MASENO UNIVERSITY
DIRECTORATE OF RESEARCH
AND INNOVATIONS

BIANNUAL RESEARCH NEWSLETTER

JULY-DECEMBER, 2022

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MESSAGE FROM DIRECTOR, RESEARCH AND INNOVATIONS—PROF. COLLINS OUMA

The Directorate of Research and Innovations at Maseno University, headed by **Prof. Collins Ouma**, is tasked with the responsibility of supporting research, innovations, publications and hosts the Maseno University's Scientific and Ethical Review Committee (MUSERC).


Prof. Collins Ouma-Director, Research

Over the last half year (2022-2023), we have engaged in various activities and we highlight some of the research-related works conducted by some of our staff. Just to highlight the successes over the last 6 months, the Directorate has been able to generate externally research grants amounting to **KShs. 76,187,944** from both research grants and ethics fees. In addition, our academic staff and students have been able to publish in peer-reviewed journals, a total of **151** publications. We are in the process of actualizing several innovations, some of which have been initiated in our establishment: Maseno University Business Incubation Center (MUBIC).

In the current newsletter, we focus on the research activities for three key researchers: Dr. Samuel B. Anyona, Prof. Chrispine Kowenje and Dr. Erick Ogello. Their respective researches span identification of biomarkers for severe malarial anemia in children, production of alternative sources of energy to aquaculture. The Directorate is highly enthusiastic that it will highlight more researchers and their activities within the next half of the year.

Finally, we hope that with more academic and non-academic staff recognizing that research is a core mandate of the University, we should be able to bring into fore more researches and accompanied capacity building.

Prof. Collins Ouma, PhD, MKNAS, FAAS

1. DR. SAMUEL BONUKE ANYONA (BIOCHEMISTRY)

Profile:

Dr Samuel Bonuke Anyona, is currently a Lecturer at the Department of Medical Biochemistry, School of Medicine, Maseno University, Maseno, Kenya. Dr. Anyona holds a PhD in Medical Biochemistry from Kenyatta University, Nairobi, Kenya and postdoctoral training in Global Infectious diseases from the University of New Mexico (UNM), NM, USA.

Dr. Anyona joined the Global Infectious Diseases training program at the UNM-Kenya Project in Kisumu and Siaya (Director; Dr. Douglas J. Perkins) in September of 2007 as a post graduate student. Dr. Anyona was trained (doctoral; 2007-2012) and (Postdoc; 2013-2014) under a Fogarty International Center (FIC), Global Infectious Diseases (GID; D43), Program (PI/Mentor; Dr. Douglas J. Perkins) that supported state-of-the-art training sessions in laboratories at UNM, NM, USA and UNM/Kenya Medical Research Training Institute (UNM/KEMRI) projects in Kisumu and Siaya, Kenya. Dr, Anyona has hands on experience in various Immunological, Biochemical, Genomic, Bioinformatics and Statistical analysis techniques.

Dr. Anyona's research work revolves around infectious diseases, specifically malaria anemia and related comorbidities (HIV, bacteremia, TB) in pediatric populations living under intense *Plasmodium falciparum* malaria transmission in regions of western Kenya. During his doctoral studies, Dr. Anyona investigated the effects of naturally acquired malarial pigment by monocytes, and the role of cyclooxygenase-2 polymorphisms on susceptibility to severe malaria through their ability to elicit functional changes in prostaglandin-E_2 production. Dr. Anyona's post-doctoral training continued along the same path.

In the 2018-2019 financial year, Dr. Anyona was a fellow under the prestigious Fogarty Global Health Program with the Harvard University, Boston University, Northwestern University, and University of New Mexico (HBNU) Consortium. The 1-year fellowship investigated the *Perturbations of the Human Ubiquitin Proteasome System (UPS) following infection with Severe Malarial Anemia (Hb<5.0g/dL) in children living in P. falciparum endemic region of western Kenya*.

In late 2019, Dr. Anyona applied for the FIC Emerging Global Leader Award (K43) grant. The application was successful and Dr. Anyona received a 4-year (August 2020- July 2024) award (K43 TW011581). The research study builds on the UPS work started during the HBNU fellowship, and is investigating the *Dysregulation of the Human Ubiquitin Proteasome System in Pediatric Severe Malarial Anemia*. The grant is currently in year 3 of its implementation.

Dr. Anyona has published over 26 articles (first and co-authored) in international peer review journals https://www.ncbi.nlm.nih.gov/myncbi/1-qxng6Gc7PcDL/bibliography/public/, and presented over 84 abstracts (1st and co-authored) at international conferences (67 of which are at the ASTMH). https://scholar.google.com/citations?hl=en&user=5bx1jH0AAAAJ.

The following are details of the project that Dr. Anyona has been involved in:

Malaria Associated Morbidities and Mortalities: Despite the increased progress made towards elimination of the malaria since the year 2000, malaria still remains a global health challenge. In 2021, there were an estimated 247 million malaria cases reported globally. The World Health Organization (WHO) African region reported an estimated 234 million cases in 2021, accounting for 95% of all global cases[1]. Consequently, there were 619,000 malaria related deaths reported in 2021, with the WHO African region accounting for 593,000 (>95%) of all global mortalities, majority (76%) of which occurred in children aged <5 years old[1]. In East Africa, malaria was highest among children <5 years old, driven largely by transmission intensity, with severe malaria presenting as a most common clinical manifestation. In Kenya, the estimated malaria cases reported in 2021 was 341 million (range 247 million – 464 million), resulting in 12,011 deaths (range 10,800 – 14,000)[1]. In western Kenya, severe malaria is among the leading causes of morbidity and mortality[2-4].

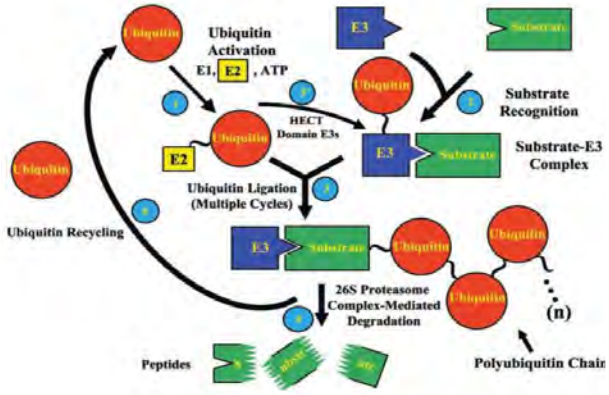

Figure 1. The ubiquitin proteolytic pathway. (1) Activation of ubiquitin by the ubiquitin-activating enzyme E1, a ubiquitin-carrier protein, E2 (ubiquitin-conjugating enzyme, UBC), and ATP; (2) Binding of the protein substrate, via a defined recognition motif, to a specific ubiquitin-protein ligase, E3; (3) Multiple cycles of conjugation of ubiquitin to the target substrate and synthesis of a polyubiquitin chain. E2 transfers the first activated ubiquitin moiety directly to the E3-bound substrate, and in following cycles, to previously conjugated ubiquitin moiety; (4) Degradation of the ubiquitin-tagged substrate by the 26S proteasome complex with release of short peptides and (5) Ubiquitin is recycled via the activity of deubiquitinating enzymes (DUBs). Adopted from[2].

The Pathogenesis of Severe Malaria: Severe clinical manifestations of malaria vary with transmission intensity, but fall into three common categories: severe malarial anemia [SMA, hemoglobin (Hb)<5.0 g/dL], cerebral malaria (CM), and metabolic acidosis[5-8]. In western Kenya, a region endemic for *Plasmodium falciparum* transmission, the primary severe malaria manifestation is SMA[4,9,10]. The severity of malarial anemia in western Kenya is further compounded by endemic co-infections (e.g., bacteremia and HIV-1), nutritional deficiencies, and host genetic factors[11-16].

The multifaceted pathogenesis of SMA, at least in part, can be attributed to altered host-immune responses that suppress erythropoiesis and enhance hemolysis, resulting in profoundly low Hb concentrations[6,17]. Although factors that are central to the SMA pathogenesis include perturbations of inflammatory mediator production[6,18,19], the complex immunological cascades and genetic pathways which promote the development of SMA remain only partially defined. Among the novel area of research that has not been investigated in human severe malaria is the ubiquitination process and its effect on inflammatory mediators. As such, the current study set out to the impact of the human Ubiquitin Proteasome System in Pediatric Severe Malarial Anemia.

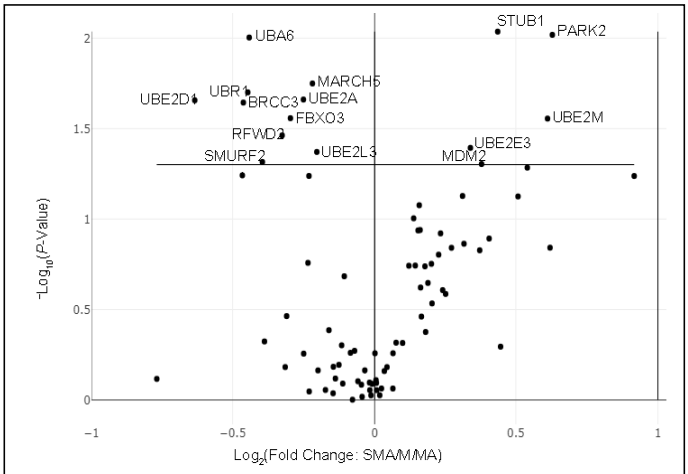

Figure 2: Comparison of ubiquitylation gene expression levels The Volcano Plot shows gene expression changes that plots the log base 2 of each gene fold change value on the x-axis versus the negative log base 10 of each genes *p*-value on the y-axis. The center vertical line indicates unchanged gene expression, while the two outer vertical lines indicate the selected fold regulation threshold, with the data points right of the solid line indicating upregulated genes and those to the left representing downregulated genes. *P*-values were calculated using the student's *t*-test of the triplicate raw C_T values.

Ubiquitin Proteasome System (UPS): The UPS is the main cellular machinery responsible for the degradation of intracellular proteins in eukaryotic cells, and key to the regulation of cellular processes, including proliferation, cell-cycle control, transcriptional regulation, and stress-respons[20]. The ubiquitin proteolytic pathway is shown in **Figure 1**.

Study Aim: To identify genes in the host UPS that contribute to the development of SMA.

Hypothesis: Children with SMA have distinct patterns of dysregulation in the UPS that promote severe anemia.

Expression patterns of 84 key UPS genes measured in children with mild malaria (controls, Hb>9.0 g/dL) and SMA (cases) at enrollment (pre-treatment; day 0).

Method: To examine the role of the ubiquitination processes in pathogenesis of SMA, differential gene expression profiles were determined in Kenyan children (n=44, aged <48 mos.) with either mild malarial anemia (M/MA; Hb≥9.0 g/dL; n=23) or SMA (Hb<6.0 g/dL; n=21) using the Qiagen Human Ubiquitination Pathway RT² Profiler PCR Array containing a set of 84 human ubiquitination genes.

Results: In children with SMA, 10 genes were down-regulated (*BRCC3*, *FBXO3*, *MARCH5*, *RFWD2*, *SMURF2*, *UBA6*, *UBE2A*, *UBE2D1*, *UBE2L3*, *UBR1*), and 5 genes were up-regulated (*MDM2*, *PARK2*, *STUB1*, *UBE2E3*, *UBE2M*) (**Figure 2**).

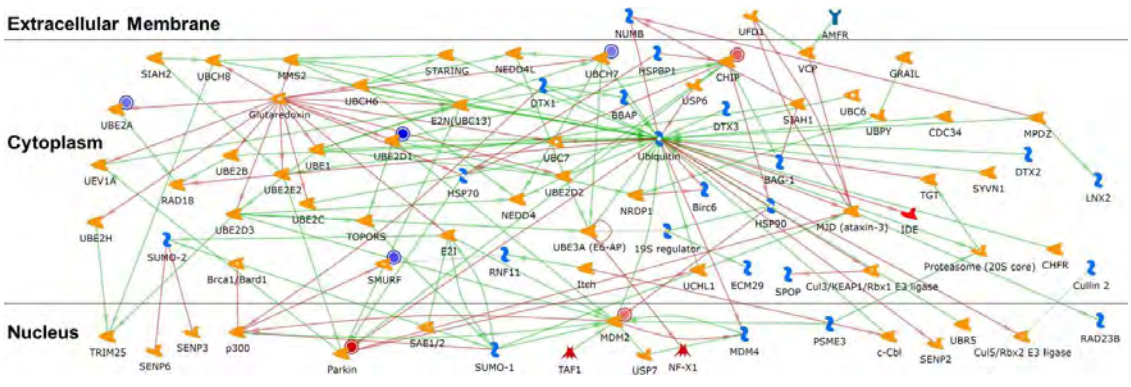

Figure 3: Differentially expressed gene enrichment analysis of the top scored process network. The Ubiquitin-Proteasomal Proteolysis (FDR, P=7.049x10^{-11}) process network that encompassed 8 of the 15 genes that were significantly dysregulated. The blue-shaded circles show down-regulated genes and the red-shaded circles are up-regulated genes, all from the ubiquitination panel.

Enrichment analyses revealed Ubiquitin-Proteasomal Proteolysis as the top disrupted process, along with altered sub-networks involved in proteasomal, protein, and ubiquitin-dependent catabolic processes (**Figure 3**).

Additional enrichment analyses were performed using canonical pathway modeling for the genes that were differentially expressed ($P \leq 0.050$) between the case (SMA) and control (M/MA) groups. The top ranked sub-network [CFTR, Proteasome (20S core), CHIP, RBP-J kappa (CBF1), and c-Jun, $P=1.610 \times 10^{-41}$] contained 11 significant differentially expressed seed nodes and 31 total nodes, with gene ontology (GO) processes identified for protein catabolic processes (**Figure 4**).

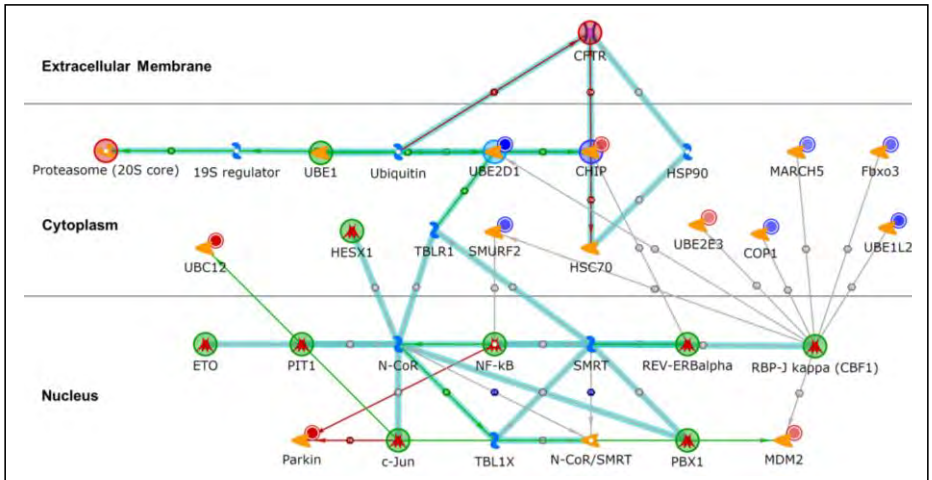

Figure 4: The sub-network [CFTR, Proteasome (20S core), CHIP, RBP-J kappa (CBF1), c-Jun, $P=1.610 \times 10^{-41}$] contains 11 seed nodes (genes with P<0.050 for differential expression between SMA and M/MA) and 31 total nodes.

Conclusion: Collectively, these novel results show that protein coding genes of the ubiquitination processes are involved in the pathogenesis of SMA.

Implications: Utilization of a targeted panel of 84 human ubiquitination genes identified differentially expressed mRNA transcripts between children with SMA versus M/MA.

Next Planned Phase: Results presented will serve as a potential list to identify genes and pathway process that shall form the basis for identification of therapeutic targets in a series of *in vitro* experiments using existing compounds known to alter the proteasomal network and sub-network identified above. Some of the target therapeutic compounds to be tested are Food and Drug Administration (FDA)-approved.

Publications: The results presented here have been published [21], and an *in vitro* model that mimics SMA showed similar trends of differential expression of genes of genes involved in the ubiquitination process[22].

International Conferences: These results were presented at the American Society of Tropical Medicine and Hygiene (ASTMH) annual conferences in 2020 (Abstract No. 1417) and 2021 (Abstract No. 0251). In addition, Dr. Anyona presented additional work titled "*RNA-Seq Reveals Differential Transcriptome Profiles in Kenyan Children with Severe Malaria Anemia and Predicts Biological Pathways Mediating Immunity*" at the 2022 ASTMH annual conference (**Figure 5**), hosted at the Seattle Conference Center, Seattle, WA, USA. Dr. Anyona co-chaired, alongside Dr. Carola Salas (U.S. Naval Medical Research Unit No. 6, Lima, Peru), the 76th Scientific Session on ***Malaria: Approaches for Understanding Malaria Biology and Pathology*** at the 2022 ASTMH annual conference.

Figure 5: 70th Annual Meeting of the American Society of Tropical Medicine and Hygiene. Seattle Convention Center, Seattle, WA, USA. October 30th – November 3rd 2022.

Funding: The work was supported by National Institutes of Health (NIH) Research Grants R01AI130473 and R01AI51305 (PI: Dr. Douglas J Perkins), NIH Fogarty International Center Grants 1K43TW011581-01(PI: Dr. Samuel B. Anyona).

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2. PROF. CHRISPINE KOWENJE (CHEMISTRY)

Profile:

Chrispin Kowenje is currently an Associate Professor within the Department of Chemistry, Maseno University (Kenya). Prof. Kowenje obtained both his BSc and MSc in Chemistry at Egerton University, Njoro, (Kenya) and a Ph.D. in Materials Physical Chemistry at Binghamton University, State University of New York (SUNY), New York, USA. He had a short Post-doctoral studies at the Chemical Systems Engineering Department, The University of Tokyo (Japan). Prof. Kowenje has additional short-term training in research project planning, monitoring and evaluation, student mentoring and Strategic leadership.

Prof. Kowenje is a trained catalysis materials chemist with applications in environmental remediation (waste water purification) and bio-fuels production. Thus, his main research and teaching areas are in Renewable Energy and applied Chemistry of Water. Prof. Kowenje who is an advisory board member of Future Talent council, chairperson of Africa Future Earth Committee (AFEC) and Sub-Saharan Africa representative to exceed partnership program, has mentored about 10 PhD, 25 MSc and a number of undergraduate students. Prof. Kowenje is a former coordinator at the Centre for research in new and renewable energy at Maseno University. Prof. Kowenje has vast experience in workshops and conference organising, and presentations. Prof. Kowenje is an active member of Kenya Chemical society, Royal society of Chemistry.

Prof. Kowenje has been participating in the following research projects:

Section 1: Optimizing Biodiesel production from Jatropha Plant Oil and Waste Cooking Oil Using Chemically Modified Zeolites.

Section 2: Optimizing Bio-gas production from water hyacinth Using Zeolites.

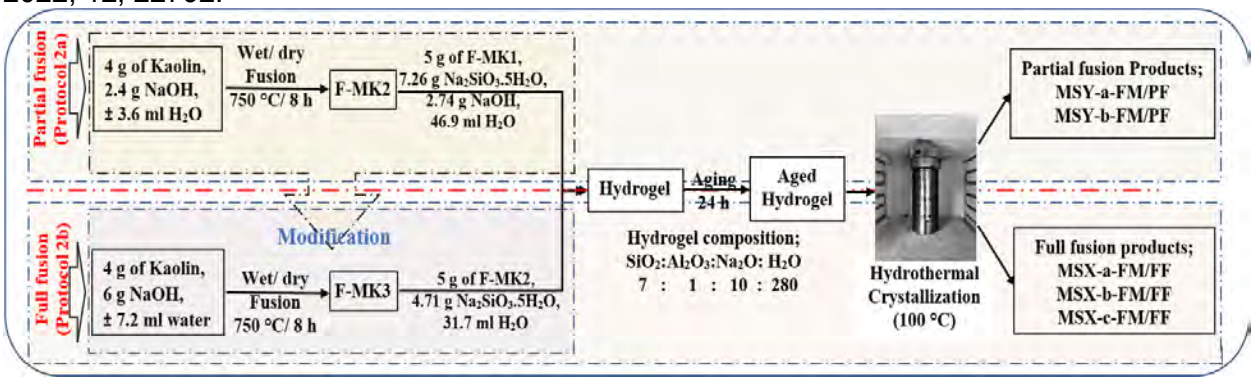
This is the summary of the milestones covered so far.

So far, the following have been achieved:

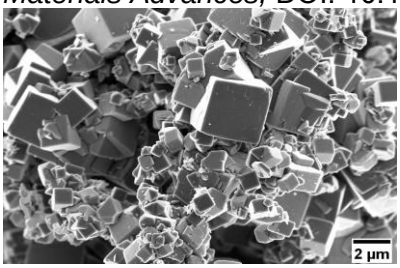
1. Collaboration between the University of Nottingham (UK), University of Younde 1 (Cameroon), Council for Scientific, and Industrial Research (S. Africa) has been realized.
2. One (1) PhD student; Dr. Stephen Otieno has been trained.
3. Tuition fee for two MSc. Students – Mr. Richard Arwa, and Ms. Purity Ngui were realized.
4. Technical staff at Maseno University have been trained on Laboratory safety and management.
5. Teaching staff have been trained on teaching pedagogy and research ethics.
6. Principal investigator (Prof. Kowenje) has been trained and certified on research project monitoring and evaluation.

Publications out of the work:

A) Stephen Otieno, Fredrick Kengara, Chrispin Kowenje and Robert Mokaya (**2022**). Optimization of biodiesel synthesis from Jatropha curcas oil using kaolin derived zeolite Na–X as a catalyst. RSC Adv., 2022, 12, 22792.



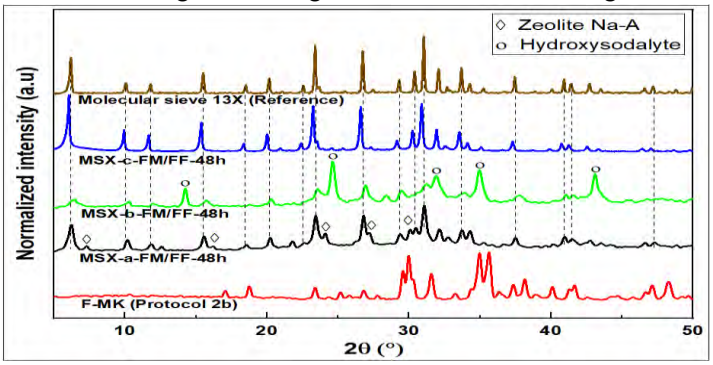
B) Stephen Otieno, Chrispin Kowenje, Fredrick Kengara, and Robert Mokaya **(2021)**; Effect of kaolin pre-treatment method and NaOH levels on the structure and properties of kaolin-derived faujasite zeolites. *Materials Advances,* DOI: 10.1039/d1ma00449b.



SEM image of MK product

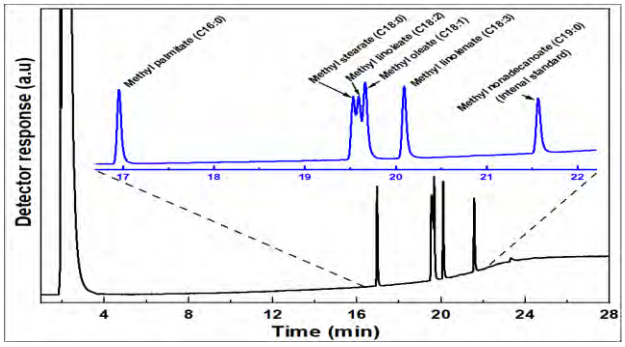
C) Kemmegne-mbouguen, Justin Claude; Tchoumi, Firmin Parfait; Mouafo Tchinda, Edwige; Langmi, Henrietta; Bambalaza, Sonwabo; Musyoka, Nicholas; Kowenje, Chrispin; Mokaya, Robert, **(2020).** Simultaneous quantification of acetaminophen and tryptophan using a composite graphene foam/Zr-MOF film modified electrode. ***New J. Chem.***, 2020,**44**, https://doi.org/10.1039/D0NJ02374D.

D) Stephen O.Otieno, Fredrick O.Kengara, Justin C.Kemmegne-Mbouguen, Henrietta W.Langmi, Chrispin B.O.Kowenje, and RobertMokaya; *The effects of metakaolinization and fused-metakaolinization on zeolites synthesized from quartz rich natural clays***.** Microporous and Mesoporous Materials. Available online 19 Aug. **2019**. https://doi.org/10.1016/j.micromeso. **2019**. 109668.



XRD patterns of FF products

E) S. O. Otieno, C. O. **Kowenje**, A. Okoyo, D. M. Onyango, K. O. Amisi, and K. M. Nzioka **(2018**). Optimizing Production of Biodiesel Catalysed by Chemically Tuned Natural Zeolites. *Materials Today: Proceedings* Vol 5, 4, Part 2, 10561-10569.



MEDIA (electronic and print) POSTS

A) **Mar. 2021:**Richard Arwa, Eddie Ochieng' and Chrispin Kowenje: Magazine Article on Turning Water hyacinth into Fuel and Hand sanitizer: https://scienceafrica.co.ke/turning-water-hyacinth-into-fuel-hand-sanitizer/. 21st Mar. 2021.

B) **Nov. 2021:** Mongabay; News: From a nuisance to a benefit, 'world's worst weed' finds new use as biofuel. https://news.mongabay.com/2021/09/from-a-nuisance-to-a-benefit-worlds-worst-weed-finds-new-use-as-biofuel/

C) **Feb. 2019**: Building a bridge: Kenyan Parliamentarians pledge to work with scientists on SDGs. https://www.sei.org/featured/kenyan-parliamentarians-on-sdgs/

3. DR. ERICK OGELLO (FISHERIES)

Profile:

Dr. Erick Ogello is a prolific scholar, research scientist and Chairman of the Department of Animal and Fisheries Sciences, Maseno University, Kenya. Dr. Ogello holds a Doctor of Philosophy Degree (PhD) in Fisheries Science from Nagasaki University Japan., Master of Science Degree (MSc) in Aquaculture (Great Distinction) in Ghent University, Belgium, and Bachelor of Science Degree (BSc) in Fisheries (First Class Honors) at Moi University, Kenya. Dr. Ogello has obtained additional professional training in 1) Sustainable Aquaculture Development (Wageningen University, The Netherlands), 2) Aquaculture Production and Management (University of Jerusalem, Israel), Streams and River Ecology (Linchoping University, Sweden), Strategic Leadership Development Program (SLDP) and Senior Management Course (SMC) at Kenya School of Government. Dr. Ogello is an African Food Fellow, having been trained under African Food Fellowship and Leadership Program in Wageningen University, Netherlands. Dr. Ogello was recently awarded the African Food Systems and Leadership Award 2022, for being the most promising food systems leader in helping building healthier, more sustainable and inclusive food systems in Africa. His research interests include; Fisheries Science, Aquaculture value chain, and Blue Economy. Dr. Ogello is currently running various projects funded by different agencies, namely 1) Climate Smart Fish Culture Systems Project (KCSAP-funded by World Bank, 2) Artemia production for sustainable mariculture funded by Western Indian Ocean Marine Science Association (WIOMSA), 3) Blue-cycling: Food systems and climate (FOSC) funded by European Union under Horizon-2020, 4) Farm to Fork- Potentials of Agroecological practices in East Africa funded by European Union. Dr. Ogello is an international consultant in matters fisheries, aquaculture and blue economy., and has previously consulted for the World Bank Group, WordFish, MasterCard Foundation among others. Dr. Ogello has published 83 scholarly articles (h-index 19., 1236 citations) in peer reviewed international journals, and presented talks in several local and international scientific conferences. Dr. Ogello is a member of African Center for Aquatic research and Education (ACARE), East African Water Association (EAWA), and Aquaculture Association of Kenya (AAK).

A: Validating Climate-Smart Fish Culture Systems (CSFCS) for Increased Aquaculture Productivity and Livelihood Security in Kenya

The Kenya Climate-Smart Agriculture Project (KCSAP) is a three-year project (2019-2022) funded by the Government of Kenya and the World Bank through Kenya Agriculture and Livestock Organization (KALRO). The project development objective was to “increase agricultural productivity and build resilience to climate change risks in the targeted smallholder farming and pastoral communities, and in the event of an Eligible Crisis or Emergency, to provide immediate and effective response.” To achieve the objective, the project is promoting adoption of climate smart agricultural Technologies, Innovations and Management Practices (TIMPs). KCSAP was a collaborative project conducted by Maseno university (lead partner), Egerton University, University of Eldoret and Kenya Marine and Fisheries Research Institute (KMFRI).

This project validated specific climate-smart fish culture technology innovations and management practices (TIMPs) developed through on-station research initiatives to promote fish production and livelihood security

in Kenya. The innovative TIMPs were 1) biofloc technology, 2) fingerpond technology, 3) integrated fish-poultry and 4) innovative high-density polyethylene (HDPE) fish cage technology.

The project validated sustainable biofloc fish farming systems to increase fish larval survival and productivity, and reduce production cost. The project implemented 50 in-pond live feed dispensers in Bukani aquapark, Busia County. The live-feed dispensers have improved fingerling survival in ponds by 40% and have increased fish production, system resilience and green-house gas mitigation. In addition, the project established a 6m-diameter state-of-the art tank-based biofloc technology in Maseno university fish farm, with a capacity to produce 900kg of fish within 5-6 months at an estimated profit of 60-70%.

In-pond live food dispenser, constructed fish hatchery in Maseno university and State-of-the art 6m-diameter tank based biofloc technology in Maseno University

The project promoted the use of high-density polyethylene (HDPE) fish cages to increase fish productivity while enhancing food safety and of aquatic biodiversity. The project implemented 15-m diameter HDPE in Mulkoba beach (Busia County) and Anyanga Beach (Siaya County) with a capacity to produce over 15 tons of tilapia in 7-8 months.

15m-HDPE fish cages constructed in Anyanga and Mulkoba beach in Siaya and Busia Counties, respectively

To promote fingerpond technology to increase fish production, reduce fishing pressure in lakes and GHG emissions, the project constructed 18 finger ponds in Uwaria beach, Siaya County. The project site is owned by Kings World youth group, and are producing over 300,000 tilapia fingerlings annually.

Fingerpond technology implemented in Uwaria beach for KingsWorld youth group

To validate integrated fish-poultry culture system to increase food productivity while conserving nutrients, the project constructed two integrated fish-poultry culture units in Kakamega County, being operated by Lwanda Muslim Widows group.

Integrated fish-poultry culture system implemented in Kakamega county. The project is

B: Optimizing *Artemia* production technology for sustainable aquaculture and livelihood security for the East African coastal communities (APTSAD)

This project was funded by The Western Indian Ocean Marine Science Association (WIOMSA), which implemented Marine and Coastal Science for Management (MASMA) Programme to assist countries of the western Indian Ocean (WIO) region to achieve the 17 United Nations Sustainable Development Goals (SDGs). As a regional programme, MASMA seeks to strengthen trans-disciplinary and multi-agency research by involving researchers from different disciplines, countries, and sectors to provide sustainable solutions to local problems. In this regard, Maseno University together with Kenya Marine & Fisheries Research Institute (KMFRI), Tanzania Fisheries Research Institute (TAFIRI), Gothenburg University, Sweden, a local coastal community group (Khadzuhoni self-help group) and Kensalt Co. Ltd., jointly developed a research proposal, which was funded by the WIOMSA under the MASMA program between 2020-2022.

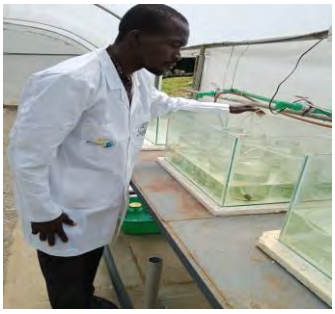
This project aimed at improving the livelihood of coastal communities in Malindi, Kenya and Tanga, Tanzania through *Artemia* Value Chain (AVC) linkages. These linkages involved 1) characterization of Kenyan and Tanzanian *Artemia* biotopes using molecular techniques to understand their evolutionary and adaptational mechanisms to the local conditions, 2) mass production of Artemia biomass using biofloc technology, 3) application of *Artemia* biomass in prawn and tilapia production, and 4) determining economic feasibility of Artemia value chain in East African coast.

The Kenyan and Tanzanian Artemia cysts were analyzed in Ghent University, Belgium. We analyzed a longer (5000 bp) Artemia mtDA amplicon target using a modern Long-read Nanopore Sequencing molecular technique.

There was significant mutational divergence of local artemia from their original inoculants, suggesting existence of local adaptational and evolutionary processes. Before mass production of Artemia biomass, we first analyzed phytoplankton abundance and diversity along salt concentration gradient in the existing ponds, to determine suitable conditions for mass culture of Artemia. Phytoplankton diversity and abundance declined with increasing salt concentrations, with optimum salinity level for mass artemia biomass production being between 52 and 93 ppt. in Tanzania, higher densities of diatoms and chlorophytes were detected during wet season, which corresponded to high density of naupliar and adult *Artemia* biomass.

Proximate and fatty acid analysis was done on local Artemia to determine the nutritional profile of the existing biotopes. Highest values of crude protein (47.43%), crude carbohydrate (10.13%) and ash contents (32.10%) were recorded during dry season from Zomba salt farms whereas the highest value of crude fat (8.98%) was recorded from MWEVUPI (8.98%). In Kenya, laboratory studies showed higher *Artemia* survival in biofloc cultures than in and control. Female pre-reproductive period (days) was longer in control cultures, while reproductive period (days) was longer in biofloc than in control. BFT enhanced the ovoviviparous reproduction cycle with higher total offspring per female and had higher concentrations of myristic acid, oleic acid, palmitic acid, linoleic acid, and arachidic acid. These attributes were used to produce up to 14kg dry weight of Artemia biomass for aqua-feed processing.

For application of *Artemia* biomass in the emerging local aquaculture activities, healthy shrimp brooders were sourced from Sabaki River at Kilifi County from local fishermen using prawn seine nets. Gravid female brooders were induced to spawn by increasing the water salinity. Upon hatching the eggs, the larvae were harvested and transferred into the experimental aquaria and subjected to three Artemia feed density replicate treatments i.e., T1 (1 naupli/ml)., T2 (3 naupli/ml) and T3 (5 naupli/ml) for 42 days. There was no significant difference in survival between larvae fed on T1 and T2. However, larvae fed on T3 had a significantly higher survival rate than T1 and T2. For tilapia culture, dry artemia biomass was used to formulate diets, which were used to feed tilapia. The diets were prepared by replacing levels of fishmeal with dry Artemia biomass meal 0% (AT_0) (negative control), 50% (AT_{50}) and 100% (AT_{100}). A commercial diet (COMM), sourced from local feed manufacturer in Nairobi was used as a positive control. Notably, an increase in the inclusion levels of artemia biomass in diets resulted into a proportional increase in weight and specific growth rate values. Survival rate was slightly higher in the diet AT0 and those supplemented with artemia biomass (AT50 and AT100) than the control diet COMM. Socio-economic studies and economic feasibility of Artemia Value Chain were done at Machui Village of Tanga City involving MWEVUPI community salt producing group by Collecting socio-economic information of the project collaborators. A Cost Benefit Analysis was used to measure the economic viability/efficiency of Artemia ponds production using Net present value (NPV), Benefit-cost Ratio (BCR) and Internal rate of return (IRR). Quality control was performed by routine determination of hatching efficiency, hatching rate and the nutritional value through laboratory experiments. The Cost Benefit Analysis (CBA) conducted from Zomba farm based on six months of data collection showed that the net present value (NPV) for Artemia production averages TZS 1,583,888/month while the Benefit Cost Ratio (BCR) was 1.2. The analysis on Internal Rate of Return (IRR) had a positive value of 4%. In addition, the analysis on return on investment (ROI) was estimated to be around 114 % while the assessment of marketing opportunities indicated better potential for farmers.




Project student Mr. Mukaburu in the lab and Dr. E.Ogello appreciating artemia flakes in the field.