3,t} + a_{1,4}x_{4,t} + a_{1,5}x_{5,t} & a_{1,6}x_{6,t} \\ a_{2,1}x_{1,t} + a_{2,2}x_{2,t} + a_{2,3}x_{3,t} + a_{2,4}x_{4,t} + a_{2,5}x_{5,t} & a_{2,6}x_{6,t} \end{bmatrix}$$

Now considering the link function of poisson GARMA models of order (1,1),(2,1) (1,2),(2,2)

$$y_t = \beta_0 + \beta_1 \xi_{1,t} + \beta_2 \xi_{2,t} + \alpha_1 y_{t-1} + \vartheta_1 e_{t-1} + e_t \quad (34)$$

$$y_t = \beta_0 + \beta_1 \xi_{1,t} + \beta_2 \xi_{2,t} + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \vartheta_1 e_{t-1} + e_t \quad (35)$$

$$y_t = \beta_0 + \beta_1 \xi_{1,t} + \beta_2 \xi_{2,t} + \alpha_1 y_{t-1} + \vartheta_1 e_{t-1} + \vartheta_2 e_{t-2} + e_t \quad (36)$$

$$y_t = \beta_0 + \beta_1 \xi_{1,t} + \beta_2 \xi_{2,t} + \alpha_1 y_{t-1} + \alpha_1 y_{t-1} + \vartheta_1 e_{t-1} + \vartheta_2 e_{t-2} + e_t \quad (37)$$

The chosen initial Values parameter for simulation study were as follows:

Order	$\beta_0$	$\beta_1$	$\beta_2$	$\varphi_1$	$\varphi_2$	$\vartheta_1$	$\vartheta_2$
GARMA(1,1)	0.65	1.24	2.21	0.60	-	0.35	-
GARMA(2,1)	1.20	1.35	2.25	0.45	-	0.44	0.30
GARMA(1,2)	0.75	1.45	3.52	0.56	0.45	0.25	-
GARMA(2,2)	0.21	1.30	1.90	0.35	0.44	0.30	0.42

Node	Mean	Sd	Mc Error	2.5%	Median	97.5%	Sample
beta0	1.88	0.2778	0.02654	1.286	1.899	2.349	1000
beta1	2.658	0.07242	0.006581	2.524	2.655	2.798	1500
beta2	0.9755	0.07206	0.0022	0.8322	0.975	1.117	1500
alpha1	0.8643	0.03392	0.00321	0.7834	0.8698	0.9128	1500
theta1	0.09884	0.01555	5.286E-4	0.0739	0.09752	0.1342	1500

## Conclusion

Based on the objective of the study we can conclude that the developed Bsem model proved to be more efficient and effective if it is applied to simulated count time series, now what remains is the application of model to real count time series being influence by latent variable. and the properties of the estimates which still under study. along with that study is under scrutiny to condition under which over dispersion exist.

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## **Prokaryotic Communities Within Threatened lakes in Kenya**

Catherine Wachera Kiama<sup>1\*</sup>, Moses Mucugi Njire<sup>1</sup>, Anne Kelly Kambura<sup>3</sup>,

Julius Ndirangu Mugweru<sup>4</sup>, Viviene Njeri Matiru<sup>1</sup>, Eliud Nalinya Wafula<sup>5</sup>, Robert Nesta

Kagali<sup>2</sup> and Josiah Ochieng Kuja<sup>1</sup>

<sup>1</sup>Department of Botany, Jomo Kenyatta University of Agriculture and Technology, P. O. Box 62000-00200 Nairobi, Kenya.

<sup>2</sup>Department of Zoology, Jomo Kenyatta University of Agriculture and Technology, P. O. Box 62000-00200 Nairobi, Kenya.

<sup>3</sup>School of Agriculture, Earth and Environmental Sciences, Taita Taveta University, P. O. Box 635-80300 Voi, Kenya.

<sup>4</sup>School of Pure and Applied Sciences, University of Embu, P. O. Box 6 -60100, Embu, Kenya.

<sup>5</sup>Department of Biological Sciences, Bomet University College, P.O Box 701-20400, Bomet Kenya.

\*Corresponding author's email: kiamac65@gmail.com

### **Abstract**

Inland lakes are rich in beneficial microbial species. Prokaryotic communities within lakes ecosystems are essential to the functioning and major biogeochemical cycles. The rapidly disappearing inland lakes Olbolosat and Oloiden experience persistent global warming and climate change thus directly affecting microbial reservoirs. Loss of microbial reservoirs leads to the breakdown of symbiotic relationships and the loss of microbial functions. Moreover, these lakes are neglected and less studied for microbial diversity and community structure. However, due to the complexity of the culture-dependent techniques, only a limited number of prokaryotes have been extensively studied. Therefore, metagenomics provides detailed

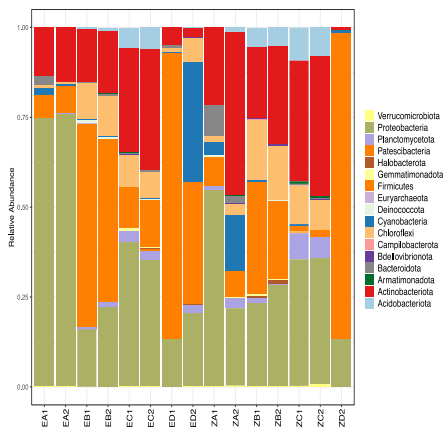
information on the microbial community. In this study, Amplicon Sequence Variant (ASVs) method was adopted to identify and classify beneficial microbial species. Proteobacteria was the most dominant phylum (33.8%), across all samples in both lakes and was highly positively connected with other microbes. The abundant archaea phyla recovered were Halobacterota (0.14%), and Euryarchaeota (0.06%). Prokaryotic diversity for lake Oloiden was lower than that of L. Olbolosat. Targeted prokaryotic isolation should be carried for the recovered novel microbial taxa.

## Introduction

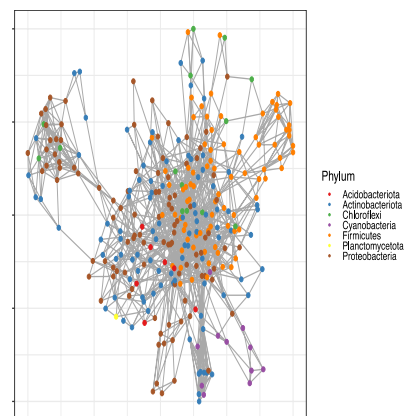
Inland lakes support the livelihoods of local communities, wildlife and livestock. The study is in line with the African Commission priority areas of the Agenda 2063 framework on the use of indigenous knowledge in science and technology and innovation for sustainable development and also acts with a sense of urgency on climate change and the environment A U[1].

## Results

Proteobacteria was the most dominant phyla across all samples in both lakes (Figure 1) and was highly positively connected with other microbes (Figure 2). The abundant archaea were Halobacterotata and Euryarchaeota (Figure 1).



**Figure 1:** Relative abundance for the predominant phyla



**Figure 2:** Interaction network

## **Discussion**

Proteobacteria play a crucial role in biodegradation within the lake ecosystem Huang et al [2]. Methanogens recovered could play a role in removing dissolved methane in the lakes and other pollutants. Some methanogens contribute to global warming while others can be used as bioenergy thus reducing carbon emission Laskar et al [3]

## **Conclusion and Recommendation**

Proteobacteria was the most dominant phyla positively connected with other microbes. Targeted prokaryotic isolation should be carried for the recovered novel microbial taxa.

## **Acknowledgement**

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# Comparison of Three Gap-Filling Approaches in the Latent Heat Flux Measurements

Miriam HOUNSINOU<sup>1,2\*</sup>, Ossénatou MAMADOU<sup>1,2</sup> and Basile KOUNOUHEWA<sup>2</sup>

<sup>1</sup>Institut de Mathématiques et de Sciences Physiques, Université d'Abomey – Calavi, Bénin.

<sup>2</sup>Laboratoire de Physique du Rayonnement (LPR), Faculté des Sciences et Techniques,  
Université d'Abomey – Calavi, Bénin.

\*Corresponding author's email: miriam.hounsinou@imsp-uac.org

## Abstract

The gaps in the water vapor flux (LE) data measured by the Eddy covariance (EC) technique absolutely need to be filled because of its crucial importance for the water balance as well as for predictions in many fields such as agriculture and meteorology. We evaluated in this work, three gap filling (GF) methods in the LE data, acquired above two ecosystems located in northern Benin (west Africa): a culture (Nalohou) and a forest (Bellefougou). These are the method using the Penman-Monteith equation (PM), the method based on the Penman-Monteith equation proposed by the FAO (FAO) and finally the Dynamic Linear Regression (DLR). The evaluation was made on the basis of the 2009-year data. The missing data during this year were 42.81% and 51.23% respectively at Nalohou and Bellefougou. The results show that the FAO method seems to be more suitable for culture while the DLR method is more adapted for forest. A good estimation of LE at night is however observed with the FAO method while the DLR method seems to better estimate LE during the day at both sites. Finally, we noticed that the estimation of LE at a certain time by the PM method considering the climatic parameters of the immediate previous time could improve the results of this method on the two sites.

## Introduction

Data collection is often affected by gaps due to several factors. This issue is frequent in all scientific fields and several approaches are used to reconstruct the missing data. In micrometeorology, Falge et al [1] was the first who have developed techniques to fill the gaps in CO<sub>2</sub>, LE and sensible heat fluxes measured with the EC method. After this work, many techniques have been developed to fill the gaps in all fluxes. However, the performance of the GF methods depends on the distribution of the gaps, the climatic and geographical locations.

The diversity of these results calls for further investigation, especially in Africa where very few studies have been conducted. The objective of this study is to compare three GF methods for LE data measured by the EC above a crop and a forest located in a tropical region characterized by two seasons (dry and wet) separated by transition phases (moistening and drying).

## Methodology

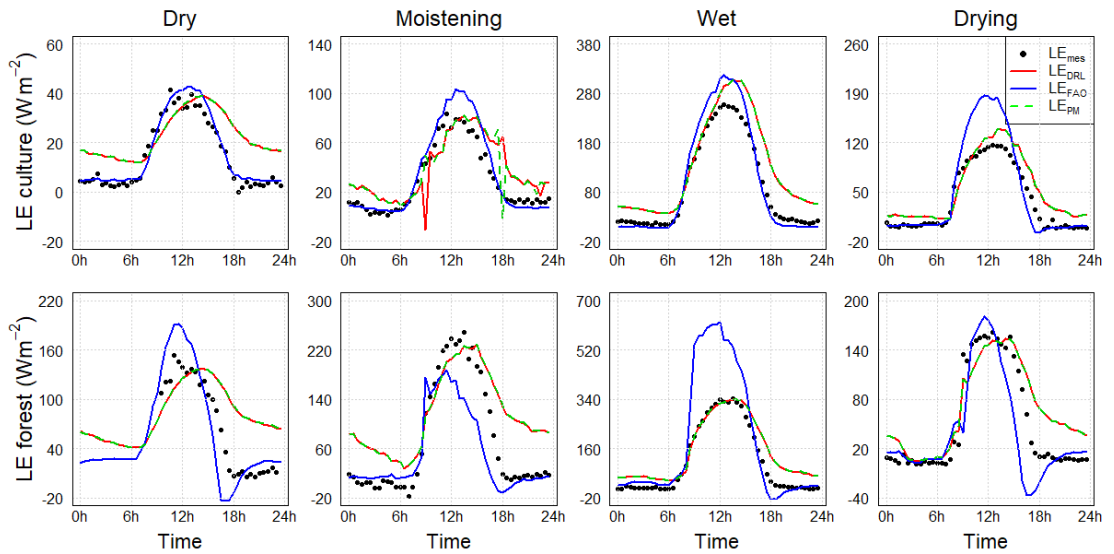
The LE, also called actual evapotranspiration, can be determined by Penman-Monteith equation (1)

$$LE_{PM} = \frac{\Delta(R_n - G) + \rho_a C_p \frac{e_s - e_a}{r_a}}{\Delta + \gamma(1 + \frac{r_s}{r_a})} \quad (1)$$

with  $R_n$  the net radiation,  $G$  the soil heat flux,  $\rho_a$  the air density at constant pressure,  $C_p$  the specific heat of the air,  $e_s$  the saturation vapor pressure,  $e_a$  the real vapor pressure,  $\Delta$  the slope of the vapor pressure curve at the mean air temperature,  $r_a$  the aerodynamic resistance,  $r_s$  the canopy resistance and the  $\gamma$  psychrometric constant. The method FAO, consists in determining LE by equation (1) considering  $r_s = 50s/m$  during the day and  $r_s = 200s/m$  during the night (Allen et al., 2006) and the cultural coefficient is calculated as the ratio of LE measured by EC and LE calculated by equation (1) (Park et al., 2015). As for DLR, it is also based on equation (1) but it uses the climate parameters of the immediate past time to calculate LE of the current time (Alavi et al., 2006).

## Results

The performance of each GF method varied by season, day and night (Figure 1). Indeed, we do not have the same gap percent in day and night and in each season. Overall for the year studied, the FAO seems to estimate LE better at the crop site with a bias of  $13.04Wm^{-2}$  and a linear correlation of 0.77. On the forest site, the DLR looks better than the others methods with a bias of  $32.91Wm^{-2}$  and a linear correlation of 0.67.



**Figure 1:** Average diurnal cycles of latent heat fluxes measured by the EC method ( $LE_{mes}$ ) and estimated by the PM, FAO and DLR gap-filling methods ( $LE_{PM}$ ,  $LE_{FAO}$  and  $LE_{DRL}$ )

## Discussion

In this study, FAO gives more satisfactory results on crop than on forest. This is in agreement with the results of Park et al [4]. As we had noted, several authors such as Alavi et al [3] had shown that the performance of a gap-filling method depends on the size of the gaps.

## Conclusion and Recommendation

The performance of each of the GF methods varies according to the data gap rate and season. Implementing a GF technique that takes into account the climatic conditions of the study region would improve the estimation of missing data at the study sites.

## Acknowledgement

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## **Genetic Diversity of Plasmodium falciparum Isolates in Minna, North Central Nigeria**

Usman-Yamman Hadijah<sup>1</sup>✉, Omalu C. J. Innocent<sup>1</sup>, Abubakar Abdulkadir<sup>2</sup>, Abolarinwa S. O<sup>1</sup>,  
Eke S. Samuel<sup>3</sup> and Otuu A. Chidiebere<sup>4</sup>

<sup>1</sup>Department of Animal Biology, Federal University of Technology, Minna, Nigeria.

<sup>2</sup>Department of Biochemistry, Federal University of Technology, Minna, Nigeria.

<sup>3</sup>Department of Biology, Air Force Institute of Technology, Kaduna, Nigeria

<sup>4</sup>Department of Zoology and Environmental Health, University of Nigeria, Nsukka, Nigeria.

\*Corresponding author's email: nnalude@gmail.com

### **Abstract**

North-Central Nigeria is a region characterized with a high incidence of malaria caused majorly by *Plasmodium falciparum*. The parasite level of antigenic diversity varies from one malaria endemic region to another, and exist at different frequencies in different geographic areas presenting different complexities of infection. Therefore, genotyping malaria parasites to assess their diversity in different geographic settings have become necessary for the selection of antigenic epitopes for vaccine development and for further implementation of regional intervention programs. This study utilizes the MSP1 and MSP2 variant forms of *P. falciparum* to examine its diversity and multiplicity of infection (MOI). Overall, 57 MSP1 genotypes, including K1, MAD20 and RO33 were identified, ranging from (250-1000bp), (100-500bp) and (200-500bp), respectively. However, a peculiarity about this study is the polyclonal nature of RO33 with 400-500bp. In addition, 54 different MSP2 genotypes of FC27 and 3D7 alleles ranging from (100-900bp) and (400-800bp), respectively was identified. Determination of gene diversity revealed MAD20 as the predominant allele for MSP1 with MOI of 1.23 and FC27 for MSP2 with 1.17 MOI. There was however, no statistical significance difference between MOI and age of the child ( $P > 0.05$ ). Meanwhile, findings from this study revealed *P. falciparum* populations were not genetically diverse with Heterozygosity ( $H_e$ ) index of 0.0636. This study has demonstrated the potential of gene diversity and MOI of *P. falciparum*, as important markers for assessing differences in malaria transmission intensity. Continuous malaria genetic surveillance is therefore recommended as an important tool in monitoring changes in gene types and for intervention programs effectiveness.

## Introduction

Malaria is a major global public health concern especially in countries where transmission occurs regularly. However, the development of an effective vaccine is being hampered by genetic diversity, even though extensive research on the diversity in the parasite field isolates have been conducted in several studies. This diversity has the potential to alter the conformation of antimalarial drug targets and render the parasites drug resistant which will hinder malaria treatment outcome. Genetic diversity and multiplicity of *P. falciparum* infections are essential parasite indices that could determine the impact of malaria intervention programs as well as the endemicity of parasite infections in varying transmission settings.

## Results

From the total of 50 *P. falciparum* positive samples presented for PCR, 46 (92.00%) tested positive for at least one allele which were typed for MSP1 or MSP2 genes. A total of 111 band sizes was produced for all the alleles of MSP 1 and 2, of which 57/111 (51.35%) and 54/111 (48.64%) of them were successfully examined for the presence of MSP1 (MAD20, K1, RO33) and MSP2 (3D7, FC27), respectively. MAD20 was the predominant allele observed in MSP1 with 31/50 isolates (62.00%) and yielded four (4) fragments (within a range of 100-500bp). Meanwhile, MSP2 gene recorded FC27 as the predominant allele with 43/50 isolates (86.00%) and produced up to eight (8) fragments (within a range of 100-900bp) and 3D7 produced three (3) fragments (within a range of 400-800bp) from 11/50 isolates (22.00%) (Table 1).

A monoclonal infections (only one band size or fragment produced per allele) of 47 (82.46%); and a polyclonal infection (more than one band size produced per allele) of 10 (17.54%) was recorded in MSP1 gene. On the other hand, MSP2 recorded 83 (74.77%) and 28 (25.23%) for monoclonal and polyclonal infections, respectively. The overall monoclonal infections recorded during the study was 83 (74.77%) and a polyclonal infection of 28 (25.23%). Furthermore, of the 46 PCR positive samples, 41 (89.13%) of the samples had poly-allelic infection i.e. they harbored more than one parasite genotype identified by the presence of two or more alleles of one or both genes, and 5(10.87%) had single allele (mono-allelic) of MSP2 genes, only.

The heterozygosity ( $H_e$ ) index determined for the antigenic markers of MSP1 and MSP2 was 0.714 and 0.830, respectively which signifies a wide range of allele diversity within the individual

genes. However, in the overall a very low level of genetic diversity was detected in Minna with expected heterozygosity ( $H_e$ ) value of 0.0636. Meanwhile, the overall mean multiplicity of infection (MOI) for both MSP1 and MSP2 gene was 2.22, and the individual antigenic marker recorded 1.23 and 1.17, respectively.

**Table 1.** Number of *P. falciparum* Alleles and Base Pair Ranges Observed per Allelic Family in

Gene/Allele	PCR Positive samples (%)	PCR band size (bp)	Number of observed bands
<b>MSP1</b>			
<b>K1</b>	<b>21(42.00)</b>	<b>250-1000</b>	<b>3</b>
<b>MAD20</b>	<b>31 (62.00)</b>	<b>100-500</b>	<b>4</b>
<b>RO33</b>	<b>5(10.00)</b>	<b>400-500</b>	<b>2</b>
<b>MSP2</b>			
<b>3D7</b>	<b>11(22.00)</b>	<b>100-800</b>	<b>4</b>
<b>FC27</b>	<b>43(86.00)</b>	<b>100-900</b>	<b>8</b>
<b>TOTAL</b>	<b>111 (100)</b>		

## Discussion

The antigenic markers used for this study were recommended for genotyping parasites in antimalarial drug efficacy trials and parasite population structure analysis by the World Health Organisation. Findings from this study revealed MAD20 to have the highest frequency of alleles in MSP1 gene, with 31 (62%) and yielded four fragments within the range of 100-500bp. Amplification of the allelic family K1 was positive for 21 isolates (42%) and yielded three fragments within the range of 250-1000bp. Allelic family RO33 which recorded the lowest frequency in MSP1 gene had only 5 isolates (10%) and yielded two fragments 400 and 500bp. However, in a similar study conducted in South-western, Nigeria Olasehinde et al [1], it detected proportion of isolates with K1 family as 68% with 4 alleles within the range of 100 to 300 bp. Proportion of isolates with MAD20 family as 40% and a total of 3 alleles were observed within 100 to 300 bp. RO33 proportion was 20% and the family was observed to be monomorphic with an allele size of 200 bp.

The predominant allele types for this study was MAD20 (MSP1) and FC27 (MSP2) with more than half of the study population infected. This observation was not in conformity with previous works conducted in South-west Ethiopia, Sudan and Malaysia, which detected the

K1, RO33 and RO33 allelic family as predominant. However, this was in conformity with a previous work by Soe et al [2] who observed MAD20 type as the most prevalent for MSP1. Meanwhile, previous works from Ethiopia, Kenya, Congo Brazzaville Myanmar and other sub-Saharan-African countries detected 3D7 as the predominant allele in the MSP2 gene, which was contrary to what was observed from this study with FC27 as the predominant allele.

Only one-third of the population (35%) harboured multiple genotypes of 2, 3 or 4 from a single isolate of either or both MSP1 and MSP2 alleles; and about one-fourth (25%) polyclonal. The high level of mixed infections indicates a high transmission intensity in Minna. The frequency was quite lower than what was obtained from a previous study by Mohammed et al [3] which reported that almost two-third of the samples (62%) and (59%) harboured multiple genotypes, respectively.

The overall mean multiplicity of infection observed from this study was 1.23 and 1.17 for the genetic markers of MSP1 and MSP2, respectively which was lower than what was observed by Mohammed et al [3] with 1.37 and 1.20 for MSP1 and MSP2, respectively, and also from findings in Côte d'Ivoire, where MOI was found to be 2.88 MSP2 Silue, et al [4]. This discrepancy may be due to differences in geographical areas and their transmission patterns and may also be due to differences in sample population. Generally, the higher the malaria transmission level, the greater becomes the tendency to get a higher MOI Mohammed et al [3]. Epidemiologic data from some studies in Africa suggest that the multiplicity of *P. falciparum* infection could be directly related to the intensity of transmission.

Findings generally observed from this study, revealed that *P. falciparum* populations were not genetically diverse (0.0636), although, a high level gene diversity within the individual antigenic markers- MSP1 and MSP2 (with 0.714 and 0.830, respectively) indicates a larger genotype diversity within the MSP1 and MSP2 loci. This was common to the antigenic marker genotyping carried out in African regions like Malaysia, Burkina Faso, Sao Tome, Malawi, Uganda and Tanzania which have identified *P. falciparum* populations with alleles occurring at a very high  $H_e$  level (0.78 to 0.99) Abd Razak et al [5]. Though, Mohammed et al [3], also observed a high  $H_e$  level of 0.79 for MSP1, this observation differs for MSP2 (0.54) with moderate  $H_e$  levels. However, the lack of major differences in parasite variants across Minna may be as a result of malaria control program across Minna and the State as a whole by the distribution of long

lasting insecticide treated nets LLINs across the health facilities and improved service delivery to control and treat malaria which may cause the genetic drift and decrease the level of He and MOI.

### **Conclusion and Recommendation**

This study has demonstrated the potential of malarial gene diversity and MOI, as important markers for assessing differences in malaria transmission intensity. The determination of gene diversity paved way to compare prevalence across the different alleles and confirm the heterogeneity in malaria transmission. This can provide promising information for future research, particularly in evaluating control interventions for malaria elimination in high transmission settings where reductions are most difficult to achieve and sustain. Continuous malaria genetic surveillance is important in monitoring the intervention programs effectiveness. However, monitoring of antimalarial drug efficacy with current genotyping strategies should be enhanced, as well as emphasizing the importance of PCR correction, improved study design and statistical methods.

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