The Development of a Remediation Approach for the Removal of Bacteria and Toxic Metals for use in Rural Uganda

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Introduction to the Project in Uganda

• Project started in response to a need for a children’s hospital in Uganda

• Transformed into a project focused on water quality and education
Ensuring “access to water and sanitation for all” is Goal 6 of the United Nations’ Sustainable Development Goals (n.d.)

Approximately 30% of the global population does not have access to “safely managed drinking water services” (United Nations, n.d.)

**Key contaminants:**
- Biological contamination
- Toxic metal contamination

According to the CDC, diarrheal diseases were the 6th leading cause of death in Uganda in 2018.
Standards for Drinking Water Quality

The World Health Organization (WHO) mandated the following contaminant thresholds for drinking water as of 2017:

**Toxic Metals (mg/L)**
- Mn: 0.04
- Cu: 2
- As: 0.01
- Pb: 0.01
- Cd: 0.003
- U: 0.03

**Biological Pathogens**
- 0 counts/100 mL of *E. coli* and thermotolerant coliform bacteria
- Other bacteria, viruses, protozoa, and helminths in various counts/100 mL
Timeline of Project

- **Spring 2019:** Started with general research about removal of toxic metals
- **Summer 2019:** Found potential effective solution that Dr. Bolender’s Chemistry Lab started testing
- **Fall 2019:** Dr. Bolender’s Lab came back with positive results
- **Fall 2019:** Engineering started to work on design for a mechanism to support the removal of these contaminants
- **January 2020:** Trip abroad to Uganda
- **Spring 2020:** Further work on the design with changes based on knowledge gained through January Trip
Current Design of System

Step 1:
Bind and remove select toxic metals using banana peels and activated carbon

Step 2:
Trap and remove bacteria using xylem filtration (Particular focus: Eucalyptus tree xylem)
Subsystem 1: Removal of Toxic Metals

- System Consists of a Tea Bag:
  - Dried Banana Peels
  - Activated Carbon
- Biosorbent: Banana Peels
  - High mechanical strength and large surface area (Annadurai, Juang, & Lee, 2002)
  - Traps toxic metals ions (Annadurai, Juang, & Lee, 2002; Al-Qahtani, 2016)
- Activated Charcoal
  - General purification
Subsystem 2: Removal of Bacteria

- System Consists of
  - Plant Xylem
  - Piston and Cylinder Set-Up
  - Sealing Mechanism
- Plant Xylem
  - Traps bacteria in the margo pits in the plant xylem cell walls (Boutilier et al., 2014)
- Piston and Cylinder Set-Up
  - Hold water and force water through the plant sample
- Sealing Mechanism
  - Ensure all water travels through the plant cells
Subsystem 2: Bacteria Testing

Water before Xylem Filtration
- Raised bumps are bacteria colonies
- Raised bumps with a blue pigmentation designate fecal coliform bacteria

Water After Xylem Filtration through Eucalyptus
Next Steps

- **Spring 2020**
  - Continue flow rate testing
    - Characterize relationship between applied pressure and flow rate
    - Determine filtration capacity before sample degrades
  - Define filtration capacity per sample of eucalyptus xylem (biological testing)
  - Determine optimal design to scale up device to meet the needs of a family of 5

- **Future Semesters**
  - More extensive biological testing
  - User testing in rural Ugandan communities of interest
  - System implementation (long term goal)
Thanks for Watching!
References