Laboratory Exercises Developed to Create Sustainable Water-Treatment Projects in Developing Countries

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I Have Tried or Observed a Variety of Water Projects

Overall Message of the Presentation
• Unexpected Key Cultural Aspects.
• Enough experience to be able to recognize a feasible project.
• Attitudes and Training of NGOs.
• Research needs exist!
• Be able (and willing) to develop substantial training materials and exercises for all pertinent water technologies.
• Try to work yourself out of a job.
A Common Type of E-Mail Message I Receive

...the case is that our community is very close to a lake which is growing with each rain (our tropical winter not as you know it in USA) and we need to treat about 2000 gallons/day to supply drinkable water for various neighborhoods, because green, rotten water is penetrating clean water pipes and we don't get appropriate response. We also have the problem of lack of Sodium Hypochlorite made by us with salt that abounds in Venezuela, but as we exported everything from abroad we don't have the technics to work with our resources here. My idea is to create a source of Hypochlorite to let people make their own bleach home to avoid infections, insects, bad odors and sickness in the area that could sprout into epidemic, or I could make or produce it for them. When I say accumulator I mean the battery of a truck (24v/1250amp) our main doubt is the lack of knowledge about what kind of electricity would fit the process correctly to avoid danger and have a good product with the tools we have here, another doubt is what is a cell and the three ways to get this important substance through the three methods (Mercury cell, Diaphragm cell, membrane cell) that really sound very abstract and theoretical to us who do not have the language skills to understand the three processes.

Marcos
Example of Key Cultural Aspect in Haiti

• The only treated water that has wide acceptance is reverse osmosis. (Distinctive taste is a “litmus” test for “treated” water.)

• Even in the best location, it is difficult to sell treated water if it does not “taste treated.”

• I rarely encounter any treatment technology other than reverse osmosis. When I see other technologies, NGOs run them, not the locals.

• Is it possible to gain acceptance for water treated by less expensive technologies?
Example of Being Able to Recognize When a Project Will be Well-Received “Convenience is king.”

• In some parts of Haiti, there is no source of water nearby.
• Rainwater collection projects are especially well-received in the mountains. But, they need follow-up.
• Options: (1) Pay someone to check on the projects. (2) Make maintenance part of a school program.
• There are parts of Haiti where well water is brackish. I see no desalination projects.
Feasible Projects Require a New Solution for Maintenance

- Broken hand pump in Arcahaie.
- Water from this well is potable as is.
- Hand pumps are often broken in rural areas on community wells.
- That same pump is broken again. Other pumps in the same region are also broken.
- Hand pumps work on wells in rural areas if the owner is charging 5 goulds per “bucket.”
- How can I harness the army of workers in our high school?
Attitudes and Training of NGOs
Be Willing to Develop Substantial Training Materials

• NGOs often specialize in one technology.

• I see examples of a technology being misapplied. For example, use of bleach stored too long, not making OSG bleach precisely, etc...

• Haitians do not know how different water technologies work and have preconceived notions. Example: “Chlorinated water tastes bad.”

• Haitian students take chemistry in 10th, 11th, 12th, and 13th grades. They study electrolysis, distillation, organic chemistry...but do not have hands-on lab activities.
Cobbling Together a Life in Haiti

• You can be educated and unemployed in Haiti.
• Children who age-out of “orphanages” lack opportunities.
• Successful people often have several ways to make money.
• Water sales can be part of the solution.
• Make water training an add-on skill.
• Set up businesses to sell water.
Game Plan – Not Fast, But Hopefully Impactful

- Chlorinate water at the K-13 school to 1 ppm free chlorine. Have people develop confidence in the water over time. We do this, and they will drink it all day.
- Develop laboratory exercises to teach all water-treatment technologies people of Haiti will encounter.
- Reinforce topics taught in high school chemistry. Improve rate of passing government tests.
- Offer a certificate in water treatment. This will enhance employability. Make maintenance of former projects part of the requirements.
- In correct situations, help graduates of the program drill a well and start a water business. Find locations where water will sell due to scarcity. Offer a variety of treatment options. Make the business sustainable. Launch an orphan.
Example 1: Reverse Osmosis Experiment
(Developed with EDM students at NWMSU who may or may not like science!)

Goals: Demystify RO; Teach Science
• Students make salt water solutions of increasing concentration. They relate salt concentration to taste.
• Students practice using different units of concentration, learn about soluble ionic compounds, roles of ions in body, osmosis versus reverse osmosis...
• Show that ions are actually added to drinks we purchase.
• Experiment requires salt, balance, and RO units.

We need something better than this for the laboratory exercise.
Example 2: Hypochlorite Experiment

**Goals: How to make OSG Bleach**

- Students prepare brine solutions and pass over electrodes.
- They dilute the bleach to increasing levels of free chlorine from 1 to 7 ppm.
- Test the free chlorine levels of commercial bleach that has been stored for extended periods of time.
- They learn about how bleach breaks down into chlorate and perchlorate over time. They review other polyatomic ions and study difference between organic compounds etc.
- Learn value of residual disinfectant.
- Believe that they can treat water to within 1 ppm free chlorine every time.
- Experiment requires OSG unit, plastic graduated cylinders, and a way to test free chlorine.

**Each Unit is Less than $100 USD.**
Validation of OSG Equipment

- Little chlorate is produced since the pH of the solutions rises quickly during electrolysis.
- Since there is little chlorate, negligible perchlorate forms.
- Bromate impurities limit the reaction time and brine concentration.

![Bromate Concentration in Water Treated to 5 ppm Free Chlorine (Preliminary LC-MS-MS data.)](image)
Other Experiments

- Use of commercially-available ultrafiltration and microfiltration systems.
- Use of ultraviolet radiation.
- Heat disinfection with solar energy.
- Distillation
- Fluoridating water.
- Pump repair and site selection for wells.
- Organic chemistry.
- Have written tests and require students to check on pumps and other projects in the area to receive certificate.
Research Needs

- Choose the best small-scale hypochlorite generator and validate its performance.
- Develop technology to make bleach as a microbusiness. May need to be divided cell technology.
- Develop technology to desalinate brackish water for a microbusiness. (OU Students?)
- Develop an inexpensive way to teach reverse osmosis in a lab in a developing country.

Photo from Rich Grant of Safe Water International Ministries
Example of the Least Expensive Scenario for a Sustainable Water Microbusiness

• Location: Grande Gonet
• Water Source: Existing Cistern with Spring Water
• Problem: Locals do not drink the water since it is not treated.
• Solution: Batch Chlorinate a Few Hundred Gallons at a Time. Sell water for 1 Gould per Gallon (or less).
• Goal: Net $50 to $100 USD per month for the elderly man who is currently supported by church members.
• This may work since we have built trust with the community.
Example of an Expensive Project with High Likelihood of Success, and High Impact
Conclusion – Why do projects fail? How can we implement successful projects? Are you willing to work yourself out of a job?

Success comes from (1) detailed understanding of the available technologies by the end users, (2) confidence in technology built over time, (3) detailed understanding of the culture by those implementing projects, (4) correct local contacts, (5) ability and willingness to implement a significant amount of the appropriate training.