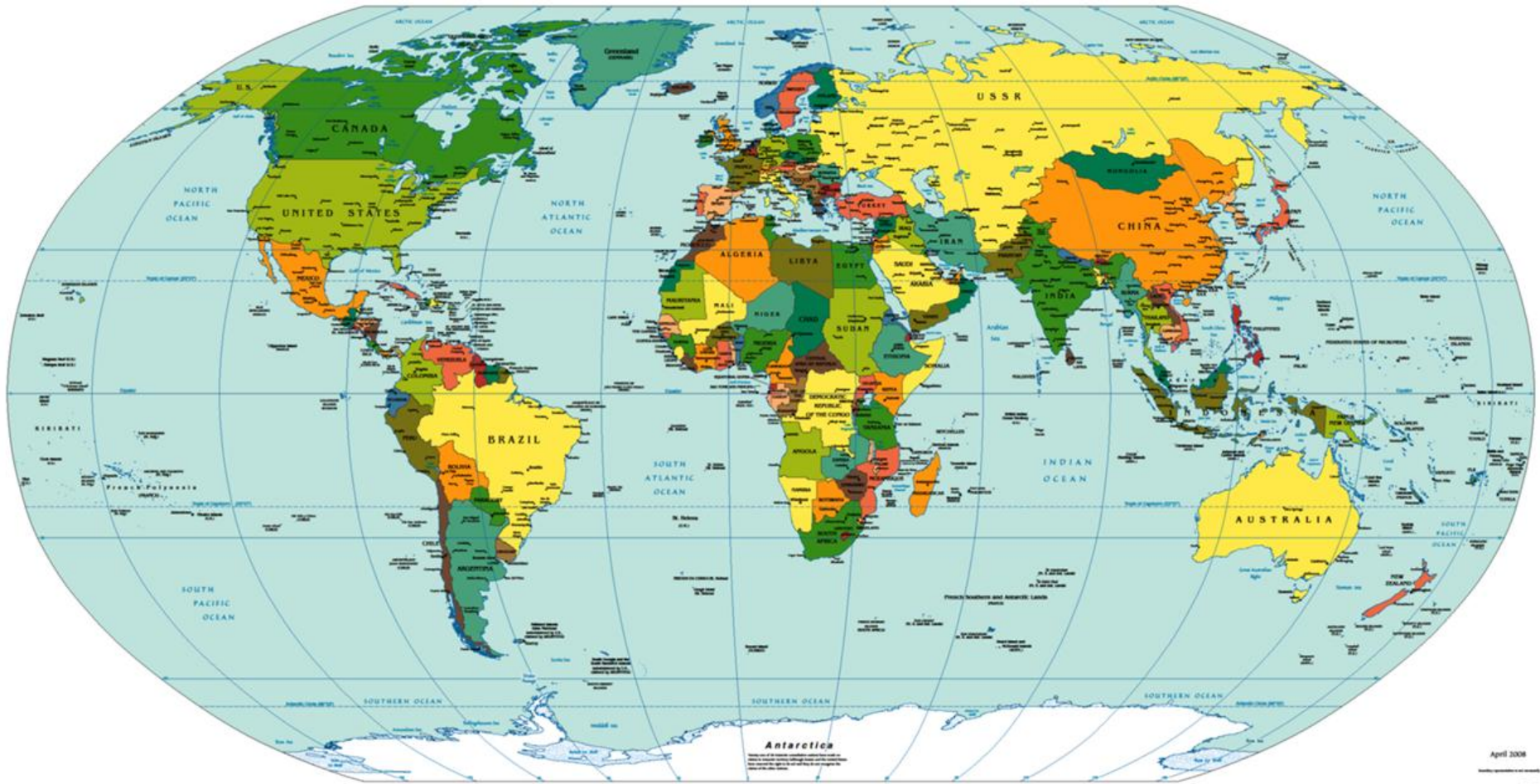


Point-of-Use Household Drinking Water Filtration: A Practical, Effective Solution for Access to Safe Drinking Water in Kenya

Laura Lackey, Ph.D., P.E.

Professor and Chair, Environmental Engineering

Presidential Scholars Weekend







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**

Fol

h



First Stop – Lake Baringo

Loongeiwuan



Loongeiwuan



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

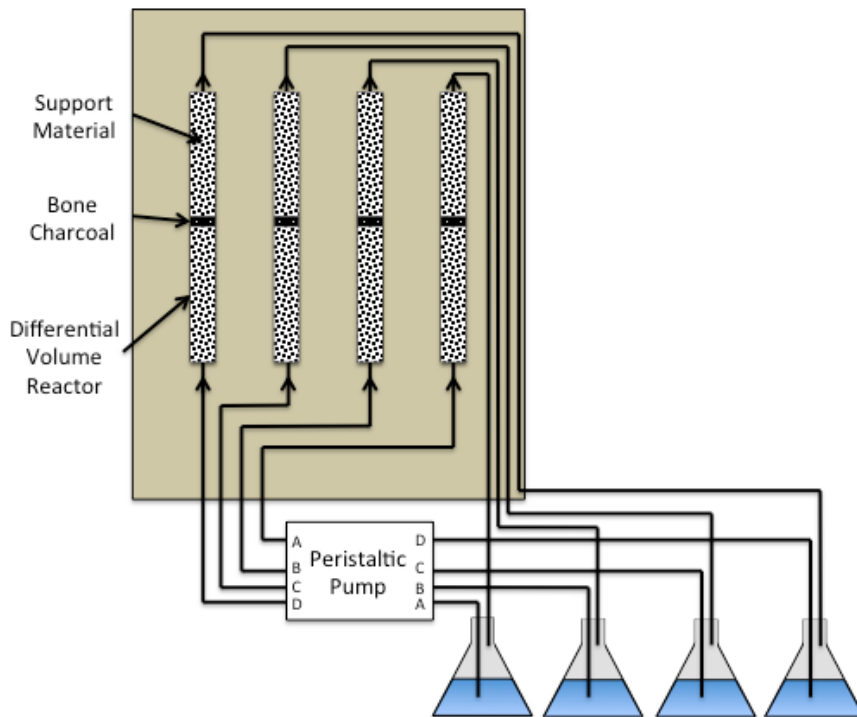
$$q_e = \frac{x}{m} = K_f C_e^{\frac{1}{n}}$$

- Halsey isotherm

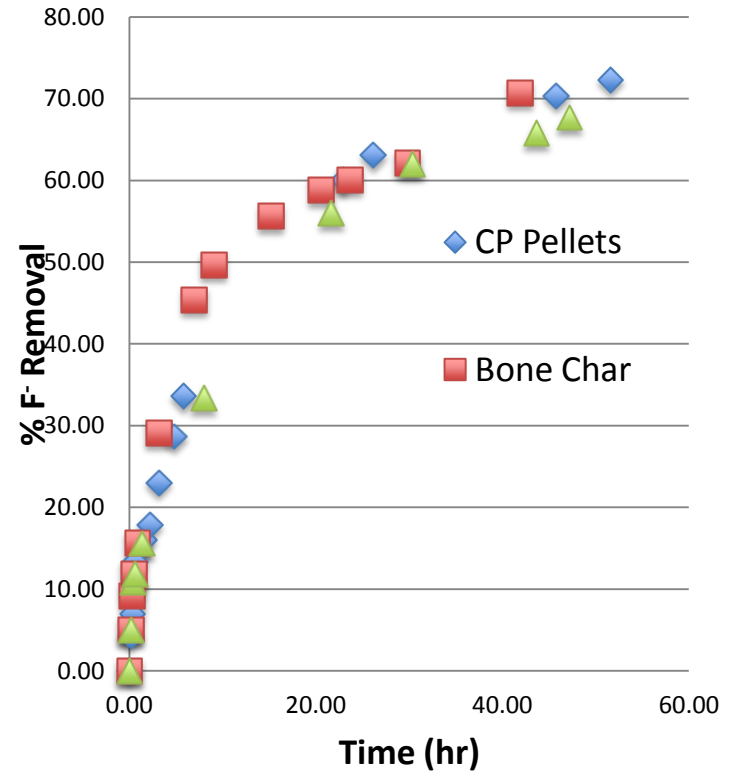
$$\ln q_e = \left[\left(\frac{1}{n_H} \right) \ln k \right] - \left(\frac{1}{n_H} \right) \ln \left(\frac{1}{c_e} \right)$$

- Kinetic Modeling

Schematic of Differential Volume Reactor



Despite differences in adsorbent composition, removal kinetics remain relatively unaffected



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

$$P = Q \times H \times \eta_h \times \rho \times g$$

- Pressure Head
 - Pump hydraulics



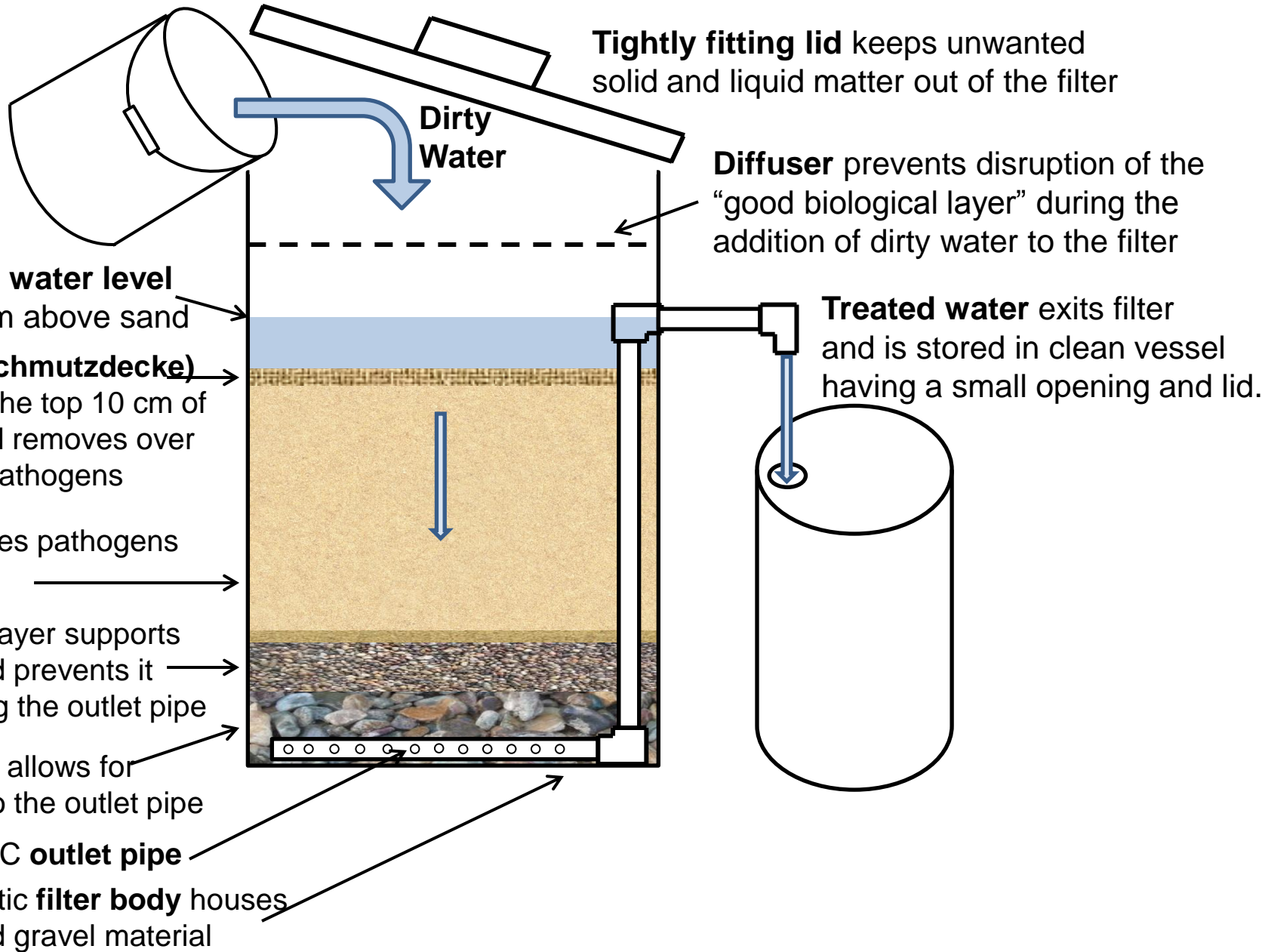
$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 + h_p = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$



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

Biological Sand Filter



Built Biological Sand Filters – Collecting and hauling sand



Sift Wash Dry Haul



Vessel Preparation



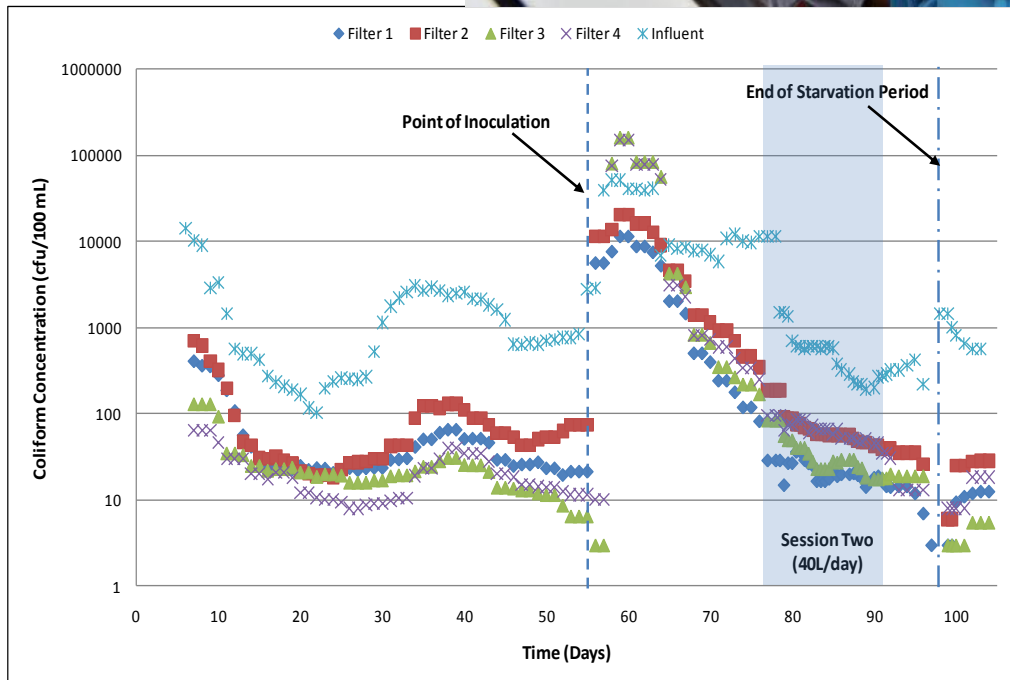
Installation



Installation—Team Lackey



What if Filters used Improperly?

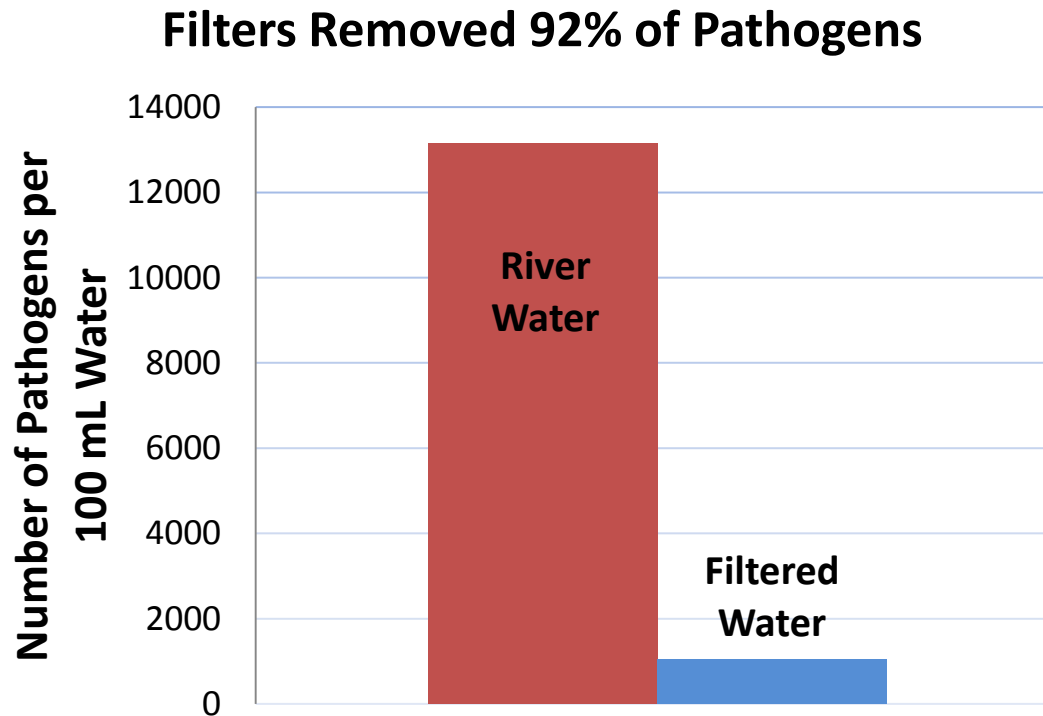


Celebration



Community Impact

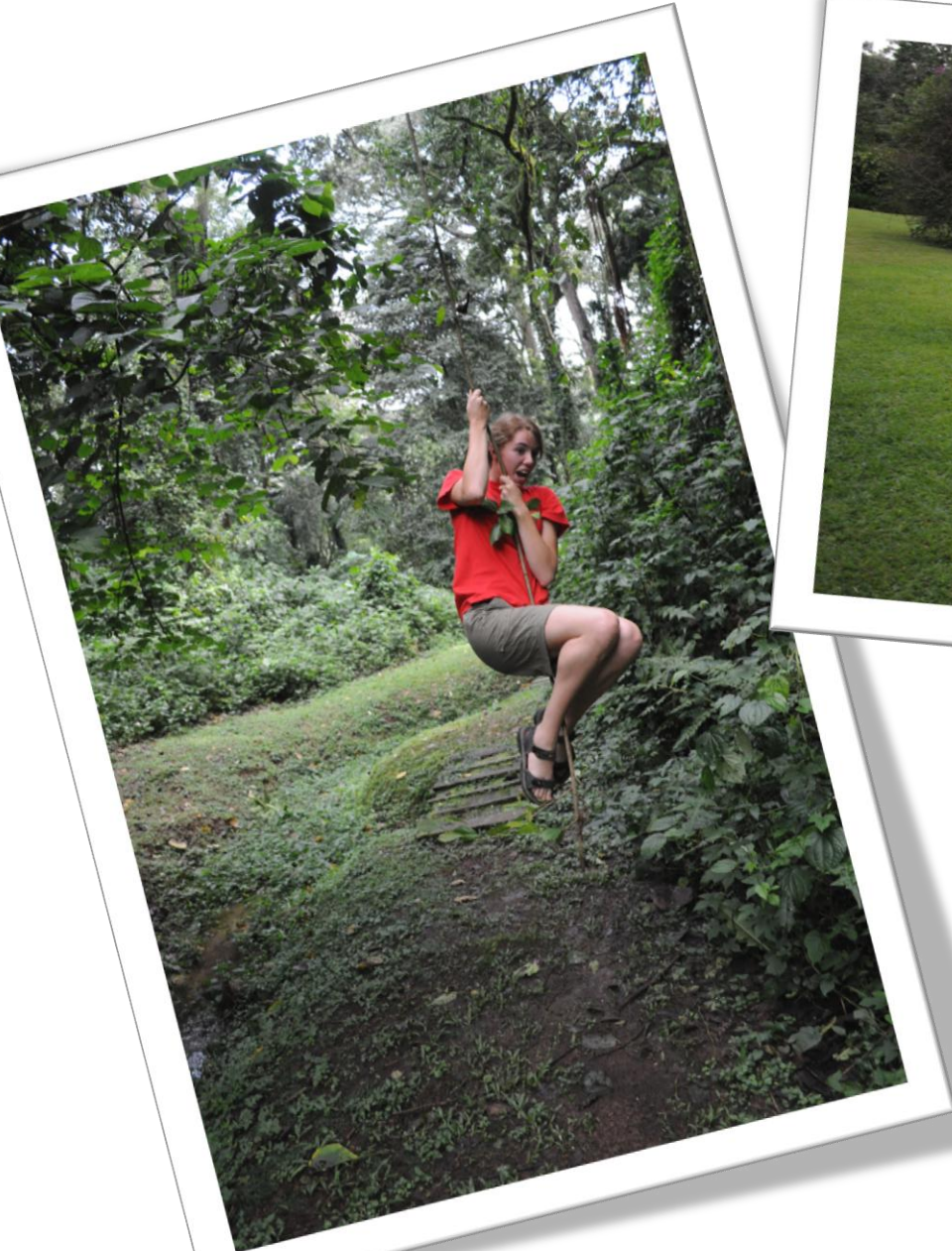
- Self reporting by families indicate dramatic decrease in diarrhea-related disease.
- Analytical results



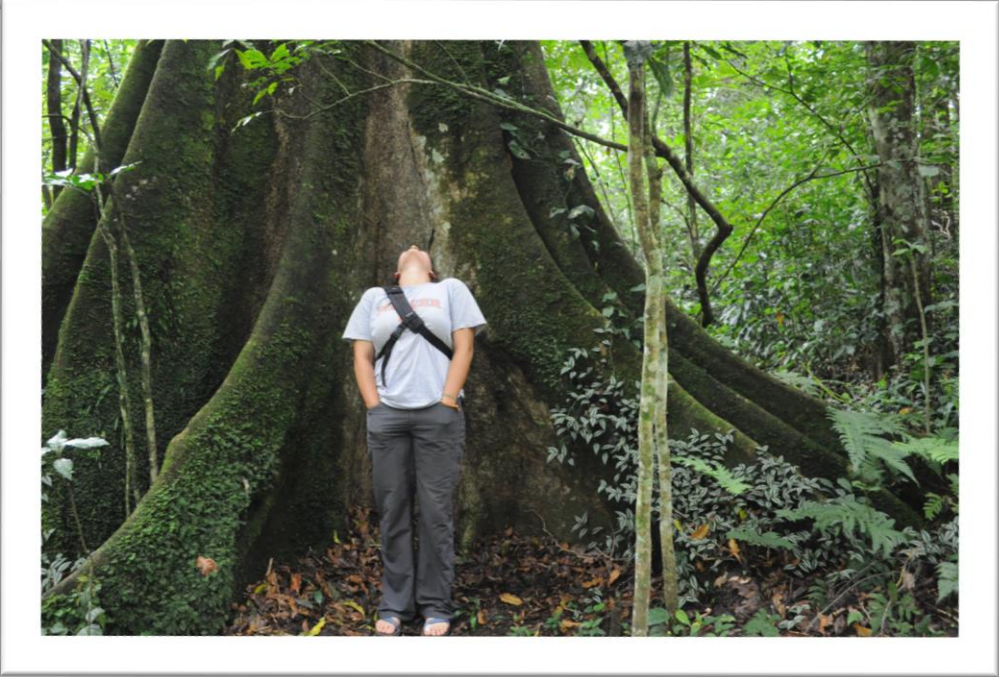


MOM 2012: Bridge, 25 new BSF, test 25 BSF installed in 2010

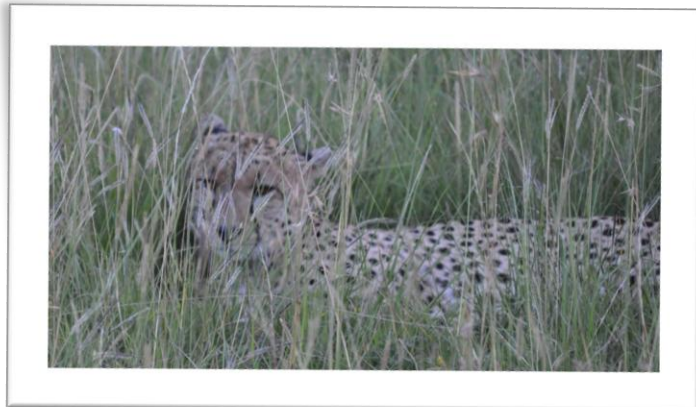
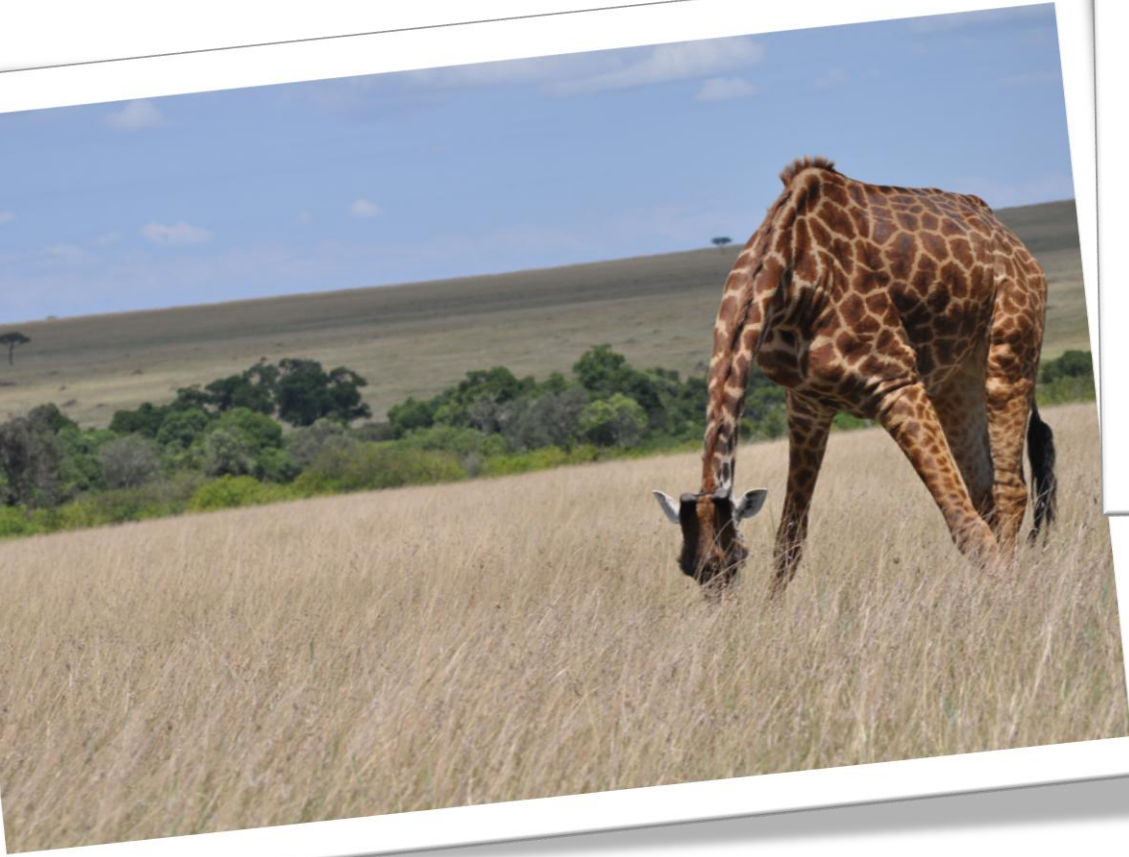
Rest and Reflect

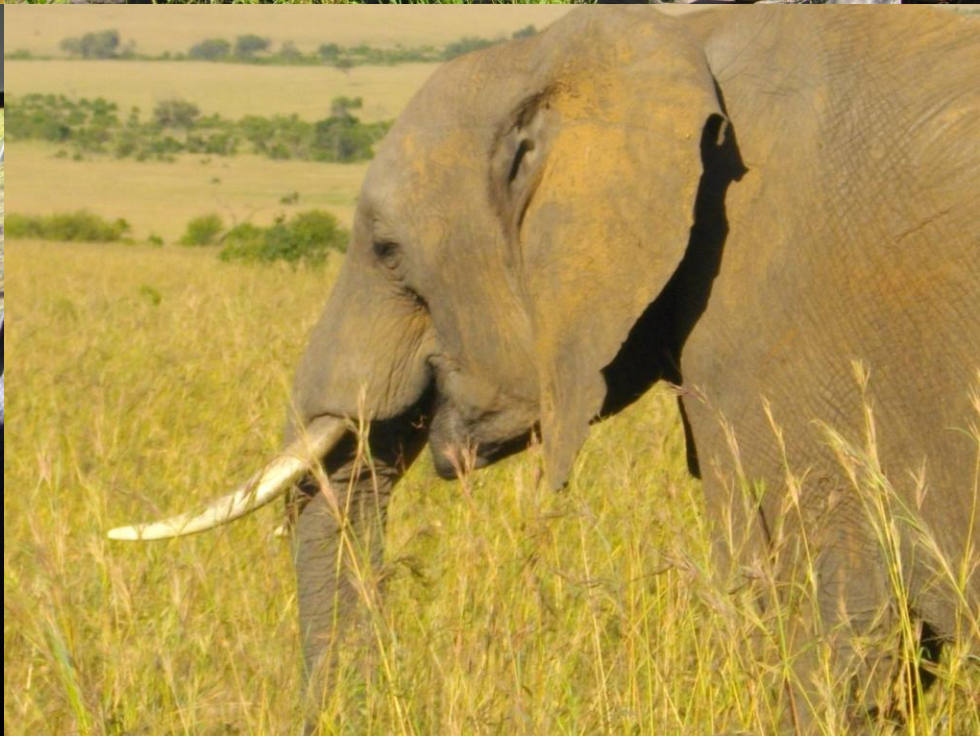


Kakamega Rain Forest



Maasi Mara





Student questions lead to learning

- Hyde, Elizabeth, M., L.W. Lackey, S. Harrell, and N. Robinson, Engineering Education as a Pathway to Sustainable Solutions, Proceedings of the 2010 ASEE SE Annual Conference, Blacksburg, VA, April 18-20, 2010.
- Hyde, Elizabeth, L.W. Lackey, R.O. Mines, Jr., L.B.S. Sumner, K. Wyckoff, Providing Sub-Saharan Africans with Drinking Water through Service Learning, Proceedings of the 2011 ASEE SE Annual Conference, Charleston, SC, April 10-12, 2011. **Awarded the Best Paper Award for the 2011 ASEE SE Conference.**
- 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 Anti-microbial 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

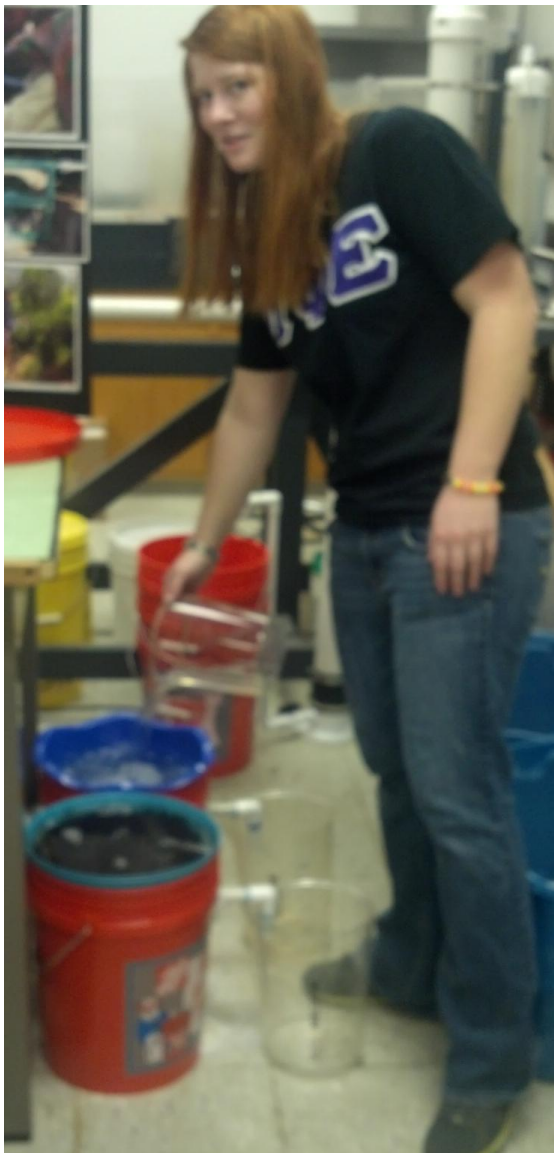


Table salt provides a cheap and effective method for activating charcoal



Mangrove forest in Vietnam



Mangrove Charcoal



Coconut shells



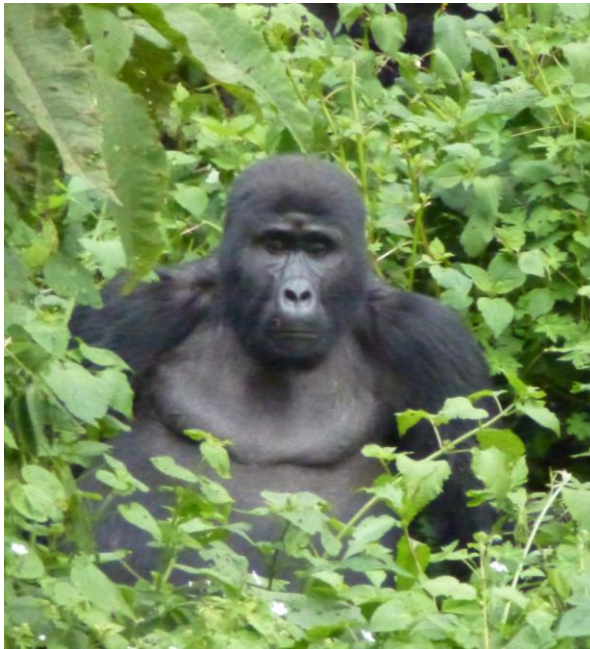
Coconut shell charcoal



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



MOM Uganda - 2013

