Point-of-Use Household Drinking Water Filtration: A Practical, Effective Solution for Access to Safe Drinking Water in Kenya

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Motivation

• **1.1 billion** people lack access to an improved water source
• **1.6 million** people die every year from diarrheal diseases attributable to lack of access to safe drinking water; 90% of these are children under 5
• In just one day, **200 million work hours** are consumed by women and girls collecting water for their families
Mercer On Mission--Kenya
Prior to traveling, two weeks of classroom learning

• discover different cultures, governments, history, language, food, etc.
• Women, self-help groups
• Micro financing
• Education
• **potable water and sanitation**—human health
• realize the staggering number of people that **lack** access to these two luxuries we take for granted
• potential solutions
Follow classroom learning with doing and experiencing Kakamega Forest, Loongeiwuan Forest, Maasai Mara, and Nairobi.
First Stop – Lake Baringo
Loongeiwuan
Loongeiwuan

INTEGRATED CHILD DEVELOPMENT CENTRE
Loongeiwuan
In Partnership with Africa Exchange

Loongeiwuan

African cuisine

Plate of food: rice and greens
Effects of Fluoride in Drinking Water

Dental Fluorosis

Skeletal Fluorosis
Adsorption to Sintered Bone Charcoal
Using engineering knowledge learned in the classroom to solve problems in developing countries

- **Equilibrium Adsorption Modeling**
  - Freundlich isotherm
    \[ q_e = \frac{x}{m} = K_f C_e^{\frac{1}{n}} \]
  - Halsey isotherm
    \[ \ln q_e = \left[ \left( \frac{1}{n_H} \right) \ln k \right] - \left( \frac{1}{n_H} \right) \ln \left( \frac{1}{c_e} \right) \]

- **Kinetic Modeling**
Worksite in Sisit
Near Sigor and the Wei Wei River
Engaged Community

- 8th grade education
- Nursery school committee
- Water committee
- Microenterprise
  - Bee keeping

The Problem: Community needs Centralized Water Source Effective Method to Treat Water for Drinking
2010: Installed a water-driven turbine pump in irrigation channel and bypass used during pump maintenance.
Design specifications for water-driven turbine pump and system

• Power

\[ P \ W = Q \times H \times \eta_h \times \rho \times g \]

• Pressure Head
  – Pump hydraulics

\[ \frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 + h_p = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L \]
Water now in the center of the community

• But it is still river water—complete with pathogens

• Parallel project—Biological Sand Filters
  – Household-scaled treatment units
  – Improved water source
Dirty water exits filter and is stored in clean vessel having a small opening and lid. Tightly fitting lid keeps unwanted solid and liquid matter out of the filter. Diffuser prevents disruption of the “good biological layer” during the addition of dirty water to the filter. Treated water exits filter and is stored in clean vessel having a small opening and lid.

Static water level is 5 cm above sand. A biofilm (Schmutzdecke) develops in the top 10 cm of the sand and removes over 90% of the pathogens. Sand removes pathogens and turbidity. Pea gravel layer supports the sand and prevents it from entering the outlet pipe. Gravel layer allows for drainage into the outlet pipe. PVC outlet pipe 70-Liter plastic filter body houses the sand and gravel material.
Built Biological Sand Filters – Collecting and hauling sand
Sift
Wash
Dry
Haul
Vessel Preparation
Installation
Installation—Team Lackey
What if Filters used Improperly?
Celebration
Community Impact

• Self reporting by families indicate dramatic decrease in diarrhea-related disease.

• Analytical results

![Graph showing that filters removed 92% of pathogens.](image)
MOM 2012: Bridge, 25 new BSF, test 25 BSF installed in 2010
Rest and Reflect

Kakamega Rain Forest
Maasi Mara
Student questions lead to learning


- Smith, Cassie, Timothy Poole, and Arneshia Fair, Design and Analysis of Biosand Filtration with Added Copper as a Disinfectant, Poster at 2011 ASEE Southeastern Section Conference, April 10-12, Citadel, Charleston, SC. Awarded 1st Place Junior/Senior Design Division.

- Wyckoff, Kristen, The Impact of Metallic Biocide and User Compliance on the Effectiveness of Biological Sand Filtration, Poster at 2011 ASEE Southeastern Section Conference, April 10-12, Citadel, Charleston, SC. Awarded 1st Place Sophomore Research Division.

- Lacey, E. Davis, Comparative Modeling of Full-scale and Small-scale Biosand Filtration Systems. Poster at 2012 ASEE SE Annual Conference, Starkville, MS.

- Brett, Emily, The Anit-microbrial Affect of Several Forms of Copper, Poster at 2012 ASEE SE Annual Conference, Starkville, MS. Awarded 3rd Place Sophomore Research Division.
2/3 of Vietnamese live on floating houses

- Vietnam has a dense river network consisting of 2,372 rivers

- Vietnam is the 13th most populous country in the world with two-thirds of its people living on floating houses along the severely polluted rivers and basins.
More than 2.1 million families reside on boats and floating homes in the Mekong Delta, Hau River, and Southwest regions of Vietnam.
80% of the diseases in Vietnam are caused by polluted water.

Water contaminated with pesticides from growing rice, and with domestic and other industrial discharge.
7 students currently working on bench-scale design of dual-media biosand filters for Vietnam
Table salt provides a cheap and effective method for activating charcoal.

Mangrove forest in Vietnam

Mangrove Charcoal

Coconut shells

Coconut shell charcoal

Activated charcoal
Jake Carpenter – 2007 MU Graduate is our host

- Work in Rukungiri, Uganda
  - Manual well drilling
  - Spring protection
  - Appropriate pumps
  - Rainwater harvesting systems
  - Sanitation education