Mission: Uganda Report 2018

An Initiative to Improve Water Quality in Small Villages Using Local Means In Rural Uganda

WeDev Water Initiative

Society of American Military Engineers – Kaiserslautern Chapter

Michael Ottensmann, PE

August 11-24, 2018

Society of SAME American Military Engineers

Executive Summary

The WeDev Water treatment initiative in small villages in rural Uganda proved successful. The primary concept was to provide simple, sustainable solutions using local materials and untrained local personnel to improve water quality. Solutions included salt chlorination using a car battery, rapid sand filtration in a rain barrel, rainwater collection, solar thermal destruction of pathogens resistant to chlorine and implementation of herbal remedies against malaria (Artemesia Annua) and general health (Moringa Oleifera). New this year was the development of a field detection method for Clostridium Perfringens (anaerobic, 45° Celsius).

The education program for young engineers and university students began to bear fruit, with several projects performed independently by prior year team members.

In the two weeks from 11-24 August, 2018, the SAME/WeDev water teams completed 7 projects in five locations, three in the Mityana District, one on Zinga Island in Lake Victoria and one in the Kapchorwa District and planned 5 other projects for future implementation. In addition to rapid sand filtration and chlorination, several herbal remedies were planted in two areas, a new thermal method to destroy Cryptosporidium and Bilharzia was field-tested, and a rainwater collection system was implemented.

Table of Contents

1.0 The WeDev Water Initiative 5

1.1 Students 7

2.0 Development Program 2018 8

2.1 Implementation of an Elevation-Driven Backwash System, Kyamagemule, Mityana District, Uganda 8

2.2 Rapid Sand Filtration, Mayobyo, Mityana District, Uganda 9

2.3 Remedial Chlorine Production Training, Kyamagemule/Mayobyo, Mityana District, Uganda 9

2.4 Initiation of the Herbal Remedies Program against Malaria and for General Health, Zinga Island, Lake Victoria, Uganda; Nyanzi, Mityana District, Uganda 10

2.5 Solar Thermal Destruction of Cryptosporidium and Bilharzia (Schistosomiasis) in Water, Zinga Island, Lake Victoria, Uganda 11

2.6 Sample Incubation Procedure, Zinga Island, Lake Victoria, Uganda 13

2.7 Site Visit for Water Distribution System Planning, Kaserem Clinic, Kapchorwa District, Uganda 15

2.8 Rainwater Collection, Kakonde Orphanage, Mityana Village, Uganda 17

2.9 Cascade Sand Filter, Kyamagemule, Mityana District, Uganda 18

3.0 Future Projects 19

3.1 Drinking Water Well, Zinga Island, Lake Victoria, Uganda 19

3.2 Sand Filtration and Chlorination, Kakonde Orphanage, Mityana Village, Uganda 20

3.3 Sand Dam, Nyanzi, Mityana District, Uganda 20

3.4 Cascading Pools, Nyanzi, Mityana District, Uganda 22

3.5 Refinement of Clostridium Field Incubator, Zinga Island, Lake Victoria, Uganda 22

3.6 Papyrus in a Facultative Pond, Zinga, Lake Victoria, Uganda 23

3.7 Disinfecting Stagnant Water using a Siphon, Entebbe/Kampala, Uganda .. 24

3.8 Field Testing the Effectiveness of Moringa Seeds on the Removal of Heavy Metals in Water, Amazon Basin, Brazil 25

3.9 The Effectiveness of Charcoal as a Substitute for Activated Carbon, Uganda 25

4.0 Requests From Other Locations 27

4.1 Music in World Cultures, Chipembi, Zambia 28

4.2 MEAP AM, Amazon Basin, Brazil **28**
4.3 Utooni Area, Kenya **28**
5.0 Team Members **29**
6.0 Special Thanks **30**

Table of Figures

Figure 1: Uganda Project Sites (Image from Google maps) **6**
Figure 2: Rapid Sand Filter and Backwash **8**
Figure 3: The Salt Chlorination Apparatus **9**
Figure 4: Artemesia Annua **10**
Figure 5: Moringa Oleifera and Seeds; Planting the Seeds **11**
Figure 6: Solar Thermal Water Heating System **12**
Figure 7: Sample Jar **13**
Figure 8: Field Incubator **14**
Figure 9: Thermal Suspension Apparatus (A sock and a rock) **14**
Figure 10: Clostridium after Incubation and Sample after Heat Treatment **15**
Figure 11: Kaserem Clinic **16**
Figure 12: Kakonde Orphanage Rainwater Collection **17**
Figure 13: Cascade Sand Filter **18**
Figure 14: Zinga Well **19**
Figure 15: Sand Dam **21**
Figure 16: Cascading Pools **22**
Figure 17: Papyrus Plant **23**
Figure 18: Chlorine Siphonage **24**
Figure 19: Activated Charcoal **26**

1.0 The WeDev Water Initiative

The WeDev Water Initiative began as an offshoot of the Mission Uganda work. The work began with the development of a slow sand filter in the garbage can in 2014/2015 by Michael Ottensmann, PE. This was followed by the development of the simple salt chlorination device, a rapid sand filter built in a garbage can, and a backwash system using an elevated tank. In 2018, a prototype solar thermal solution for the destruction of Cryptosporidium and Bilharzia (schistosomiasis) was tested on Zinga Island in Lake Victoria. (Greater detail on the methods used and apparatus developed is available upon request.)

The WeDev Water initiative is not the intended to replace full-scale water treatment alternatives to WHO and EPA standards when they, the associated utilities, and trained operators become available. Rather, our goal is to improve water quality by eliminating common pathogens that have an immediate impact on public health. We seek to reduce the exposure to such pathogens until such time as suitable alternatives for a permanent solution become available.

Typical project population is roughly 100 persons and project size is roughly €1000 each site.

WeDev partners with various organizations in implementing projects in underdeveloped countries. For the last three years, engineering support was provided by the SAME Kaiserslautern chapter. In country support was provided by Mission Uganda in the Mityana District, Island Missions and WorldProject.ong in Zinga, and Trinity Center for World Mission in Kaserem, Kapchorwa District.

WeDev provides young engineers the opportunity to perform fieldwork and research into methods for improving water quality side-by-side with a senior engineer in remote under-developed countries. This provides the young engineers within an opportunity to learn problem-solving skills in an environment where store-bought solutions and textbook solutions are not suitable.

WeDev also provides an opportunity for university students at a bachelors and masters level to complete their thesis on water research projects that directly benefit the health of the local population under the mentoring of the senior engineer. The senior engineer accompanies the student from the initial development through the prototype, the field implementation, and finally the integration in the local culture stages.

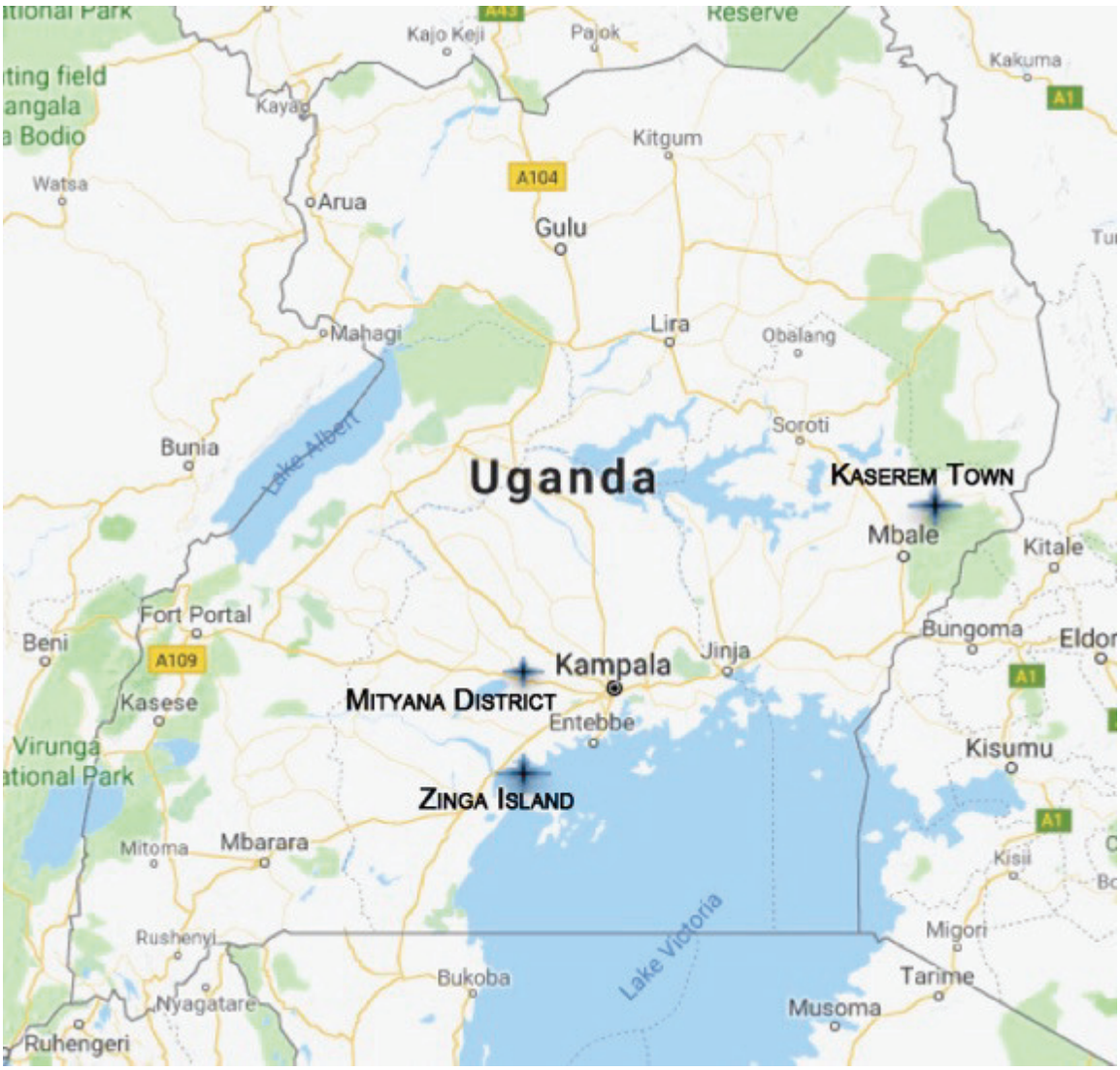

Figure 1: Uganda Project Sites (Image from Google maps)

1.1 Students

The education program offers opportunities for students worldwide to develop practical solutions to improve water quality in under-developed rural communities under the supervision of a senior engineer.

The program received its first two students in 2016. Daniel Kaufmann completed his master's thesis on filtration methods (University of Trier). This was followed by the master's thesis on the effectiveness of a cascade sand filter by Violeta Dimitresku (University of Grenoble, 2017). This year's master student, Isabel Trinidad Mendez Mora (University of Grenada), is developing her thesis on a solar thermal solution for pathogens unaffected by chlorine.

In addition, two recent graduates from SAE film Institute in Frankfurt are preparing documentaries on the work performed in Uganda.

Another student, from the Institute of Natural Science, Isny, Valentina Stoll, completed her internship in field lab work in Uganda. A particular success was the development of a new field method for detecting clostridium.

The program also offers opportunities for junior engineers to gain practical experience through the implementation of water solutions using local materials adapted to the local culture. Each solution is tailored to the culture of the local community integrating local knowledge with traditional engineering practice overseen by a senior engineer.

The mentoring program began to bear fruit during this year's work as the backwash filter upgrade, sand filter installation, and remedial chlorination training work was performed independently by young engineers associated with the program for the past two years without supervision.

2.0 Development Program 2018

2.1 Implementation of an Elevation-Driven Backwash System, Kyamagemule, Mityana District, Uganda

In 2017, the first rapid sand filter, built in a 1000 L rain barrel, was field-tested in Kyamagemule. The initial concept was a continuous feed system using jerry cans. Concept proved effective (turbidity greater than 40 NTUs reduced to 9.5 NTUs), but not ideally suited to culture, as water was normally gathered mornings and evenings. The sand filter was converted to a batch reactor, filling the filter in the evening and recovering the filtrate the next morning. This had the effect of both being acceptable to culture and producing turbidity results 5-8 NTUs. The system has been successfully used for close to one and a half years prior to our return in August 2018.

During that time, the filter was not backwashed. Although the results remained favorable (2-5 NTUs), it is not expected to continue producing such results long-term. Precisely for this reason, WeDev developed a simplified backwash system based on a similar full-scale treatment plant design (http://site.iugaza.edu.ps/frabah/files/2012/02/Water-treatment-Lecture-5-EENV.pdf). The principal design uses gravity from a small, elevated tank producing upward flow from the bottom of the filter of sufficient pressure to lift the smaller dirt particles, but insufficient to carry away the fine filter sand. The prototype was built in Kaiserslautern and proved effective.

The apparatus was built over a period of two weeks in Kyamagemule. Field tests were unable to be performed due to time limitations, but the method is simple enough to be performed by untrained personnel (turn the valve and adjust so the dirt is washed out and the clean sand remains) with WhatsApp support from Germany.

Figure 2: Rapid Sand Filter and Backwash

2.2 Rapid Sand Filtration, Mayobyo, Mityana District, Uganda

Myobyo was chosen as the second location for implementation of a rapid sand filter because of the presence of a mud hole as a primary water source (high turbidity) and the availability of personnel familiar with the procedure (the local leader had participated in the construction of the first rapid sand filter).

The sand filter was outfitted with the backwash apparatus for future connection to an elevated backwash tank. The sand was washed and received two cycles of filtration. The results were still turbid, but it is expected, from experience, to pass within five days.

2.3 Remedial Chlorine Production Training, Kyamagemule/Mayobyo, Mityana District, Uganda

The salt chlorination unit used in the villages in Uganda is a modified and simplified version of the WaterStep unit designed by GE engineers Steve Froelicher and Sam DuPlessis. The adapted unit was reduced down to its simplest effective, usable form consisting of a bucket of salt water with 40 g of salt, two titanium electrodes, a solar battery, and a 50 W solar panel. The chlorine produced in 20 minutes is of sufficient concentration that a jerry can capful per 20 later jerry can is sufficient to disinfect the water. The unit produces enough chlorine to disinfect the drinking water supply of a roughly 100-person village.

At both locations, the solar battery installed in 2016 had reached the end of its lifecycle. Chlorination had not been practiced regularly in approximately one half year and the village leaders were concerned about making untrained mistakes. Two team members performed remedial training for the village leaders. Thereafter, both leaders felt confident in their ability to create chlorine in the future.

Figure 3: The Salt Chlorination Apparatus

2.4 Initiation of the Herbal Remedies Program against Malaria and for General Health, Zinga Island, Lake Victoria, Uganda; Nyanzi, Mityana District, Uganda

Artemesia Annua has been shown in numerous studies to reduce the likelihood of contracting malaria and reducing the severity of malaria symptoms.

Moringa Oleifera (also Malinga in the local language) has many beneficial properties. Its leaves are high in antioxidants; it can be used in tea to boost the immune system. Its seeds provide a nutritious food source for animals, forms a natural coagulant for water treatment, has mild antibacterial properties and provides an essential oil on par with olive oil as a cash crop. The seeds, according to literature, show great promise in the reduction of heavy metals in water.

Both plants do not grow well in flatland areas where the temperatures are high. Zinga, because of its milder lake climate and incidents of malaria, and Nyanzi, because of its higher elevation and incidence of malaria were perceived as more suitable locations for a pilot project for the implementation of the herbal remedies.

Seeds of both species were planted and local citizens trained in the care of the seedlings. Since growth of the species is problematic and since both seed types are sunlight-activated, the seeds were planted on the surface of coconut discs and planted in sandy soil. Over the period of two weeks, substantial growth was seen in both species at the Zinga location and locals appeared adequately trained. At Nyanzi, one citizen was a botanist and minimal training was required.

Figure 4: Artemesia Annua

Figure 5: Moringa Oleifera and Seeds; Planting the Seeds

2.5 Solar Thermal Destruction of Cryptosporidium and Bilharzia (Schistosomiasis) in Water, Zinga Island, Lake Victoria, Uganda

Many pathogens show strong resistance to disinfection with chlorine. Two such species are Cryptosporidium and Bilharzia. Bilharzia is prevalent in Lake Victoria water. The primary mode of transmission is through the skin. Infection by drinking primarily takes place through the skin of the lips. The most observable symptom of a bilharzia infection is the bloated bellies seen in children.

Cryptosporidium is contracted by drinking contaminated water. Cryptosporidium is very prevalent in Lake Victoria water. The symptoms of a Cryptosporidium infection are very similar to those of malaria.

While both species are chlorine resistant, they are susceptible to heat treatment. Much like Legionella, heating water to 60°C for 30 minutes or 70°C for one minute appears, from literature research, to be sufficient for disinfection.

A solar collector with supplemental heat in the form of a 300 W - 12 V heating element, was installed at Zinga. Initial calculations indicate that two 300 W - 12 V heating elements would be needed to achieve 70°C on cloudy days. The apparatus was limited by local conditions. The solar collector had only a single port and larger 12-volt heating elements were unavailable locally.

On sunny days, the solar collector achieved temperatures as high as 53°C without supplemental heat energy. On cloudy days, similar results were achieved using three 150 W solar panels and three 100-Ah batteries (56°C), each connected in parallel, through a charge controller to the heating element.[1]

As expected, the undersized system required a day of recharge after use before reintroduction into the thermal system. A smaller system was chosen because of the aforementioned heating element limitation and a lack of funds. With these limitations, the goal was revised to “proof of concept”. By achieving 53°C under worst-case conditions it is clear that adding a second heating element (or larger one) would be sufficient to achieve the necessary temperatures.

Additionally, for test purposes, the water temperature of 70°C was achieved using traditional methods (charcoal fire). The lake water sample was treated for roughly ½ hour (additional time to allow for the sample temperature to reach 70°C). The sample was incubated at approximately 45°C under anaerobic conditions for 18 hours. After 18 hours, the sample was clean; no growth had occurred.

Figure 6: Solar Thermal Water Heating System

As a side benefit, the heat system also provides warm water for sponge baths, which has heretofore been unavailable on Zinga.

[1] Note: A good quality solar charge controller is essential to ensure the proper functioning of the system. It is not recommended to save money by buying a cheap one.

2.6 Sample Incubation Procedure, Zinga Island, Lake Victoria, Uganda

One of the primary limitations for evaluating the effectiveness of treatment of a cryptosporidium infection is the detection method. Under laboratory conditions, clostridium perfringens is used as an indicator organism for cryptosporidium. The difficulty in using this method in fieldwork is the need for anaerobic incubation at 45°C. In most cases, a commercial lab is required, which is very cost prohibitive, and, in the case of Zinga Island, because of the distance to the mainland and limited transport possibilities, difficult to achieve. A field test was developed to detect clostridium. The field test should be used as a screening tool. Final confirmatory samples should be sent to an accredited lab.

One side benefit the solar thermal heat method is that water with a temperature of 40 to 50°C is readily available.

Anaerobic conditions were achieved by using a candle. A mayonnaise jar was emptied and cleaned. Samples were prepared using blood agar (the tryptose-sulfate-cycloserine-agar, more specific to clostridium, was unavailable). After preparation, the Petri dishes were affixed to the bottom of the jar with candlewax. A candle was inserted, lit, and the jar closed. The flame used up the oxygen in the jar, creating anaerobic conditions.

Figure 7: Sample Jar

A 50-L water barrel was converted into an incubator. The outsides, top and bottom were insulated with four layers of Styrofoam packing material and one layer of silver-backed yellow fiberglass insulation. The barrel was filled with 53°C water and closed.

Figure 8: Field Incubator

In order to keep the jar in an upright position, an athletic sock was passed over the jar, knotted at the bottom and tied to rock. The apparatus was inserted in the water bath and sealed.

Figure 9: Thermal Suspension Apparatus (A sock and a rock)

After 18 hours, the samples were removed. The lake samples, known to have clostridium, showed roughly 20 colonies. Microscopic analysis showed both the rods and the spores typical of clostridium. Although certain species identification was impossible with the limited microscope capabilities, there is a strong probability, given a known presence of clostridia in the sample, that the analysis was correct.

The procedure was repeated with the heat-treated sample and no colonies were observed.

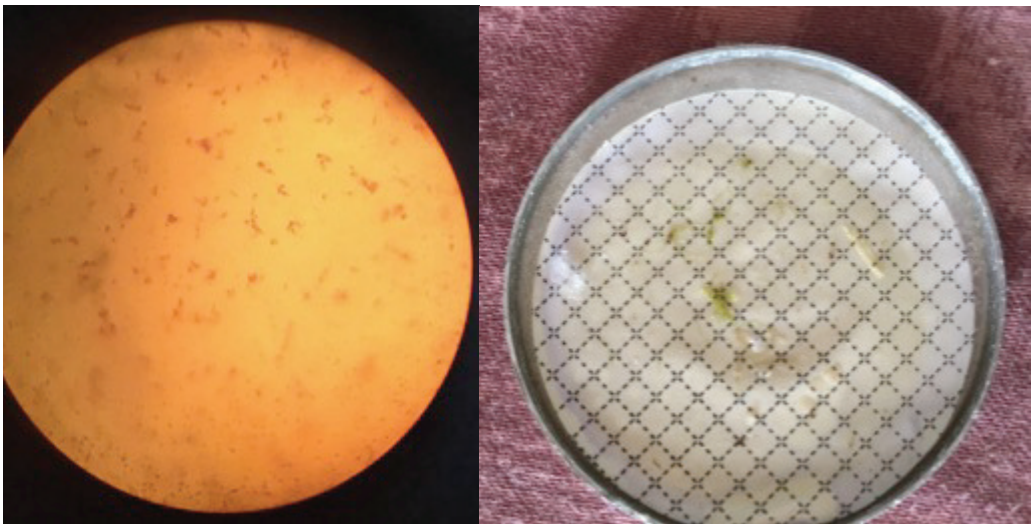

Figure 10: Clostridium after Incubation and Sample after Heat Treatment [2]

[2] The green observed in the sample is algae

2.7 Site Visit for Water Distribution System Planning, Kaserem Clinic, Kapchorwa District, Uganda

Four weeks before departure, we were contacted by a maternity clinic approximately 8 hours from our main site with an inactive well. We were requested to develop a distribution system with running water for the clinic and its lab (two buildings).

We performed a site visit on Thursday, 16 August 2018. During the site visit, we mapped the entire site including a limited elevation survey. The wellhead was opened and water samples obtained.

The local municipality has installed a 6-inch water pipeline immediately across the road from the site. The new water line has not yet been tested and charged, but is expected to provide the water supply for the site in the near future. The existing well maybe used as a backup supply as the municipal water supply in Uganda is often intermittent.

The existing well has a depth of 3 m and the water level starts at 2 m below ground. The water well in its present state is insufficient to provide the needed water supply for the site. Deepening the well is recommended.

Because of the elevation difference between the top and bottom of the site, an elevated water tank at the top of the site should provide sufficient pressure for both buildings.

Figure 11: Kaserem Clinic

A letter report with cost estimate will be prepared for the site and delivered to the customer for further action.

2.8 Rainwater Collection, Kakonde Orphanage, Mityana Village, Uganda

During our stay at the Enro hotel, we were approached by the leader of an orphanage 20 minutes from the hotel, asking for water quality assistance. A team was dispatched to verify the described conditions and the reality of the need. The site had a typical mud hole as its primary water source. Although we would be unable to provide immediate assistance with sand filtration and chlorination, the location has been placed on the list for next year's program.

However, through twist of fate, we accidentally obtained two 1000 L water tanks, with each person thinking it was their responsibility to buy the tank. The availability of a second tank enabled us to offer and implement a rainwater collection alternative. Gutters were installed on the main building and the extra tank was utilized as a rain barrel. While undersized for the purpose, it did provide temporary relief in the form of cleaner water, at least during the rainy season, and hope for the future.

Figure 12: Kakonde Orphanage Rainwater Collection

2.9 Cascade Sand Filter, Kyamagemule, Mityana District, Uganda

The cascade sand filter, built in 2017, was revisited during this trip. The condition of the sand filter illustrates the limitations of short-term engineering projects. The cascade sand filter was completed after the team left the site in 2017.

The cascade sand filter was built on a small spring delivering roughly 6 L per minute. The sand filter was designed with three chambers, each 60 cm in length and 30 cm deep. Horizontal flow would pass through gabion walls separating each chamber. The first chamber utilizes golf ball-sized rock to remove large particles and leaves. The second chamber was filled with gravel to remove smaller particles and the third chamber was fine sand 0.5 to 0.8 mm to remove color and turbidity.

The outlet pipe in the headwall was sized at ½-inch in order to force backpressure to allow a continuous outlet flow.

After our departure, several modifications were made to this design. The outlet pipe had been raised from the bottom of the filter to roughly the middle of the headwall and diameter increased to two 2-inch pipes. This eliminated the planned backpressure and reduced the outflow to a drip.

In addition, to avoid washout of the fine sand, filter cloth was used rather than a gravel pack. While preventing washout, the filter cloth had the undesirable side effect of trapping fine particles and quickly clogging the filter.

The headwall was constructed far too close to the spring outlet channel reducing the channel length from 2 m down to 1.5 m. Consequently, the first two chambers were reduced in length to 50 cm and the last, most important, fine sand chamber to 30 cm (the remainder of the length being gabion walls). This configuration rendered the filtration process ineffective.

Subsequent analysis by the locals showed that the spring is not a naturally-occurring spring, rather a rainwater-fed spring (seasonal). The site has been reverted to its former use, a rainwater-fed pond.

Figure 13: Cascade Sand Filter

3.0 Future Projects

The WeDev Water Initiative will continue with the on-going sand filtration and chlorination program, which will be implemented village by village, as funds become available. In addition, several projects have been identified either for implementation in the coming year or further research by university students. The projects are listed below.

3.1 Drinking Water Well, Zinga Island, Lake Victoria, Uganda

One of the main difficulties in dealing with the drinking water source on Zinga Island is that the shallow unconfined aquifer contains both cryptosporidium and Bilharzia (schistosomiasis). As previously mentioned both species are resistant to disinfection with chlorination. There are four main treatment possibilities: ultrafiltration/ reverse osmosis, UV treatment, ozone, and thermal. Each of the choices is either cost or operationally difficult. Even the traditional method of boiling water involves considerable cost with the requirement to buy sufficient charcoal daily to meet the drinking water needs of the community (as well as being unfriendly to the environment). The solar thermal apparatus was developed as a potential treatment method to combat these two pathogens.

During the course of discussing alternatives, a groundwater survey report was produced by a local driller. A second, confined, aquifer was located beneath the main unconfined aquifer. This second aquifer is relatively unknown because the cost to reach it is beyond the means of most of the small communities on the island.

Figure 14: Zinga Well

In consideration of the cost and difficulty of the treatment alternatives for cryptosporidium and bilharzia, drilling into the deeper aquifer is an attractive alternative. Because the aquifer is confined it is likely less contaminated than the upper aquifer. The depth of the confined aquifer is still well above the depth of

the lake. For this reason, it is likely that the ultimate water source is the lake itself. Therefore, there is no guarantee that the water quality will be substantially better than that of the lake or the shallow aquifer. Since the cost of the additional drilling depth is small when compared to the cost of treatment, it was decided that drilling into the confined aquifer would be the best alternative.

The driller is presently being put under contract and is expected to begin in early September.

3.2 Sand Filtration and Chlorination, Kakonde Orphanage, Mityana Village, Uganda

In addition to the completed work at this site described under 2.7, further water treatment will be needed to improve the water quality of the existing water source. As with sites already completed, a simple rapid sand filter in the 1000 L water tank already obtained and a salt chlorination unit will be needed at the site. A larger storm water collection barrel would be advantageous to maximize the rainwater collection. This project is ready for implementation and it is expected that no additional design services will be needed.

3.3 Sand Dam, Nyanzi, Mityana District, Uganda

The Nyanzi site has no permanent water supply source. The primary water supply is obtained through seepage water ponds in low-lying areas. The ponds are seasonal, drying up towards the end of the dry season. Some additional, non-seasonal, small ponds are available at higher elevation on private grounds. Storm water collection is underutilized.

It is intended, with next year's project, to enhance the storm water and seepage water collection. A site visit of the entire Nyanzi site was performed on Sunday, 19 August 2018. A suitable site for storm water collection was identified. A V-shaped valley along the mountainside ending in a flat plain would provide a usable site for building a sand dam reservoir. Seepage water could be enhanced through the insertion of perforated pipes in the rock face similar to that used in the Canary Islands. The landowner is willing to allow use of his land for this purpose.

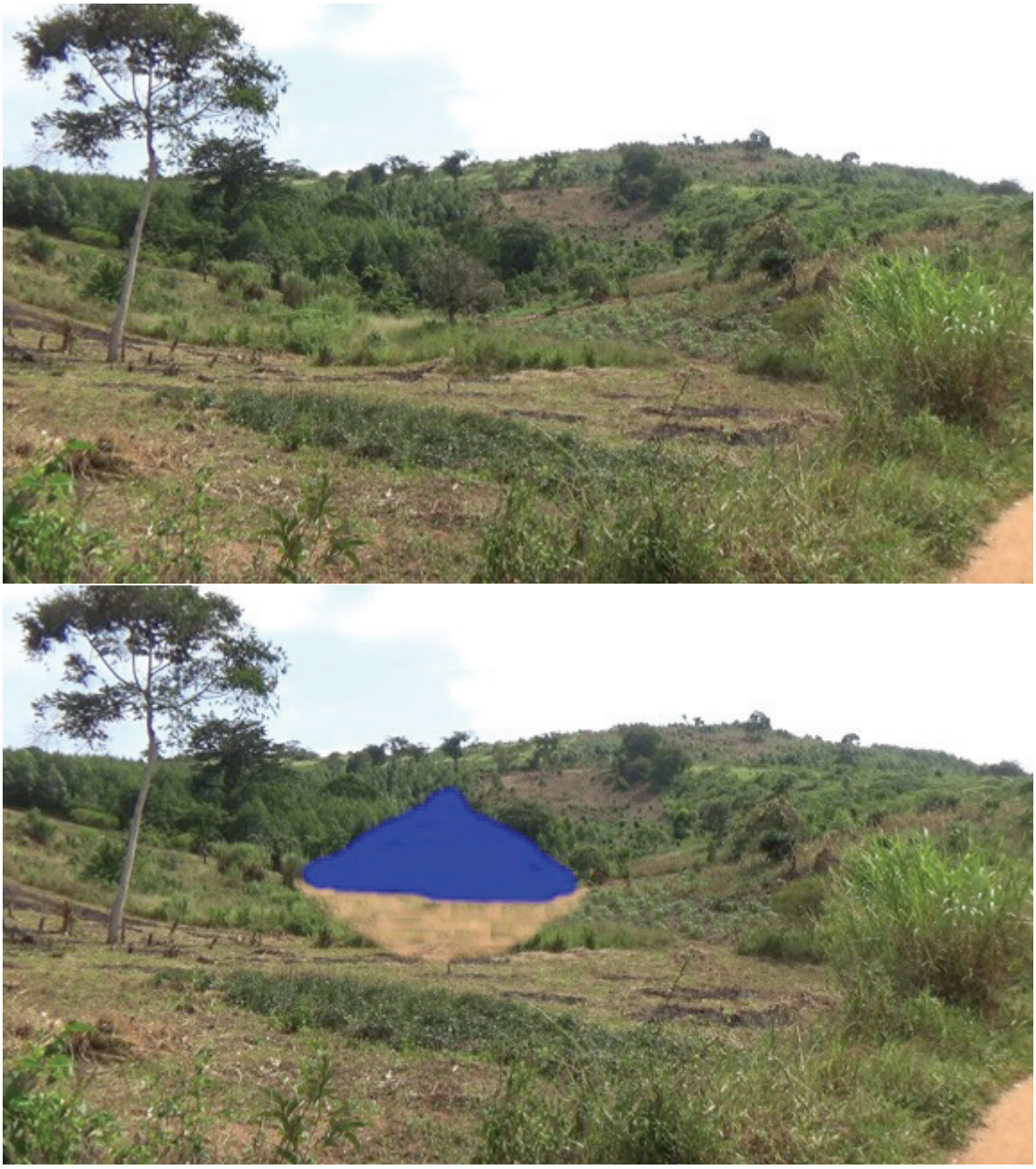

Figure 15: Sand Dam

Research into the best sand dam design and the technology for using perforated pipes for seepage water should be performed during the coming year and a preliminary design for the site completed.

3.4 Cascading Pools, Nyanzi, Mityana District, Uganda

In addition to stormwater collection, there are also permanent seepage-fed ponds at higher elevation in the Nyanzi Area. The ponds are owned by a person willing to donate the water to the village, should a usable method be found to harvest it, so property rights are not an issue.

Because of their size and location, 100 to 200 m above the valley floor, with very steep slopes, implementation of a solution will be difficult. An inlet structure, piping connecting the ponds, and an outlet structure with velocity reduction will be needed at this location. It is likely that turbidity reduction and chlorination will also be needed.

Figure 16: Cascading Pools

A preliminary design will be needed in the coming year.

3.5 Refinement of Clostridium Field Incubator, Zinga Island, Lake Victoria, Uganda

Although the prototype incubator developed in 2018 was practical and sufficient to the task, further refinement would make this field incubator more effective. More sturdy materials, such as a double-thermos container, would improve insulation properties and retention of water heat.

Ideally, the new unit would be sized to fit into a suitcase so that it could be implemented in locations worldwide.

A refinement of the anaerobic sample incubation jar would also be advantageous. The jar mouth should be large enough to allow easy access for the Petri dishes and size large enough to accommodate a small candle. The jar lid should be air- and water-tight.

It is hoped that the laboratory assistant accompanying the 2018 team will receive permission to research this project at her Institute in Isny, Germany. It should be noted that while there are engineering factors involved in the design, the primary need is for laboratory research, because of the requirement to test for clostridium, which is not readily available at engineering schools.

3.6 Papyrus in a Facultative Pond, Zinga, Lake Victoria, Uganda

In addition to engineering considerations, focus should also be placed on projects that provide the opportunity for small businesses to generate income. Papyrus plants, which are of the reed family, provide the potential additional income, where they're implemented.

Facultative ponds as tertiary treatment in wastewater systems or prior to leech-fields are relatively widespread in the industry. Because of their nature, Papyrus could also be integrated into a facultative pond. Papyrus already finds widespread use as matting or roofing material in Uganda. Harvesting the full-grown papyrus from the reed bed should provide additional income.

The effectiveness of papyrus as a reed in wastewater treatment should be researched, studied and tested. A student from University of Darmstadt, accompanying us on the 2018 trip, has expressed interest in pursuing this project as her bachelors project.

Figure 17: Papyrus Plant

3.7 Disinfecting Stagnant Water using a Siphon, Entebbe/Kampala, Uganda

In many areas worldwide, the municipal chlorination system is inadequate to provide residual chlorine at the outer edges of the system. Most areas in the underdeveloped world have individual household-sized elevated water tanks on the rooftops to provide water pressure for the building. The water in these tanks is typically emptied over several days to several weeks without the addition of additional chlorine. This increases the potential that the water will stagnate and become a breeding ground for bacteria.

It is postulated that by the use of local chlorine production or purchase of chlorine bleach siphoned into the storage tank when it is filled could reduce this risk. Under this scenario, a bucket of chlorine with a small diameter hose would be hooked up to the intake line to the storage tank. The water pump filling the tank should provide sufficient pressure to siphon the chlorine into the tank.

The rate at which water is consumed in a household is unclear. The typical degradation rate of chlorine in a household-sized elevated storage tank has also not been established. This project would provide the opportunity for a Masters or PhD student to perform an on-site statistical analysis of water consumption and chlorine degradation at 4 to 6 locations for a period of several months in order to prove the concept and optimize the process. Local contacts are available in Uganda to provide suitable sites for the testing, although this project could be performed anywhere in the world where such facilities are present and local logistical support is available.

Figure 18: Chlorine Siphonage

3.8 Field Testing the Effectiveness of Moringa Seeds on the Removal of Heavy Metals in Water, Amazon Basin, Brazil

As mentioned in section 2.4, Moringa seeds show promise in removing heavy metals in water. Many fishing communities in the Amazon Basin in Brazil and Peru have drinking water wells contaminated with heavy metals, particularly arsenic. These metals are the by-product of years of gold and silver mining.

Logistical support is available in the Amazon Basin in Brazil (see section 6.2). Consequently, there is an opportunity to field test the process in a known location. After developing a practical solution to pilot test, the prototype could be field-tested in Brazil.

n.b. Moringa oil is both marketable and profitable. The coagulation properties are similar whether the seeds are pressed first for oil or not. Thus some of the cost could be defrayed through the investment in an oil press.

3.9 The Effectiveness of Charcoal as a Substitute for Activated Carbon, Uganda

The process by which charcoal is produced (high heat, low oxygen) is very similar in nature to the production of activated carbon. Studies on bamboo wood, prepared similarly, have shown promise in reducing volatile organics (solvents) in water. Activated carbon is also known to reduce taste and odor problems.

Because of the prevalence of charcoal on the Ugandan market, if it could be shown that its properties are similar, locally produced charcoal could be put to beneficial use. A method would need to be developed to reduce the size of the charcoal using local materials down to granular or powder and then tested for its ability to remove solvents under laboratory conditions. Additionally, the treated water should be tested for naturally occurring contaminants that may have leeched out of the charcoal to ensure that local charcoal is clean enough to be used.

After the effectiveness as a solvent-remover has been tested, a simple apparatus would need to be developed with local materials, so that the local community could put the method to practical use. The method of use would need to be field-tested and documented and locals trained to ensure effectiveness.

Figure 19: Activated Charcoal

4.0 Requests From Other Locations

4.1 Music in World Cultures, Chipembi, Zambia

WeDev was requested to perform a site visit in the Chipembi area to perform assistance in enhancing the water resources of the area to take advantage of the rich soils available in promoting agriculture.

4.2 MEAP AM, Amazon Basin, Brazil

WeDev was requested to perform a site visit to the Amazon Basin to determine whether the water program in Uganda would be suitable for transfer to small fishing villages along the Amazon.

A great deal speaks in favor of the venture. The location lies at almost the same distance from the Equator as the Ugandan sites, meaning conditions are favorable for solar power. The presence of raw materials, particularly sand, is very prevalent in the area. The size and education level of the villages is similar.

One particular issue is the presence of arsenic in the water supply from mining activities. This would be a good location to field test Moringa seeds for their effectiveness, as well as to improve the general health. Artemesia seeds were gifted to MEAP during their last visit to Germany.

4.3 Utooni Area, Kenya

The Utooni Development Organization requested a visit from the WeDev team to assist them in implementing a water quality improvement program similar to that begun by the WeDev Initiative in Uganda. The Utooni Development Organization has funding available to implement the program.

5.0 Team Members

Michael Ottensmann, PE, Team Lead
Samuel Ottensmann, Cameraman, Editor
Karolin Woitke, Jr Engineer, Hydrogeology
Violeta Dimitresku, Jr Engineer, Water Quality, Filtration
Mahmud Uthman, Water Technician, Construction Services and Groundwater
Natalija Milanovic, Student, Technical University of Darmstadt, Wastewater Treatment
Valentina Stoll, Laboratory Technician, Institute of Natural Science, Isny
Leon Roskoni, Cameraman
Daniel Kaufmann, Jr Engineer, Construction Services
Isabel Trinidad Méndez Mora, Masters Student, University of Grenada
Anna Sofokleous, Jr Engineer, Herbal Remedies

6.0 Special Thanks

The WeDev Water initiative is primarily funded by small donations from private individuals. On behalf of all who donated, we are grateful.

A special thanks to the AECOM Blueprint Travel Grant Program without which the extent of this year's program would have been far smaller.

A continuing thanks to the Veolia Foundation for their donation of analytical field equipment, which enables us to measure water quality parameters.

Joh. Wacht GmbH & Co. KG, Erd-, Tief, und Wasserbau, Saarburger Straße 37-39, 54329 Konz-Könen, Germany for their kind donation to assist with the water work.

Matthias Blauth, for his assistance in developing the solar thermal prototype.

Bryan Quinn, University of Maryland, for his assistance in understanding solar systems.

A special thanks to Eva López, Biologist and Dr. Estela Menéndez Rivero for their assistance in identifying pathogens and understanding the local health picture at Zinga (and providing medical services to the team during the visit!).

And lastly, a special thanks to Pastor George Yawe, our host in the Mityana Area, Diana Nabuuma, our hostess on Zinga Island and Akim Sekadde, our driver. And of course to the many Ugandans we encountered who always met us with great hospitality.