

# Closure Report: Bionutrient Circularity in Lake Victoria Basin

## CALS Charitable Trust Academic Enrichment Grant

Awardee: Eli Newell

Major: International Agriculture & Rural Development, Department of Global Development.  
Class of 2024.

Project Advisor: Prof. Rebecca Nelson, School of Integrative Plant Sciences; Dept. of Global  
Development

Academic Advisor: Prof. Janice Thies, School of Integrative Plant Sciences

Award: \$2,500

Award Term: Winter/Spring 2023

Completion Date: 21 January 2023

Submission Date: 1 March 2023

## OVERVIEW

With CALS Charitable Trust's support, I traveled to Kisumu, Kenya, in January 2023 to participate in the *East Africa Circular Economy Workshop* co-hosted by Poverty and Health Integrated Solutions (PHIS) and Cornell University. The workshop began with ribbon-cutting and opening ceremonies at PHIS's Circularity Empowerment Center (CEC) and included 1.5 days of discussions and group work with academics and leaders in East Africa's sanitation and fertilizer industries. The Cornell delegation included Prof. Johannes Lehmann, Prof. Rebecca Nelson, Jean Marie Nizigiyimana, Bella Culotta, and me, pictured at the CEC opening (Fig. 1).



*Fig. 1.* Left to right - Prof. Callistus Ogot (PHIS, Kenyatta University), Prof. Laura Barasa (University of Nairobi), Prof. Aloys Odeck (Maseno University), Diana Byali (Giving Hope), Nolbert Muhumza (Giving Hope), Prof. Johannes Lehmann (Cornell), Prof. Kristen Odeck (Maseno University), Chizzy Orwa (PHIS), Prof. Rebecca Nelson (Cornell), Jean Marie Nizigiyimana (Humphrey Fellow, Cornell), Bella Culotta (Cornell), Soliver Che Fusi (UC Berkeley), Eli Newell (Cornell), Prof. George Odhiambo (PHIS, Maseno University). Photo: Alex Campbell.

Additionally, our trip featured a courtesy call to Kisumu County Governor Peter Anyang' Nyong'o (Fig. 2) and visits with community-based organizations Nyalenda Young Turks and United Destiny Shapers. We also toured FreshLife's (Sanergy) facility and KIWASCO sewage treatment ponds, ran biochar pyrolysis at the CEC, and explored the lakefront (Fig. 3).



*Fig. 2.* Left to right- Prof. Benjamin Ombok (Maseno Univ.), Soliver Che Fusi (UC Berkeley), Gov. Peter Anyang' Nyong'o, Prof. Rebecca Nelson (Cornell) Prof. Charles Midega (PHIS), Eli Newell (Cornell). Photo: Chizzy Orwa.



*Fig. 3.* Lake Victoria shoreline smothered by piles of washed-up dead snails.

## BACKGROUND

East Africa's Lake Victoria hosts a robust fishery bearing over a million metric tons of catch annually and a broader lake basin that supports a large and rapidly growing population — from 54.5 million people in 2000 to 73.6 million just ten years later (Roegner et al., 2020; Glaser et al., 2019; Njiru et al., 2014). Nutrient pollution from various sources, including urban sewage, fertilizes toxic algal blooms that have produced microcystin levels that vastly exceed WHO-accepted limits and have led to anoxia and devastating fish kills (Olokotum et al., 2020; Mchau et al., 2019; Njiru et al., 2018; Sitoki et al., 2012; Stager et al., 2009; Ochumba, 1990). Today, excess nutrient loading poses an existential threat to Lake Victoria, its fisheries, and the tens of millions of livelihoods supported by the lake (Roegner et al., 2020; Njiru et al., 2019; Hecky et al., 2010).

While Lake Victoria suffocates from nutrient pollution, the surrounding agriculture is severely nutrient-limited, often performing far below its potential yield attainment (Foley et al., 2011). Every country in East Africa suffers from a net flow of nutrients out of agricultural use; more nutrients are discharged in human excreta than are applied in fertilizer (Devault et al., 2023). Additionally, most excreta are inadequately managed. For example, in Kisumu, Kenya, half of all excreta is emptied from latrines but never delivered to treatment (Midega, 2022; Peal et al., 2020; Furlong & SFD Promotion Initiative, 2016). Alternatively, sanitation could provide much-needed nutrients to agriculture and agriculture could provide vast absorptive capacity to an overwhelmed sanitation system. By diverting nutrient-rich waste streams out of the aquatic environments and instead recapturing the nutrients for agricultural use, nutrient pressure on the lake's fishery would be reduced, crop yields would increase, and a host of public health outcomes could be attained from improved sanitation services and food security to reduced toxic exposures from microcystin and mycotoxins (Midega, 2022; Roegner et al., 2020). Lastly, waste valorization will allow entrepreneurs to build enterprises that drive the necessary value chains (Trimmer et al., 2020).

Professors Rebecca Nelson (Cornell) and Charles Midega (PHIS) share parallel grants through the McKnight Foundation's Collaborative Crop Research Program to develop a framework for a circular bionutrient economy in the Lake Victoria Basin (McKnight Foundation, 2022-2025).

## ACTIVITIES

The *East Africa Circular Economy Workshop* forged connections between many of us who strive for a circular nutrient economy that reverses the currently polluting linear nutrient flows. We discussed technical barriers to implementation, regulatory needs, and much-needed standardization of protocols.

PHIS's Circularity Empowerment Center features agricultural test plots, a black soldier fly (*Hermetia illucens*) rearing facility, a poultry research facility, laboratories, and a kon-tiki biochar pyrolysis unit. Pyrolyzed organic matter, or biochar, is a valuable and persistent soil amendment and potential sanitation technology. We ran the kon-tiki with maize stalks (Fig. 4) and experimented with incorporating dried feces as a feedstock. We extracted the hot char from a trap door (conceived by Prof. Nelson) at the bottom of the kon-tiki (Fig. 5). We quenched the hot coals with collected urine (Fig. 6); the resulting product (Fig. 7) is known to bind nutrients from urine and perform highly as a fertilizer (Sutradhar et al., 2021; Pandit et al., 2017).



Fig. 4. Prof. Nelson loading maize stalks.



Fig. 5. Extracting hot coals.

Despite all the CEC's facilities for research and innovation, there is not yet a toilet on site, so we hosted a source-separating toilet design competition with the Nyalenda Young Turks community-based organization. We spent an afternoon with a dozen of their members and a pile of cardboard prototyping designs and then voting democratically on a winner. Their youngest member, Amos, created the winning design.

On our last full day in Kisumu, we visited the KIWASCO sewage treatment ponds, FreshLife/Sanergy toilet factory and office, and Benjamin Odhiambo's toilet system that won an award for the most innovative toilet in the world at COP27 (Kirwa, 2022). The KIWASCO site

treats piped sewerage for 20% of the city and fecal sludge from several dozen pump trucks daily. The pond system includes anaerobic, facultative, and aerobic lagoons in sequence and an astonishing diversity of birds thriving off the lagoon ecosystem. FreshLife services nearly 700 toilets in high population density areas of Kisumu, collecting source-separated urine and feces. Odhiambo's Saniwise toilet system uses black soldier flies to process feces in situ and an evaporation chamber to create a dried urine fertilizer product for his tree nursery.



*Fig. 6. Prof. Nelson quenching hot char with collected urine.*



*Fig. 7. Fertilizer product.*

## **OUTCOMES AND IMPACT**

Working with the PHIS team in person after a year of meeting over Zoom was a treat. I am thrilled that I will be able to return for several months this coming summer with the support of my Laidlaw Scholarship. In addition to the fruits of the workshop and all our other activities, this trip served valuable scouting purposes, informing my academic and research priorities for the Spring semester and upcoming summer.

Prof. Midega has already published an extensive inventory of organic waste streams in Kisumu (Midega, 2022), but the geospatial analysis and engagement with community-based organizations to realize the value chains remain to be done. I have been studying geospatial analysis in my coursework at Cornell and look forward to putting it into practice with PHIS this summer. I am also excited about the organic waste to black soldier fly to poultry feed value chain that Charles is working on and will be able to support those studies with my years of poultry production and research experience (e.g., Lowy, 2019). I am particularly excited to return to Kisumu because I have been studying Swahili at Cornell for the past two years and am eager to improve through immersion. Additionally, connecting with the Nyalenda Young Turks and United Destiny Shapers CBOs on this trip will be invaluable for future community-engaged work.

Lastly, my January trip to Kisumu has given me much-needed context as I work with Prof. Nelson and postdoctoral fellow Dr. Alyssa Kim to determine the field data I need to collect this summer and appropriate methods to support our lab work at Cornell.

**USE OF FUNDS**

Category	Description	KES	USD	Quantity	Total
Airfare	Round-trip flight USA-Kenya: <i>BOS → ORD (1/6/23; BA1723)</i> <i>ORD → LHR (1/6/23; BA0294)</i> <i>LHR → NBO (1/7/23; BA0065)</i> <i>NBO → LHR (1/20/23; BA0064)</i> <i>LHR → PHL (1/21/23; BA0067)</i> <i>PHL → SYR (1/21/23; BA6887)</i>		\$1,785.88	1	\$1,785.88
Airfare	Round-trip flight Nairobi-Kisumu: <i>NBO → KIS (1/8/23; KQ0656)</i> <i>KIS → NBO (1/20/23; KQ0657)</i>		\$126.80	1	\$126.80
<b>Category Total: Airfare</b>					<b>\$1,912.68</b>
Accommodation	67 Airport Hotel, Nairobi. 1/7-8/23, per night	Ksh 7,000.00	\$56.70	1	\$56.70
Accommodation	Maseno University Kisumu Hotel. 1/8-12/23, per night	Ksh 5,898.31	\$47.78	4	\$191.11
Accommodation	The Little Cave Kisumu. 1/12-20/23, per night	Ksh 2,531.25	\$20.50	8	\$164.03
<b>Category Total: Accommodation</b>					<b>\$411.84</b>
Misc: Visa	90-day single-entry visa fee		\$50.00	1	\$50.00
Misc: Prizes	Prize money for toilet design competition with Nyalenda Young Turks Community-Based Organization; 1 <sup>st</sup> place: Ksh 3,000. 2 <sup>nd</sup> place: Ksh 2,000. 3 <sup>rd</sup> place: Ksh 1,000.	Ksh 6,000	\$48.00		\$48.00
Misc: Conference	Maseno University Kisumu Hotel. Pre-conference dinner for 14 participating academics and industry leaders. 1/9/23	12,042.38	\$97.54	1	\$97.54
Misc: Telecom	Verizon TravelPass international plan, per day		\$10.00	14	\$140.00
<b>Category Total: Miscellaneous</b>					<b>\$335.54</b>
<b>TOTAL</b>					<b>\$2,660.06</b>
CALs Charitable Trust award					-
					\$2,500.00
Difference (covered with personal funds)					\$160.06

## OUTREACH

- Presented on Kisumu trip and surrounding scholarship in presentation “Connecting Sanitation and Agriculture” in Alpha Zeta’s Applied Agriculture speaker program, 28 January 2023.
- Presented on Kisumu trip and surrounding scholarship in updated presentation “Connecting Sanitation and Agriculture: Augmenting fertilizer supply while reducing nutrient pollution,” 15 February 2023.
- Upcoming feature by CALS Department of Global Development (Department Communications)
- Upcoming feature by Cornell University (University Relations)

## ACKNOWLEDGEMENTS

Thank you to Charles Midega and Chizzy Orwa (PHIS) for generously hosting our visit, Prof. Benjamin Ombok and the rest of the Maseno University team for welcoming us, and Bella Culotta and Johannes Lehmann for organizing such a productive workshop.

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