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**Summer 2024 Research Plan**

# **Circular Bionutrient Economy: Fertilizer Derived from Human Waste**

## **Background and Key Project Objectives**

As it currently stands, our agricultural systems are not equipped to meet the needs of the world's growing population. Expansion and intensification of existing agricultural practices is resulting in increased soil degradation and ecological peril. We add fertilizer to soil to ensure crop health, but two of the primary elements in fertilizer, nitrogen and phosphorus, are derived through non-renewable and energy intensive processes.

Simultaneous to this impending agricultural crisis, existing sanitation systems pose a global ecological and public health crisis. In the global north we flush human excreta down the toilet into sewage treatment facilities that ultimately lead to excess nutrients (like nitrogen and phosphorus) in nearby waterways. These nutrients lead to algal blooms harmful to both humans and the ecosystem. In areas of the global south, lack of proper sewage creates health concerns and sewage mismanagement leads to CO<sub>2</sub> emissions.

The circular bionutrient economy (CBE) aims to turn the problem of sanitation into one of the solutions for sustainable agriculture. Instead of the single direction flow of nutrients from rural soil into urban waste streams, the CBE aims to salvage these nutrients and find effective ways of bringing them back to farmlands. Using sewage sludge as an agricultural input is not a novel method. However, concerns about PFAS (man-made chemicals that persist in the environment) and pharmaceuticals harmful to human health in sewage streams have caused some states to ban its use. Furthermore, the nutrients in sewage sludge currently applied to fields only contain a small percentage of the potential nutrients in wastewater at large.

This study uses pyrolysis, a process which produces biochar, as a way to address the health concerns and inefficiencies associated with directly applying sewage sludge to agricultural land. Pyrolysis burns organic material with the presence of no oxygen. Although still releasing some CO<sub>2</sub>, it is significantly less than traditional burning and allows for carbon to be better stored in the soil. Importantly, pyrolysis also destroys PFAS and the resulting biochar can be used as a medium to absorb more nutrients from liquid waste streams. Current biochar on the market uses wood and yard waste as the materials to be burned, but incorporating human waste offers an opportunity to address sanitation, another of the world's largest issues. The impact of this project is to find feasible and scalable ways to use biosolids, one of the biggest sanitation problems, as a renewable source of fertilizer to create long term soil health.

While the long term goals of this project are large, over the course of this summer I will be working with post-doc Lucinda Li to build a reactor to extract nitrogen and phosphorus from human urine and load these nutrients onto biosolids derived biochar. The resulting nutrient loaded biochar is a safe to use and easily transported agricultural fertilizer.

## **Global Impacts**

As sanitation and food security are inherently global issues, stakeholders include farmers and consumers across the globe. Currently, there is considerable stigma surrounding the use of human waste as an agricultural input. People view it as unsanitary, and when mismanaged, solid waste can pose health threats.

## **LiA Plans**

During my second summer I plan to travel to Kenya where Dr. Nelson's colleague, Dr. Charles Midega, works. Dr. Midega works on implementing the circular bionutrient economy in the context of Kisumu, Kenya, a lakeside agricultural town. Getting to take part in the implementation of the CBE lets me bridge the gap between lab and field. Sustainable agricultural solutions can only be effective if they are feasibly able to be implemented. Taking part in the CBE in person will also better inform me what elements would benefit from more laboratory based research.