Award Number: Cooperative Agreement No. AID-521-A-13-00008; CFDA No. 98.001

Program: Development in Innovation Ventures – Haiti.

Project Title: Incentivizing Sanitation with Biogas in Haiti—Stage 1 Pilot Digester Evaluation Creation

Implementing Partner (Authors):
Prime Partner: University of Maryland (Dr. Stephanie Lansing)
Subcontracting Partners: IRRI-Mexico (Alexander Eaton) and Clemson Engineers for Developing Countries (David Vaughn)

USAID Contact: Webert José, Monitoring and Evaluation Team, Health Office - USAID/ Haiti

Date of Publication:
September 4, 2015

Language: English

Submitted by: Dr. Stephanie Lansing, University of Maryland. Department of Environmental Science and Technology. 8127 Regents Dr. College Park, MD 20742. USA. Phone: 301-789-7241; Fax: 301-314-9023; Email: slansing@umd.edu

I. EXECUTIVE SUMMARY:

In this project, it was shown that anaerobic digestion can be utilized in Haiti as an affordable way to treat human waste, produce energy, and provide fertilizer for agricultural production. Less than 25% of the Haitian population has access to improved sanitation facilities. The recent introduction of cholera to Haiti and massive health burden related to diarrheal diseases clearly demonstrate the human and economic toll of this striking gap in sanitation infrastructure. In addition, to meet most of their energy needs, more than 70% of Haiti's population uses charcoal on open fire pits, an expensive, unhealthy and ecologically devastating practice for the country. The main objective of the project "Incentivizing

Sanitation with Biogas in Haiti—Stage 1 Pilot Digester Evaluation" was to demonstrate the viability of small-scale biodigesters as a solution for human waste treatment in Haiti, with utilization of the resulting biogas as a cooking fuel in order to incentivize system adoption. Alongside the installation of key demonstration systems with local institutions, the project specifically aimed to create a digestion learned community through multiple digester operator workshops, creation of a digestion laboratory, and creation and distribution of Field Digestion Test Kits in order to track treatment levels and biogas production. The training and research rigor accomplished by this project was stated as a great need for digesters in Haiti and has been lacking in previous wastewater digestion studies.

In addition to the dramatic sanitation needs in Haiti, the installation of approximately 99 concrete dome digesters in Haiti between 2010 and 2013 had shown mixed overall results, specifically a lack of productive gas use (only 6% of installed projects have viable biogas production) and poor management. This USAID project proposed the use of advanced modular biodigesters designs that could be more easily and reliably installed, providing higher operating temperatures for better waste treatment and guaranteed biogas recovery through impermeable geomembrane materials. With improved technology and a focus on building local management capacity, the project was able to advance the Haitian biogas sector forward with a focus on economic viability and technical rigor.

Following the installation of three institutional biodigester systems, the project proved that small-scale biodigester systems could provide effective treatment for human waste in Haiti. The project demonstrated scale at user numbers in the ranges of 5-15 persons/day (at CFFL), 10-30 persons/day (at Haiti Communitere), and 20-100 persons/day (at Zamni Lasante). In addition, the technical viability of single-family units (3-8 persons/day) was shown during a short trial at 40 rural households (at Food for the Poor).

The installed systems were found to be capable of achieving 99.1% reduction in total coliforms and 98.5% reduction in *E.coli*. The project also demonstrated that the developed simple kits for biogas and water quality testing could be utilized as reliable Digester Field Kits, capable of testing multiple chemical and microbiological parameters in order to provide Haitian technicians with a clear strategy to monitor treatment efficacy. The ability of the technicians to monitor their own digestion systems is seen as a welcome improvement to current management tools, which previously had concentrated on toilet management and cleaning with little attention to monitoring the digester effluent and biogas quality.

To help support the biodigesters installation, the project developed an adjusted toilet installation to reduce toilet flush volume, overall water use and improve the anaerobic digestion process. The project also developed secondary treatment options for the various system sizes that provide additional waste treatment in the form of infiltration systems, gravel treatment wetlands, and agricultural canals for immediate field use for the fertilizer.

The project found that human waste was converted into biogas at a rate of 25-50 liters of biogas per kilogram of human waste (3.5 to 6.5 L of biogas/use), consistent with reported results from other countries, but the first instance of high biogas production documented from Haitian digesters. All of the installed biodigesters produced gas and had biogas burners installed. For the smallest household systems (3-8 persons), the quantity of biogas produced from the limited human waste input was not enough gas to provide cooking fuel for the long enough periods typical of Haitian meals, such as rice and beans, but was able to provide fuel for reheating of meals and water sterilization. Much larger quantities of biogas were available at the larger digester systems, allowing for cooking over longer time

frames, which could be used as a motivation for adoption and use. The expectations around the quantity of biogas and how it can be used productively must be clearly established based on the size of the installed system. Alternatively, household biodigesters as sanitation systems where animal and food waste can be easily collected has the potential to significantly increase biogas production. Small farmers with the waste of a few cows, goats, or pigs, mixed with household waste, could use biogas to cover all of their cooking needs. In this way, biogas could be widely used as a cooking fuel for households, restaurants, city markets, schools, hospitals and other public places.

The project demonstrated challenges around financing of biodigester systems, given that savings and returns from biogas use generated solely from human waste may not be sufficient to drive wider adoption of the technology. The work also clearly demonstrated the need for integrated stakeholder involvement and training in project planning and implementation. Finally, the project also demonstrated significant interest in biogas treatment for sanitation from both government and NGO groups, based on the attendance of 19 groups during the three digester workshops, and successful training of 31 agronomy students, including 5 women, as biogas technicians in cooperation with the Centre Formation Fritz Lafontant (CFFL) located in Corporant, Haiti.

The sanitation surveys showed that of the 550 people surveyed, 39% of people in the rural area (Cange) and 18% in the peri-urban area (Mirebalais) had no access to sanitation and that only 4% and 12%, respectively, had access to a flush toilet, which is lower than the country average. The same survey showed 42% of the respondents in Cange and 51% in Mirebalais listed finances as the greatest limitation to sanitation access. An element of the survey investigated preferences regarding sanitation options in their homes and in public settings, including their willingness-to-pay for a pay-per-use bathroom service where a biodigester may be installed. These results showed there is interest in improved sanitation access, even for small monthly or per-use fees.

Next steps for the project include further development of the application of small-scale biodigesters in households for human waste treatment in Haiti. In other Latin American countries and elsewhere in the world it has been proven possible to combine sanitary waste with animal waste treatment in order to augment biogas production and deliver larger benefits to the user. This would be achieved by working with CFFL, a local agricultural school and one of the stakeholders of this project. Additionally, future work should aim to work with the trained agronomy students on the distribution and sale of digester effluent as organic fertilizer for use in agriculture, orchards and reforestation work, developing the market in Haiti.

Additional next steps would include the further development and dissemination of the Biogas Field Test Kit and building capacity within local laboratories such as Université Quisqueya to undertake water quality and biogas testing on installed systems to increase the understanding of on-the-ground conditions affecting treatment levels in Haiti. Further growth of the Biogas Learned Community will allow for greater knowledge sharing, stakeholder involvement and increased project implementation for the biogas sector in Haiti.

II. KEY ACHIEVEMENTS:

Less than 25% of the Haitian population has access to improved sanitation facilities. The recent introduction of cholera to Haiti and massive health burden related to diarrheal diseases clearly demonstrate the human and economic toll of this striking gap in sanitation infrastructure. In addition, to meet the majority of their energy needs, more than 70% of Haiti's population use charcoal on open fires an expensive, unhealthy and ecologically devastating practice for the country.

The main objective of the project "Incentivizing Sanitation with Biogas in Haiti—Stage 1 Pilot Digester Evaluation" was to demonstrate the viability of the use of small-scale biodigesters as solution for human waste treatment in Haiti, with utilization of the resulting biogas for cooking fuel, providing an incentive for system use. Alongside the installation of key demonstration systems with local institutions, the project specifically aimed to create a digestion learned community through multiple digester operator workshops, create a digestion laboratory, and create and distribute Field Digestion Test Kits in order to demonstrate and track treatment levels and biogas production. This training and research rigor accomplished by this project was stated as a great need for digesters in Haiti and has been lacking in previous wastewater digestion studies.

In this project, it was shown that anaerobic digestion can be utilized in Haiti as an affordable way to treat waste, produce energy, and provide fertilizer for agricultural production. The modular digestion technology was installed in Haiti using three different contexts/design scales: a hospital system at the PIH-Cange complex for 100+ users, a residential system at Haiti Communitere for 20+ users, and a combined swine manure and sanitation system at CFFL in Corporant. The waste is conveyed by gravity using 4" PVC to a series of two or three digesters with a 30-100 day retention time, significantly reducing organic matter and pathogens. The outflow, which is largely odor-free but still contains nitrogen and phosphorus nutrients, can be used as a fertilizer to increase crop growth and enhance soil quality. The biogas can be used for cooking or water heating in an adapted gas burner. The gas is stored inside the reactors and conveyed to the burner through 1" hose. A pressure release valve and an outflow valve are installed within the hose for safety.

Alongside the installation of the three demonstration digestion systems, the project created a digestion learned community through digester operator workshops, conducted rigorous testing of the pilot systems, created a digestion laboratory and field digestion test kits, conducted sanitation surveys of over 550 locals in Cange and Mirebalais, and created a Haitian-specific business model to drive future adoption of the technology.

Specifically, this project addressed a large need for a Research-based approach to Biogas implementation in Haiti. A recent report entitled "Lessons Learned from the Dissemination of Biodigesters for Sanitation in Haiti from 2010 to 2013," released March 2014, documented successes, failures, and recommendations for future work based on 99 dome-shaped sanitation biodigesters installed in Haiti. The recommendations of the report included the items below, and this USAID project worked to address these needs.

- "Pilot schemes should have research and learning as their principal objectives, and therefore be implemented together with relevant research and training partners."
- "More research on the biodigesters presented in this report is needed in order to determine their performance characteristics."
- "A range of training needs & training partners . . . should be identified . . . in the form of seminars, workshops & customized training programs for different stakeholder groups."

Stakeholder Engagement and Training

The project engaged several stakeholder organizations through three workshops on 1) Digester Learning Community in Haiti (30 participations: 10 women, 20 men), 2) a two-day Biodigester Training and Installation Workshop (31 participants: 5 women, 26 men), and 3) Use of the Field Test Kit Training (24 participants: 5 women, 19 men). The Digester Learning Community Workshop (Photo 1), the first workshop of the DIV project, was held on August 23, 2014. The two-day workshop on biodigester basics, including the installation of the CFFL biodigestion system by the participants on the second day of the workshop (Photos 2-3), was held on March 14-15, 2014. In the all-day Biogas Kit training workshop (Photos 4-6) held April 1, 2014, tools were given to the biogas operators to evaluate digestion system through the development and distribution of five Biogas Test Kits along with an all day digester laboratory and field-based training. There were also 4 laboratory technicians trained (1 women, 3 men), and two in-country laboratories were upgraded to test the digestion systems (CFFL and University of Quisqueya) (Photo 7). The following stakeholder groups attended at least one of the workshops: USAID, Univ. of Maryland, IRRI-Mexico, Partners in Health, VivaRio, Sustainable Sanitation, DINEPA, Ministry of Health-DOSS, UN MINUSTAH, Islamic Relief, CFFL, Universitè Quisqueya, HELVETAS Swiss Intercooperation, Food for the Poor, Haiti Communitere, Hôpital Albert Schweitzer, PROPRE-Haiti, Global Alliance for Clean Cookstoves, Harvard Univ., Chemonics, Builders Without Borders, Ohio State Univ., SOIL, CTMO-HOPE, and private interest individuals.

Principal stakeholder relationships were formed with Partners in Health (referred to as Zamni Lasante within Haiti), Haiti Communitere, Food for the Poor and CFFL/Zanmi Agrikol, who were involved in the installation of biodigester systems, training of staff and community surveys. Through the survey work and stakeholder input, it was determined to install systems with these partners which involved discussions with their senior management on the implementation requirement, site visits, evaluations to assess technical feasibility of the installations, and identification and training of on-site managers. In addition, to the three on-site managers trained at each location, four interns from CFFL were further trained in a one-month program on the household-scale digestion systems at Food for the Poor.

Water Quality and Biogas Testing

Laboratory personnel at Université Quisqueya (uniQ) were trained in biodigester sampling and were integral in the water quality testing of the systems. The partnership with uniQ was a key partnership that formed out of implementation of this project, as identifying qualified technicians to quantify the performance of the biodigester system was a challenge prior to network formation achieved during this project. UniQ was chosen after multiple laboratories in Porte-au-Prince were evaluated on their testing capabilities, including personnel and necessary testing equipment for wastewater analyses. The following laboratories were evaluated: Jedco Services S.A, DINEPA – National Directorate of Potable Water and Sanitation, National Public Health Laboratory, Laboratory for the National Faculty of Agriculture, Titanyen Sewage Treatment Plant, and Université Quisqueya. After choosing uniQ as a key testing partner, multiple visits were made with Deans and supervisors, with the technicians participating in a full day individual training with Dr. Lansing to ensure the biodigestion testing was conducted according to scientific standards.

Water quality tests were performed for each digestion system to evaluate its performance (Tables 1 and 2). Reduction in the quantity of solids and organic matter is an

important treatment criterion of anaerobic digestion. As the organic matter is transformed into biogas, the resulting effluent of the digester has less solids, odor and pathogens, which adhere to the solid particles. On average, the digesters reduced total solids (TS) by 78.7% and volatile solids (VS) by 85.1%. Chemical oxygen demand (COD) is a test used to evaluate the organic matter, and thus the pollution potential in wastewater. COD was reduced by 93.6%, indicating a large decrease in organic pollutants. The digesters were evaluated on their ability to reduce pathogens. Total coliforms were reduced by 99.1% and *E.coli* was reduced by 98.5%. Alkalinity measures the buffering capacity of the digester, i.e. ability to maintain a neutral pH (7.0), which is essential for methane-producing microorganisms. The alkalinity was reduced by 19.6% during digestion, but the pH was reduced by only 2.4% (7.13 to 6.96), illustrating the stability of the digestion environment.

While reductions of nutrients occur with digestion treatment, a large quantity remains with the effluent providing a fertilizer with a greatly reduced pathogen risk. As the nutrients are still present, if the effluent is not utilized on-site it should be treated with infiltration pits or gravel-bed wetlands before release into waterways. Total nitrogen (TN) was reduced by 79.7% (449 to 91 mg/L TN), with the total nitrogen in the effluent in the ammonium form (NH_4^+). Phosphorus was reduced by 88.5%, with the total phosphorus (TP) in the effluent in the orthophosphate form (PO_4^{3-}) (105 to 12 mg/L TP) (Table 3).

Total biogas production, as well as the methane (CH_4) and hydrogen sulfide (H_2S) content of the biogas, were measured. The biogas averaged 65.4% CH_4 and 0.10% H_2S (Table 4). The average biogas production of Zamni Lasante was 108 L/day (70.9 L CH_4/day), equating to a production of 3.48 L of biogas/user (2.28 L of CH_4/user (Table 5).

Sanitation Surveys

The 550 completed sanitation surveys showed that 39% of people in the rural area (Cange) and 18% in the peri-urban area (Mirebalais) had no access to sanitation, which is lower than the country average, possibly due to the free latrine usage at the PIH Hospital (Figure 1). Only 4% in Cange and 12% in Mirebalais had access to a flush toilet. Finances were listed as the greatest limitation to accessing improved sanitation by 42% of the respondents in Cange and 51% in Mirebalais (Figure 2). In Cange, 57% of the respondents have used a pay for use sanitation facility, with 39% in Mirebalais (Figure 3). In Cange, 38% of the respondents were very interested and 46% slightly to moderately interested in using pay-for-use facilities, with 46% and 54%, respectively, in Mirebalais (Figure 4). The majority of the participants were willing to pay $0.10 - $0.30 per use at a pay-for-use facility (Figure 5), with higher prices for toilet-based facilities (Figure 6). The majority of participants estimated payment of $500-1200 last year for their own sanitation infrastructure or services related to pay for use facilities. The top three factors that influenced their desire to use such a facility were the cleanliness of the facility, safety, and their desire to help local businesses (Figures 7-10). Additional quotations from survey participants on their current sanitation practices and future needs are given in the Appendix.

Business Model Development

A business model was proposed with the use of local entrepreneurs and businesses to sell, install and service prefabricated, high quality biodigester systems using micro-franchise marketing, technical and service package. Households, hotels, and other institutions would purchase the systems as a sanitation and energy alternative. Other local businesses owners

would purchase systems to set up pay-for-use toilets (monthly subscriptions of individual use payments). Local sanitation group SOIL has used similar models to collect composted human waste. While this model has not been tested for biogas systems in the Haitian sanitation context, it has been used successfully by the project directors elsewhere in Latin America by thousands of farmers for farm-based digestion systems.

Based on the costs of our projects, the estimated up-front investment cost would be approximately $35 US/person for medium-scale applications of shared toilet systems, with O&M of $1.50/person/year. If an entrepreneur were to charge market rates for use of the toilet, and utilize the resulting biogas, the capital investment would pay back in less than two years, and allow for profits above operating costs for the 10-15 year life of the system.

Ideally, the technology suppliers ideally would leverage development funding to help reduce end users' cost and drive the adoption of the technology through market-based incentives. Academic and institutional partners would still be needed to support research, promotion, quality control and capacity building in the short to medium term.

The cost estimate, excluding shipping and importation, was $800 for a hostel/multi-household (2 m^3 at Haiti Communitere), which consisted of a two-cell digestion system after a wooden flush toilet and sink structure with post-treatment soil infiltration and effluent use prior to post-treatment in local gardens. The CFFL system cost was $1400 for a three-cell digestion system (3 m^3) with concrete flush toilet and sink and use of the effluent for agriculture. The Institutional Model (PIH) cost $7,800 for a three-cell digester (36 m^3) with a concrete structure for four toilets, a urinal and aboveground gravel post-treatment wetland.

The Client Economic Model would involve creating conditions with the lowest cost per user with higher level of service and lower O&M. Each cubic meter of gas provides 2.5-3.5 hours of cooking time per day ($0.50-0.70 value), with higher number of users and additional animal input increasing the quantity of biogas produced. The fertilizer could be worth up to $0.05/L based on Haiti latrine compost and the increase in crop yields. The sale of fertilizer was not utilized in this project, with the effluent either treated directly at the hospital system or used locally at the other two systems. Given continued risks of transport of human waste, the fertilizer value was only considered for on-site utilization. The surveys showed that the potential for pay-per-use toilets of $0.10-0.30/use. Depending on the number of users, there could be a 1 to 3 year payback on digestion investment. It should be noted that other traditional sanitation options DO NOT have payback in real terms and have running costs related to pumping and emptying. Additional health, timesaving, quality of life, and environmental considerations will be definitely realized but were not included in the calculations above. Further steps should be taken to quantify these externalities in order to develop a true cost/benefit analysis of sanitation-based digestion systems in Haiti.

Future Work and Recommendations

Next steps include further development and application of small-scale digesters for sanitary waste treatment, especially where animal or food waste can be incorporated to augment biogas production and deliver larger benefits to the user. This could be achieved by working with CFFL, a local agricultural school and a project stakeholder. Future projects will work with the agronomy students on distribution and sale of digester effluent as an organic fertilizer, developing the market in Haiti, as well as further development and dissemination of the Biogas Field Kit. We will continue to collaborate and build capacity within local laboratories, such as the Université Quisqueya, to undertake water quality and

biogas testing on installed systems to further understand conditions affecting treatment in Haiti. Additionally, further growth of the biogas learned community would allow for more knowledge sharing, stakeholder involvement and biogas project implementation in Haiti.

Indicators Table

INDICATORS	Reporting Period:			
	Target for the reporting period	**Achievements for the reporting period**	**% realized**	**Comments**
Indicator 1: Complete construction of PIH Sanitation Center	Complete all indicator activities	Completed: Sanitation Center with 6 toilets and 1 urinal built to code; A three cell 36 m^3 digester constructed; Post-treatment wetland constructed; Operation of sanitary digestion system	100%	See Photo 8, Treatment and Biogas Production Tables
Indicator 2: Digester Site 2 Design & Construction	Complete all indicator activities	Completed: CFFL chosen as appropriate site and digester designed; Restroom with 1 toilets constructed and built to code; A three cell 3 m^3 digester constructed; Operation of sanitary digestion system	100%	See Photo 9, Treatment and Biogas Production Tables
Indicator 3: Education	Complete all indicator activities	Completed: Digester Workshop 1: Digester Learning Community (August 23, 2013); Digester Workshop 2: Digester Installation (March 14-15, 2014); Assemble digester field kits; Digester Workshop 3 – Biogas Field Kit Training (April 3, 2014)	100%	See Photos 1-6 Workshop Materials and Workshop Discussion Document
Indicator 4: Digester Evaluation	Complete all indicator activities	Complete: Assessment of WQ testing infrastructure in Haiti; WQ testing; Surveys – in Cange and Mirebalais; Economic analyses	100%	See Survey Evaluation Figures

III. MANAGEMENT ISSUES

There were no major issues with the financial expenditures and pipeline of the grant once finances were transferred to the University of Maryland (UMD). A no-cost extension was granted due to delays in approval of a subcontract to Université Quisqueya (uniQ) for in-country water quality testing. Once the sub-award was approved, the testing of the biodigesters proceeded and the grant deliverables were successfully completed.

A fruitful collaboration was developed between UMD and uniQ during this time, but exploring all of the laboratories in Haiti to determine their capabilities was challenging. A research assistant at UMD visited multiple possible collaborators, including: 1) Jedco Services - Haiti's largest sanitation services companies, which had no wastewater testing capabilities and deliver their waste to treatment sites run by the national government; 2) DINEPA – National Directorate of Potable Water and Sanitation (Direction Nationale de l'Eau Potable et de l'Assainissement)'s Water Quality Lab (Unité de Laboratoire et Contrôle de la Qualite de l'Eau), which performs only water quality testing (not wastewater), but could test the fully treated effluent from a digester system for Total Coliforms, E. Coli, pH, Conductivity, Alkalinity, and Total Dissolved Solids (TDS); 3) National Public Health Laboratory (Laboratoire de la Sante Publique), which does not perform wastewater analyses, only drinking water testing of coliform and *E. Coli* for free; 4) Laboratory for the National Faculty of Agriculture – Tamarinier, which does not perform wastewater analyses, only water quality testing, and 5) Titanyen Sewage Treatment Plant, which also does not perform any wastewater testing procedures.

There were no challenges with staffing, as time was taken both before the grant commenced and during the granting period to establish strong networks with our local stakeholders. The main stakeholders: Zanmi Lasante (Partners in Health), Zanmi Agrikol/CFFL, and Haiti Communitere have deep roots in Haiti and strong local support. This trust in our local partners was key in the acceptance of the technology and willingness to attend training, perform routine maintenance and keep the systems operating successfully. There were no consultants used in the projects, as the main PIs on the projects, Dr. Lansing and Alex Eaton, are known experts in the field and conducted all of the trainings.

The international travel included five trips from the PI, Dr. Stephanie Lansing, and six trips by Alexander Eaton. In addition, the research assistant at UMD, David Waters, resided in Haiti for four months to assist in assessing laboratories capabilities in country and building relationships with these laboratories. Rachel Smith, a lead researcher at IRRI traveled to Haiti two times to assist in the education workshops. There were four interns from Clemson University that worked on the project, with each intern living in Haiti for 6 to 12 months and working on the project and making 2-3 international trips during that time (their airfare was not part of the finances of this project).

IV. CHALLENGES FACED DURING THE REPORTING PERIOD

There were a couple of key challenges during this reporting period, mostly in the technical and financial components of the work. First, local technical capacity in Haiti related to sanitation, plumbing, and biogas is extremely limited. This is to be expected, given the extremely low sanitation coverage. However, many of the basic skill sets that would allow for effective training of local technicians were also missing. This lead to extended training periods to build capacities for testing, installations, and long-term follow-up. These challenges were overcome by spending additional resources on training and building alliances with local Universities and Vocational schools to add value to our training efforts.

This project brought co-financing to the table through the University of Maryland, Clemson University and IRRI-Mexico. However, there was hope that these efforts would demonstrate the benefits of the technology in such a way that additional funding sources would have participated by funding additional projects and capacity building. We had participation from Food for Poor and Islamic Relief, but other potential commitments have not been realized. The goal was that the additional projects would have helped keep project participants actively working on new and expanding projects to build momentum from the positive findings of this work. This has been slower that we had hoped, but our efforts to continue to find new funding sources for this work continue. There are a number of good funding options remaining, and we will continue to actively pursue additional funding.

V. SUCCESS STORY

Before this project, the 20-30 field staff and students that worked at the agricultural and vocational school Zamni Agrikol practiced open defecation in and around the agricultural lands of the school. This project included the installation of a multi-reactor Sistema Biobolsa biogas system that is now providing a flush toilet with waste treatment to this group, with hand washing and gas use for heating food and water. The waste is treated to a level that allows the effluent to be an effective and safe fertilizer for the fruit trees, corn, and other crops at the farm. The gas can be used for heating meals in a small break area.

This system was installed as part of a two-day biogas course, the first of its kind in the region, including over 20 students from the school and representatives of local development organizations. All curriculum materials were translated to Creole and adapted to the Haitian context from the work of IRRI-Mexico in Latin America.

The teachers of the school where given additional training in the material so that they could provide future trainings, and three of the top students were selected to complete a two-month internship working with a rural community on the installation of 40 trial household biodigesters at Food for the Poor.

This transfer of knowledge, capacity, and technology to these local students and teachers embodies the goals of this project because is sets a foundation of positive experiences surrounding biogas technology that will allow for the effective replication of the technology in the future. The experience with the technology showed the technical viability and served as an educational opportunity.

As a vocational institution, Zamni Agrikol/CFFL could be a strong promoter and implementer of the technology, and this experience could be replicated at other schools, universities, organizations and businesses around the country.

Students and the CFF Instructor Installing Their On-site Biodgestion System

VI. CONCLUSION AND RECOMMENDATIONS

Small-scale biogas technology has been shown to be a technically viable waste treatment option to support the development of dignified modern sanitation services in Haiti. Technical viability of digesters to treat wastewater to biogas and effluent to a high quality fertilizer were scientifically verified in order to help meet the critical sanitation, energy, agricultural, and women's health/safety gaps in Haiti. This project was able to bring together a low-cost sanitation solution that was adapted to the Haitian context combined with scientific rigor, stakeholder input, and high quality training of digester technicians. Moving forward, more training is always needed with the involvement of skilled and experienced professionals to create qualified managers and on-site attendant to ensure cleanliness and patron safety. Digester economic models were built around the production and use of the produced biogas, but production can be variable with only human waste addition, which can lead to sporadic biogas use. Business models should concentrate on pay-for use model to pay for operation and management costs rather than concentrating only on biogas for income, unless animal waste is incorporated or high daily user numbers are ensured. Increasing use of the toilets and combining other organic wastes (animal waste, market slaughter house waste, kitchen scraps) will increase biogas production and make the economics of the digestion systems more predictable. When biogas is produced, we have shown that the quality of the produced biogas is high (averaging 65%). In addition, low- or no-flush toilets should be incorporated into sanitary wastewater treatment models in order to minimize water input and ensure high digester retention times, proper treatment of pathogens, and high quality biogas production.

Photos, Tables and Figures:

Photo 1: Digester Learning Community Workshop

Photo 2: Biodigester Training and Installation Workshop

Photo 3: Biodigester Training and Installation Workshop

Photo 4: Haiti Biogas Test Kit

Photo 5: Haiti Biogas Test Kit Workshop

Photo 6: Haiti Biogas Test Kit Workshop Certificate Presentation

Photo 7: Dr. Lansing training a UniQ technician on use of a CH_4 and H_2S meter

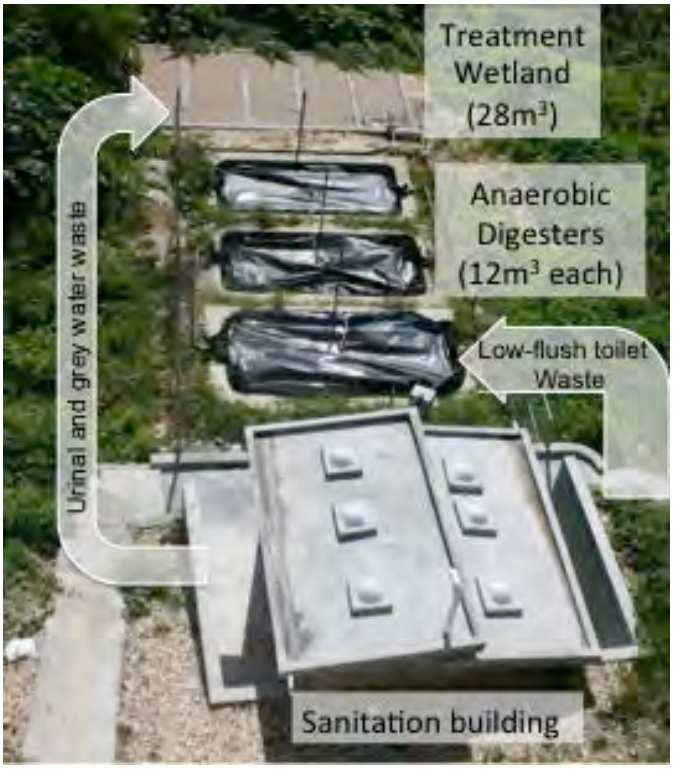

Photo 8: Partners in Health/Zanmi Lasante Sanitation Treatment System

Photo 9: CFFL/Zanmi Agrikol Sanitation Treatment System

Table 1: Wastewater Treatment Efficiency for All Digesters (Average Values)

Substrate	TS[a] (g/L)	VS[b] (g/L)	COD[c] (mg/L)	Total Coliforms (CFU[d]/100 mL)	*E. coli* (CFU/100 mL)	Alkalinity (mg $CaCO_3$/L)	pH	Temperature (°C)
Influent	2.71 ± 0.39	2.09 ± 0.35	2453 ± 329	6040 ± 949	2730 ± 550	764 ± 46	7.13 ± 0.09	31.4 ± 0.5
Effluent	0.58 ± 0.04	0.31 ± 0.03	158 ± 21	56 ± 6	41 ± 5	614 ± 81	6.96 ± 0.06	31.0 ± 0.3
% Reduction	78.6%	85.2%	93.6%	99.1%	98.5%	19.6%	2.4%	1.3%

[a]TS: Total Solids [b]VS: Volatile Solids [c]COD: Chemical Oxygen Demand [d]CFU: Colony Forming Units

Table 2: Water Quality Efficiency Indicators for Individual Digesters (Average Values)

Substrate	TS[a] (g/L)	VS[b] (g/L)	COD[c] (mg/L)	Total Coliforms (CFU[d]/100 mL)	*E. coli* (CFU/100 mL)	Alkalinity (mg $CaCO_3$/L)	pH	Temperature (°C)
HC[e] Digester (influent)	1.90 ± 0.09	1.27 ± 0.09	1086 ± 88	5710 ± 1020	4760 ± 933	1060 ± 72	7.20 ± 0.06	30.22 ± 0.30
HC Digester (effluent)	1.16 ± 0.09	0.59 ± 0.05	320 ± 45	154 ± 16.1	122 ± 14.7	990 ± 176	7.08 ± 0.05	29.88 ± 0.47
% Reduction	39.0%	53.5%	70.5%	97.3%	97.4%	6.6%	1.7%	1.1%
ZL[f] Digester (influent)	5.02 ± 1.01	4.21 ± 0.91	6110 ± 849	11,000 ±1470	2770 ± 567	260 ± 40	6.99 ± 0.16	29.43 ± 0.61
ZL Digester (effluent)	0.33 ± 0.02	0.17 ± 0.03	91.7 ± 14.4	13.2 ± 2.46	1.40 ± 0.19	473 ± 37	6.84 ± 0.07	29.55 ± 0.22
% Reduction	93.4%	96.0%	98.5%	99.9%	99.95%	-81.9%	2.1%	-0.41%
CFFL[g] Digester (influent)	1.22 ± 0.05	0.80 ± 0.03	159 ± 51	1460 ± 358	667 ± 150	973 ± 27	7.20 ± 0.04	34.60 ± 0.61
CFFL Digester (effluent)	0.25 ± 0.02	0.17 ± 0.01	62.6 ± 3.91	2.23 ± 0.5	0.84 ± 0.28	380 ± 31	6.95 ± 0.06	33.64 ± 0.17
% Reduction	79.5%	78.7%	60.6%	99.8%	99.9%	60.9%	3.5%	2.8%

[a]TS: Total Solids [b]VS: Volatile Solids [c]COD: Chemical Oxygen Demand [d]CFU: Colony Forming Units
[e]HC: Haiti Communitere, Port-au-Prince, Haiti
[f]ZL: Zanmi Lasante - Partners in Health in Cange, Central Plateau, Haiti
[g]CFFL: Centre de Formation Fritz Lafontant in Corporant, Central Plateau, Haiti

Table 3: Nutrients in the Influent and Effluent of the Digesters (Average Values)

Substrate	NH_4^+ (mg/L)	TKN[a] (mg/L)	PO_4^{3-} (mg/L)	TP[b] (mg/L)
Influent	163 ± 24	449 ± 146	23.2 ± 2.6	105 ± 36
Effluent	99 ± 12	91 ± 12	10.6 ± 1.4	12 ± 1.4

[a]TKN: Total Kjeldahl Nitrogen [b]TP : Total Phosphorous

Table 4: Methane (CH_4) and Hydrogen Sulfide (H_2S) Concentrations in the Produced Biogas

Substrate	CH_4 (%)	H_2S (%)
All Digesters (Average)	65.4%	0.10%
HC[a] Digester	72.7%	0.19%
ZL[b] Digester	65.4%	0.06%
CFFL[c] Digester	58.2%	0.04%

[a]HC: Haiti Communitere, Port-au-Prince, Haiti
[b]ZL: Zanmi Lasante - Partners in Health in Cange, Central Plateau, Haiti
[c]CFFL: Centre de Formation Fritz Lafontant in Corporant, Central Plateau, Haiti

Table 5: Biogas and Methane Production from Zanmi Lasante (PIH) Digester in Cange

	Biogas	Methane (CH_4)[a]
Daily Production	108 L/day	70.9 L/day
Daily Production Per Use	3.48 L/use-day[b]	2.28 L/use-day[b]
Daily Production Per VS[c] Input	0.207 L/g VS	0.135 L/g VS

[a] energy value: methane production at 65.5% of total biogas
[b] volume of biogas produced per use, averaged over a day
[c] VS: Volatile Solids

Survey Data Collected in Cange and Mirebalais, Central Plateau, Haiti

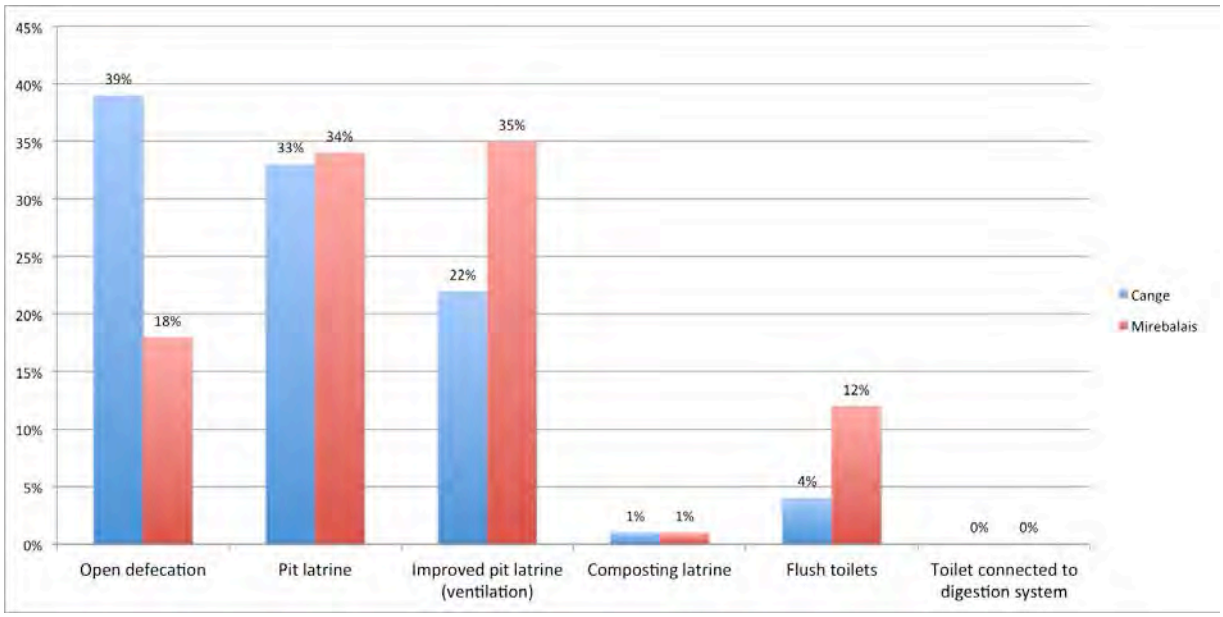

Figure 1: Current Sanitation Practices.

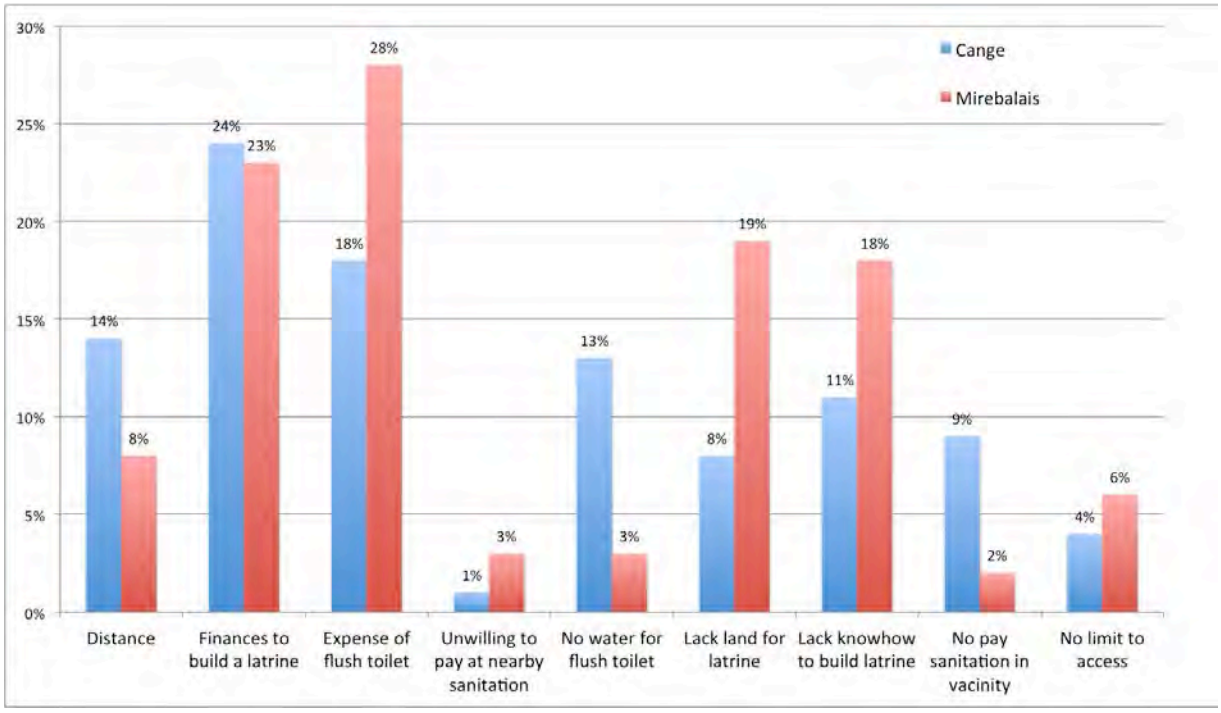

Figure 2: Limitations to Accessing Improved Sanitation.

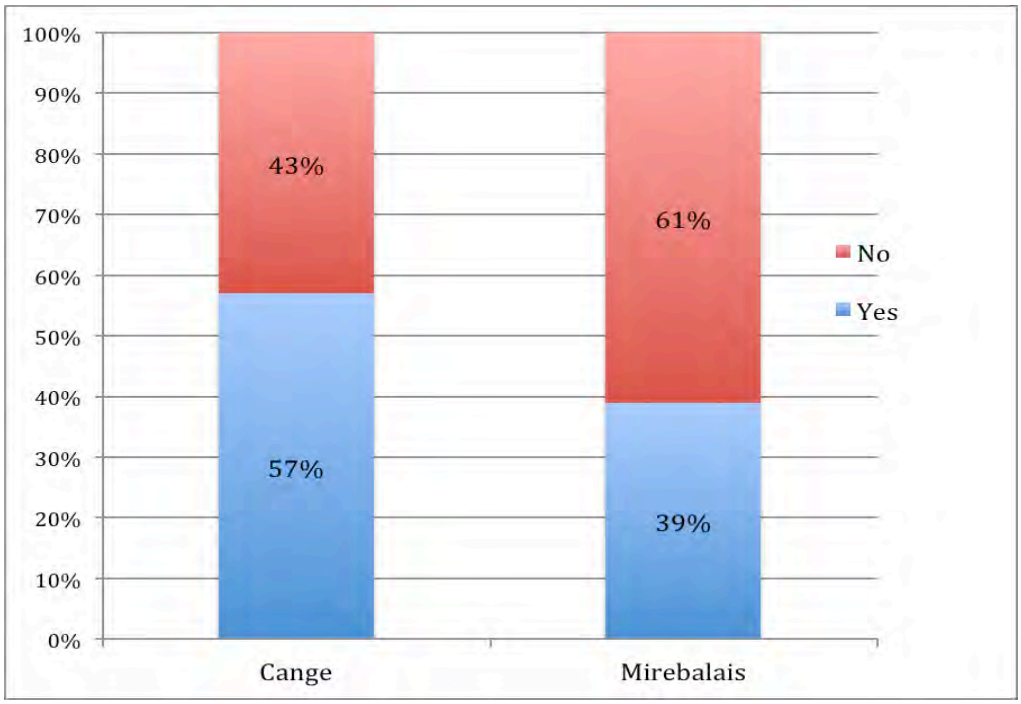

Figure 3: Currently paying for use of sanitation facility?

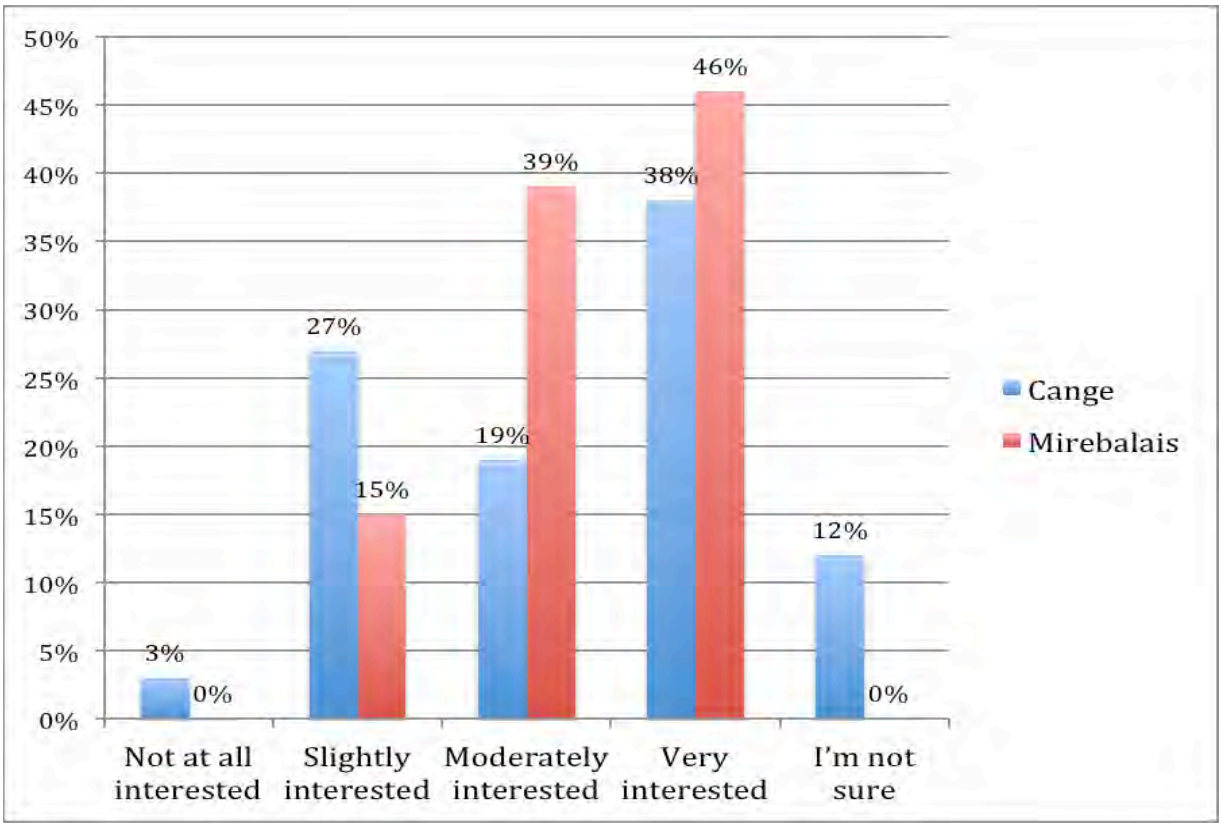

Figure 4: Interest in Transitioning to a Pay for Use Sanitation Facility.

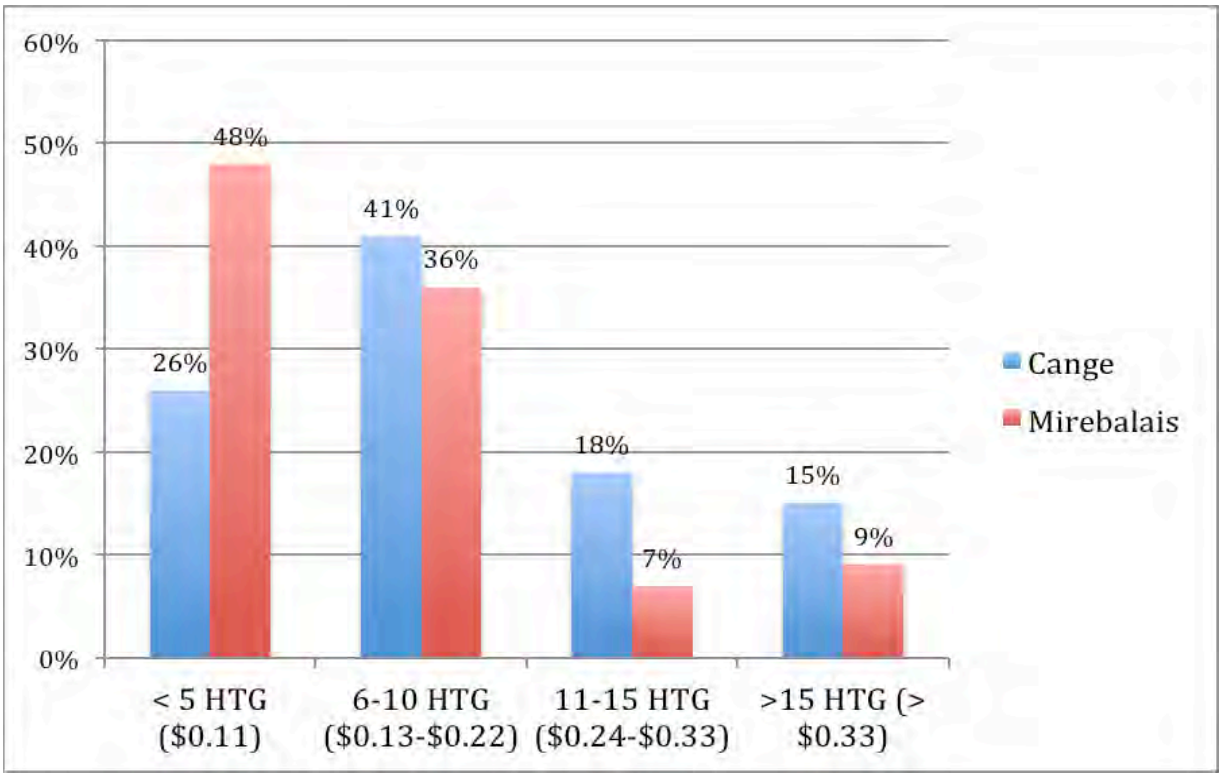

Figure 5: Willingness to Pay for Pay for Use Facility. *HTG: Haitian Gourde. US Treasury exchange rate: 45 HTG = US$1.00.

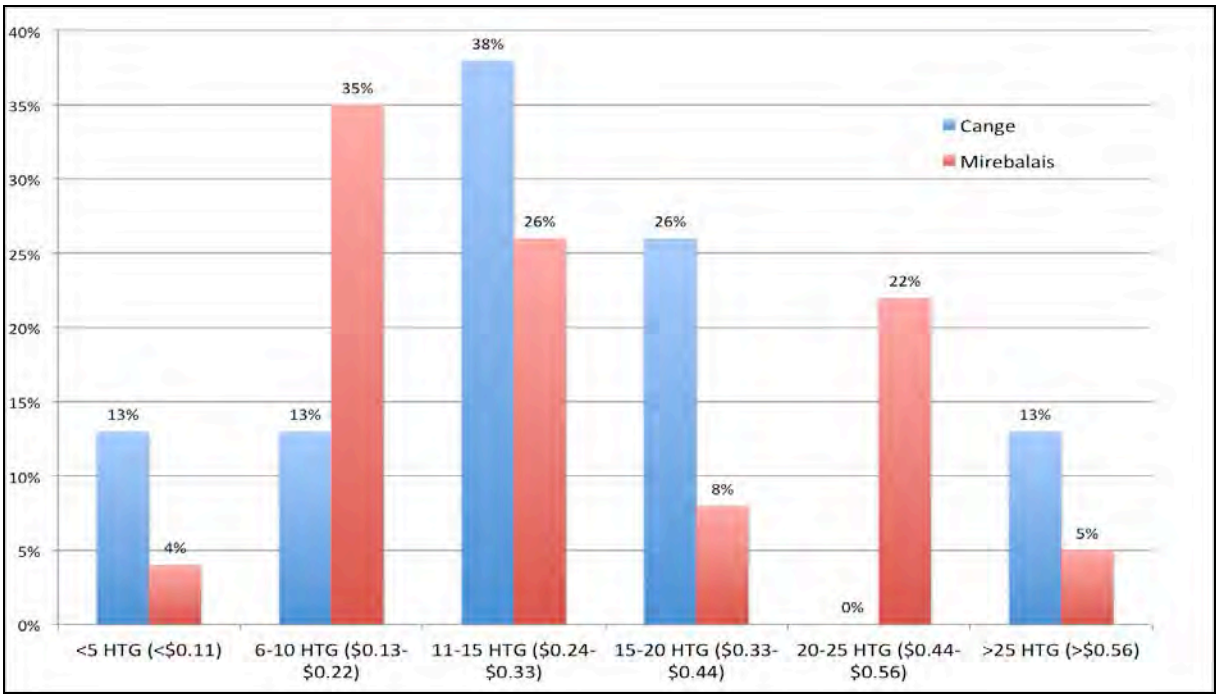

Figure 6: How Much Are You Willing to Pay for Daily Use of Toilet-based Facilities *HTG: Haitian Gourde. US Treasury exchange rate: 45 HTG = US$1.00.

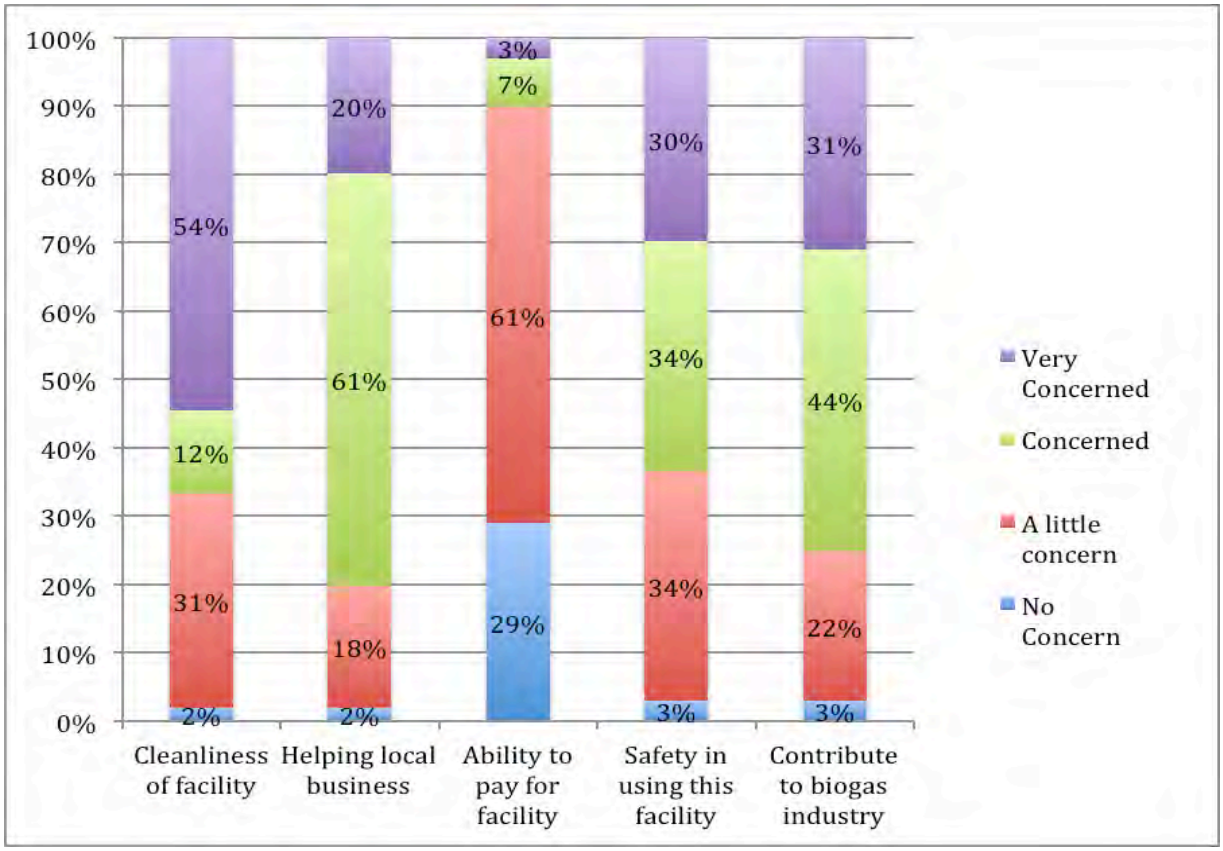

Figure 7: Factors Influencing Willingness to Pay for a Sanitation Facility (Cange only).

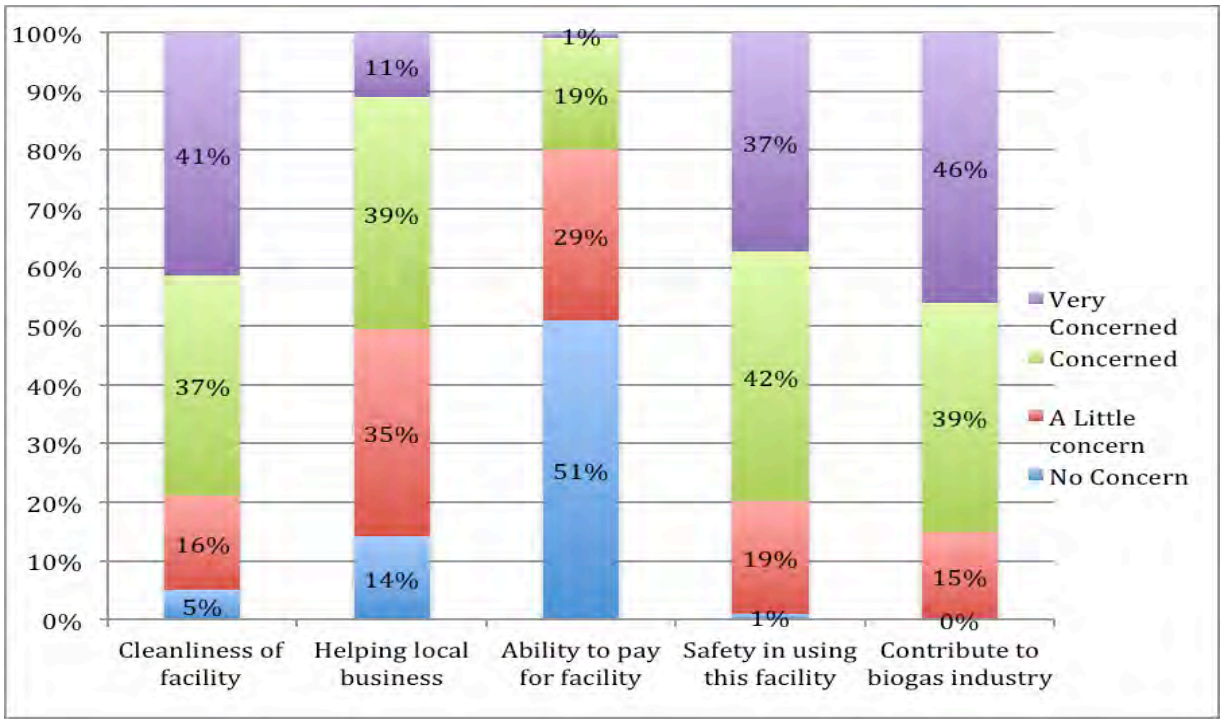

Figure 8: Factors Influencing Willingness to Pay for a Sanitation Facility (Mirebalais only).

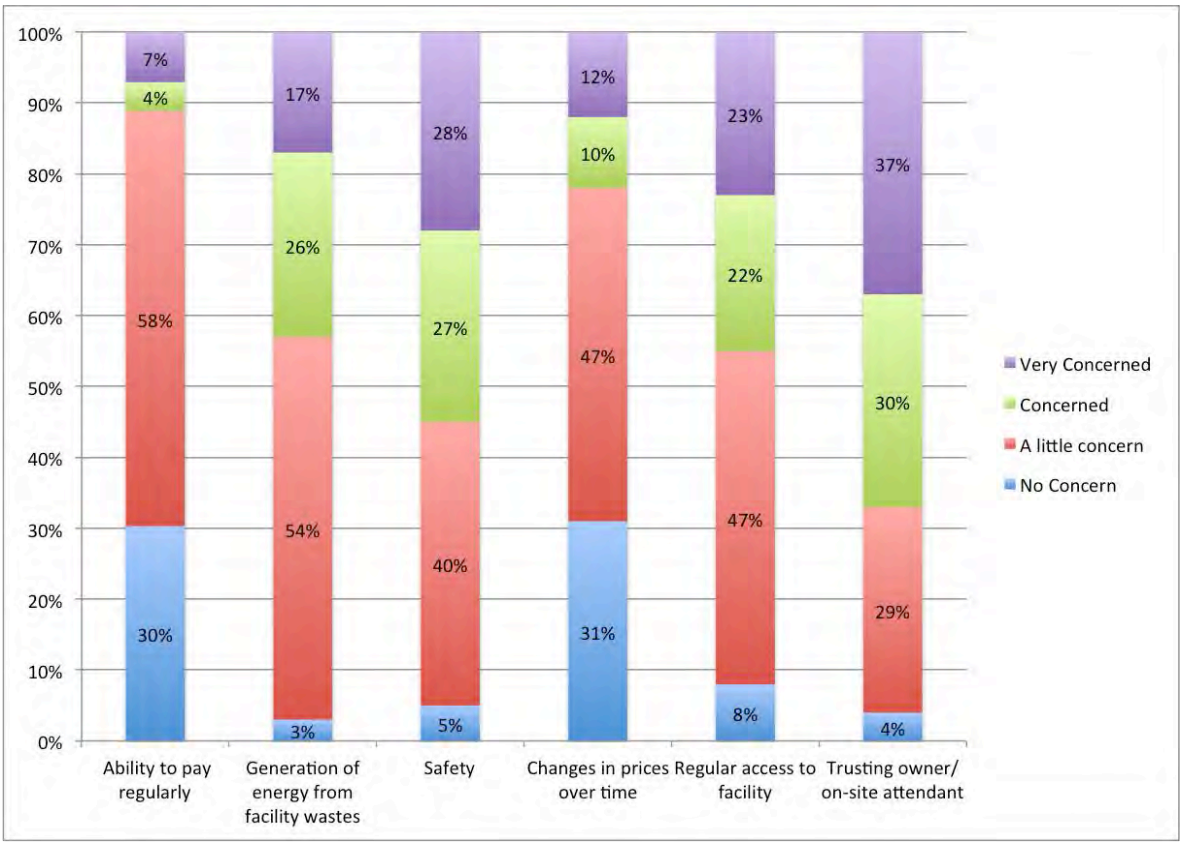

Figure 9: Factors Influencing Willingness to Pay for a Sanitation Facility (Cange only).

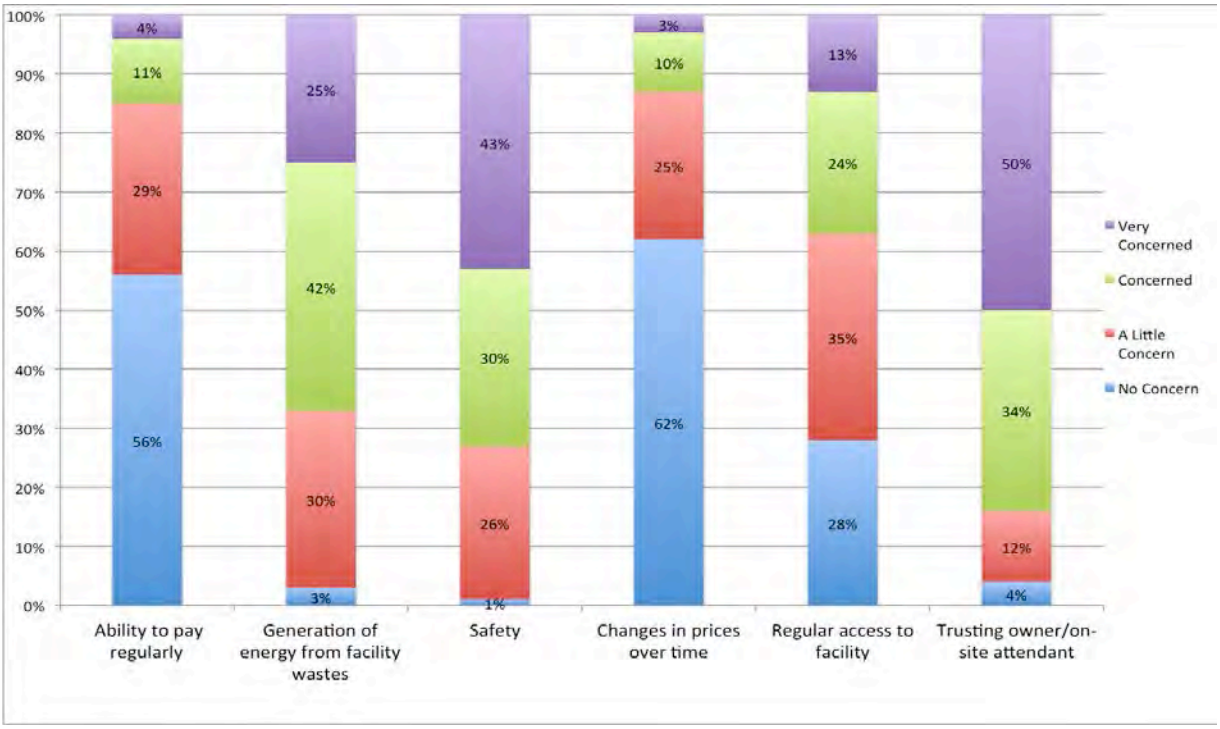

Figure 10: Factors Influencing Willingness to Pay for a Sanitation Facility (Mirebalais only).

Quotations from Survey Concerning Current Sanitation Practices and Conditions:

- "Where I live, I must pay for my [sanitation] needs because there is not a way at all for me to make a toilet. Especially when it rains, it is very difficult for me not having a toilet. It is those times I pay to use the toilet."
- "In Haiti, the way we function in [regards] to the toilet in Haiti is in various ways: 1) relieve oneself on the ground 2) if you don't have a toilet, they make you pay a little fee to use the toilet."
- "Normally, we do it wherever we are, but if we had a toilet, we wouldn't do that anymore. We don't have a way to do that. We would really be happy to pay if we found good service."
- "In Haiti, the majority of toilets are impractical to use because they are so dirty."
- "Haitians always crouch on the toilet because the toilet openings are always dirty."
- "We do not have a way [to go to the toilet]. That's what makes it so that everyone who doesn't have money must go on the ground."
- "There are those who go to the toilet in the brush and those who go in the neighborhood since they don't have a [toilet] at their house."
- "The way folks use the toilet in Haiti is not good at all because there are people who go to the toilet on the ground and there are others who use leaves from trees to wipe."
- "In Haiti, we could have access to toilets but there is not enough money to make one."
- For myself, about how the toilet is of use to me, before we go any further, I paid a tradesperson to make the floor, I paid for the block construction, I paid a lot to make food for the tradesperson and I paid for sand and for water to be carried. And my toilet has provided me with good service since when the rain was falling, I did not get wet."
- "We in Haiti, it's a minority that has a toilet at their house because we do not have enough money to make them."
- "Folks use the toilet in a lot of bad conditions. They do not take care of the toilets, if you could help in terms of a contribution for a good, clean toilet, it would be good, seeing that the community does not have employment, people are not working, they don't have means to build a toilet. If there were a better way, we'll wait for it and if people could work, we could contribute better. If this project were truly to be realized, this would be a great comfort for all of the population in Cange, especially with the disease cholera that ravages Haitian families. Let's [go for] a better toilet in Haiti, with contribution."
- "We have to go [to the toilet] on the ground, not because we want to but because there's not enough money available [to make toilets]."
- "The toilet [would be] very useful in the community where we live. There are times when it's raining and there is no latrine, which means a lot of people die of rotten diseases such as cholera."
- "For me, if I had a good toilet now, I would stop squatting in the brush, but I do not have enough money to finance it. We should, but we do not know when grace will descend upon us to know if we will have such a good-looking, well-made toilet."
- "I would like all the toilets to be clean and for them to be safe."
- "People in Haiti should have toilets and they should have water to use them, so that the toilets don't give you disease."
- "The way people would use a toilet in Haiti would be to have a special place so it does not get into the water and cause health problems."

Technical Analyses

1.1 Research Objectives

The majority of research on AD of wastewater has focused on activated sludge digestion at wastewater treatment plants or manure-based digesters but little research has been conducted on treating human wastewater through AD at the small-scale. Specifically, the objectives were to: (1) compare three full-scale systems in terms of treatment potential and CH_4 production, (2) determine the willingness to pay for pay-per-use sanitation facilities and the greatest limiting factor of their use, (3) demonstrate the viability of small-scale digesters for human waste treatment in Haiti as well as biogas utilization for cooking fuel (4) create a digester learned community as well as (5) financial viability of the systems.

2.0 Materials and Methods

2.1 Anaerobic Digestion System Descriptions

The Partners in Health (PIH) medical complex in Cange is situated sixty miles northeast of Port-au-Prince, Haiti (18°55'0N; 71°58'60W) and provides healthcare to approximately 2,000 people per day from the local rural population and includes an outpatient clinic, serving 100-400 patients a day, and a 1,000-student K-12 school. The AD system for the Zanmi Lasante (ZL) outpatient clinic was designed with low-flush toilets (4 L of conveyance water), with the black water conveyed to a three-cell, 36 m^3 AD system with post-treatment subsurface wetlands (28.4 m^3) at a cost of $7,800. Each digester bag has a liquid phase of 12 m^3, with 10 m^3 of combined gas space within the three-cell AD system. The wetland has gravel substrate with a void volume of 0.5, creating an effective treatment volume of 14.2 m^3. The urinal waste and sink grey water are conveyed directly to the post-treatment wetlands in order to reduce flush water and nitrogen concentration in the digestion system (Photo 8). The ZL AD system began receiving black water in October 2013, with dairy manure used as the inoculum source to increase biogas production during the start-up phase.

The AD system at Haiti Communitere (HC) was designed as a hostel/multi-household models (2 m^3) serving 20-40 guests per day at an estimated cost of $800. The model consisted of a two-cell digestion system with a flush toilet inside a wooden structure with a sink. The effluent from the sink served as the flush water for the toilet. Post-treatment soil infiltration was used in a lined seepage pit, followed by an unlined seepage zone planted with banana trees. Part of the effluent from the last digester bag was collected prior to post-treatment and used in local gardens as a fertilizer.

The AD system for the agricultural school at the Centre Formation Fritz Lafontant (CFFL) is a three-cell digestion system (3 m^3) with concrete flush toilet and sink, costing approximately $1400. The digester received black water/sanitary waste from low flush toilets, after digestion the effluent was used directly in surrounding agricultural fields as a fertilizer. The AD system serves 10-30 persons/day. The CFFL AD system was installed during a two-day AD workshop by the Haitian participants in May 2014 (Photos 3 and 9).

2.2 Wastewater Sample Characterization

Samples were collected over seven sampling events during a seven month period beginning in April 2014, and analyzed at the Laboratoire de Qualité de L Éau et de L Énvironmement at Université Quisqueya in Haiti, with additional samples collected and transported on ice from Haiti to College Park, MD, USA within two days of collection, stored at

4°C, and analyzed in the USA for quality control. All samples were analyzed for pH, COD, total solids (TS), volatile solids (VS), total and fecal coliforms, according to Standard Methods. Subsamples were also analyzed for volatile fatty acids (VFAs), ammonium, orthophosphate and total kjedahl nitrogen from the HC and ZL digesters only.

Samples for ammonium analysis were acidified with 15 N sulfuric acid to pH 2, filtered through 0.45µm membrane filter and analyzed on the Lachet (QuikChem Method 10-107-06-2-O). Orthophosphate samples were filtered through 0.45µm membrane filter, and analyzed on the Lachet (QuikChem Method 10-115-01-1-V). TKN and TKP samples were Kjeldhal digested with 15 N sulfuric acid and $CuSO_4*5H_20$, filtered through 0.45µm membrane filter and analyzed on the Lachet (QuikChem Method 13-107-06-2-D for TKN and QuikChem Method 13-115-01-1-B for TKP).

Total coliforms were quantified using the MPN-dilution method for detection of lactose fermenting organisms, modified for analysis of high solids wastewater samples as follows: 10^{-1} - 10^{-12} dilutions (v/v) of aqueous samples were incubated in tryptic soy broth (TSB) at 37°C for 24 h. One test tube was filled with TSB but was not inoculated and served as the control. An MPN calculator (USEPA MPN Calculator, v 2.0) was used to estimate total coliform densities as the no CFU/100 mL based on the number of tubes showing positive growth after inoculation. A sub-set of samples were also analyzed for fecal coliform density, where the same steps were followed, except that dilutions were incubated at 44°C, and 0. 5 µL of each dilution was subsequently plated onto MacConkey agar, and again incubated at 44°C for 24 h. A UV light was used to check agar plates for colony growth.

Biogas production was measured using a low-flow gas meter (EKM ¾" Pulse Output Gas Meter, Santa Cruz, CA, USA). Biogas composition readings (CH_4 and H_2S) were taken weekly using a handheld LandTec Biogas 5000 meter (LANDTEC, Colton, CA, USA).

3.0 Results

3.1 Biogas

The three AD systems average had high percent CH_4 (65.4%) in the biogas and low percent H_2S (0.10%) (Table 4). The HC AD systems had the highest percent CH_4 and H_2S (72.7 and 0.19%, respectively) of the three systems. The CFFL digester, which was the newest digester had the lowest percent CH_4 (58.2%) and H_2S (0.04%). The average biogas production of the ZL system was 108 L/day (70.9 L CH_4/day), equating to a production of 3.48 L of biogas/user (2.28 L of CH_4/user) (Table 5).

The average usage of the PIH toilets during this period was only 31 uses day^{-1}, resulting in a CH_4 production value of 0.002 m^3 use^{-1} day^{-1} (0.011 m^3 $person^{-1}$ day^{-1} based on 5 uses per person in one day).

3.2 Temperature

The digesters had an average effluent temperature of 31.0ºC, which closely approximated the ambient temperature in Cange with mean January and August temperatures of 27.1 ºC and 29.7 ºC, respectively. The digester with the lowest effluent temperature was ZL at 29.6 ºC compared with the highest effluent temperature of 33.64 ºC at CFFL.

3.3 pH and alkalinity

While alkalinity was reduced on average by 19.6% during digestion, the pH was reduced by only 2.4% (7.13 to 6.96) (Table 1). There was an 89.1 % increase (Table 2) in alkalinity for the PIH digester, but the effluent pH (6.84) remained within the circumneutral pH range needed for effective CH_4 production.

3.3.1 Organic matter and solids

The COD was reduced by 93.6% for all digesters (Table 1). The digester with the greatest reduction in organic matter was PIH (98.5%) compared with the lowest reduction at CFFL (60.6%) (Table 2). On average, the digesters reduced total solids (TS) by 78.7% and volatile solids (VS) by 85.1% (Table 1).

3.3.2 Ammonium, orthophosphates, total nitrogen and phosphorus

The digesters had an average influent NH_4^+ concentration of 163 mg/L NH_4^+ and an average effluent value of 99.4 mg/L NH_4^+ (Table 3), with the greatest reduction in the PIH digester (84.9%). The PIH digester also had the greatest reduction of total nitrogen (TKN) at 96.9%. Total kjeldahl nitrogen (TKN) averaged for all digesters was 449 mg/L for the influent and 91 mg/L for the effluent (Table 4), a 79.7% reduction. Phosphorus values for the digesters (Table 4) averaged at 23.2 mg/L PO_4^{3-} for the influent and 10.6 mg/L PO_4^{3-} for the effluent, with an 88.6% reduction. The digester with the greatest reduction in total phosphorus (TP) and PO_4^{3-} was the ZL digester at 96.5% and 87.7% respectively.

3.3.3 Pathogen removal

High pathogen removal rates were shown for the digesters, averaging at 99.1% for total coliforms and 98.5% for *E. coli* (Table 1). The PIH digester had high pathogen removal rates, with 99.9 and 99.95% (Table 2) reduction in total coliforms and *Escherichia coli*, respectively. While 100% elimination was not achieved in the digestion systems, *E. coli* levels of 1.40 CFU 100 ml^{-1} were achieved in the effluent.

3.4 Sanitation Survey

The sanitation surveys showed that 39% of the population in Cange and 18% in Mirebalais do not have access to sanitation, which is a lower percentage than country average of 27%. Only 4% of survey participants had access to flush toilets in Cange (12% in Mirebalais). In Cange, 57% of respondents had used pay for use facilities, with 39% utilizing these facilities in Mirebalais. More than half the respondents were very interested (38% in Cange and 46% in Mirebalais) or moderately interested (46% in Cange and 54% in Mirebalais) in using pay for use facilities. The greatest limitation to accessing improved sanitation was finances: 42% of the respondents in Cange and 51% in Mirebalais. In the previous year, most survey participants estimated that they spent $500-1200 on their own sanitation infrastructure or services related to a pay for use facilities. Most survey participants were willing to pay $0.10 - $0.30 per use at a pay for use facility (higher prices corresponded to using toilet-based facilities – in contrast to latrine based systems at $0.10/use). The top three factors influencing desire to use a pay for use facility were the cleanliness of the facility, safety, and wanting to help local businesses.

Scientific Technical Publications and Presentations Given on Project

Publications

Ceccarelli, D., Spagnoletti, M., Hasan, N.A., Lansing, S., Huq, A., Colwell, R.R., 2013. A new integrative conjugative element detected in Haitian isolates of *Vibrio cholerae* non-O1/non-O139. Research in Microbiology 164(9): 891-893.

Lansing, S., 2013. Methane production potential from source separated human wastewater in Haiti. Northeast Agricultural and Biological Engineers Conference Proceedings. Altoona, PA. June 16-19, 2013.

Lansing, S., Bowen, H., Gregoire, K., Klavon, K., Moss, A., Lai, Y., Iwata, K. (in review). Determining methane production potential for sanitation improvement in Haiti. Biomass and Bioenergy. Revisions submitted March 25, 2015.

Scientific Presentations

Lansing, S., 2013. Methane production from source-separated human wastewater in Haiti. 5th Annual Engineering Sustainability Workshop. College Park, MD. April 22, 2013. (Invited)

Lansing, S., Bowen, H., Gregoire, K., Klavon, K., Moss, A., Lai, Y.J., Iwata, K., 2013. Methane production potential from source separated human wastewater in Haiti. American Ecological Engineering Society Conference. East Lansing, MI. June 10-12, 2013.

Lansing, S., 2014. Anaerobic digestion as a sewage treatment alternative for Haiti. American Society of Agricultural and Biological Engineers Conference. Montreal, Canada. July 14 - 16, 2014.

Lansing, S., Eaton, A., Maile-Moskowitz, A., Galligan, T., 2015. Anaerobic digestion for sustainable sanitation linked to agricultural production in Haiti. American Ecological Engineering Society Conference. Stillwater, OK. June 2-5, 2015.

Maile-Moskowitz, A., Lansing, S., Eaton, A., Galligan, T., 2015. Haiti survey results: Sanitation practices, limitations and willingness to pay for sanitation facilities (poster). American Ecological Engineering Society Conference. Stillwater, OK. June 2-5, 2015.

Environmental Evaluation and Assessments:

Survey Material in Creole and English

Challenges, Opportunities and Willingness to Pay Sanitation in Haiti Survey

Part 1) Current Sanitation Practices ALL Participants

1. **Which of the following best describes your current sanitation practices?**
   - ☐ No access to pit latrines or toilets – regular defecation directly on the land
   - ☐ Regular use of pit latrine
   - ☐ Regular use of improved pit latrine (with ventilation of pit)
   - ☐ Regular use of composting latrine
   - ☐ Regular use of flush toilets
   - ☐ Regular use of toilet connected to a digestion system
   - ☐ Other (please specify): _____

2. **What limits your ability to access improved sanitation?** (Choose two items that are most limiting to your ability to access improved sanitation and fill in the circle.)

   - ☐ Location – no sanitation close to home or work
   - ☐ Finances to build a latrine
   - ☐ Finances to build a flush toilet
   - ☐ No nearby pay sanitation facilities available
   - ☐ Unwilling to pay at nearby sanitation facility
   - ☐ Access to water for flush toilet
   - ☐ Enough land to build latrine
   - ☐ Inadequate soil for latrine structure
   - ☐ Lack of knowledge to build latrine
   - ☐ No limitations in my sanitation access

3. **What is your current interest in transitioning to a pay for use sanitation facility**
   - ` Not at all interested.
   - ` Slightly interested
   - ` Moderately interested
   - ` Very interested
   - ` I'm not sure

4. **What is the amount per use of sanitation facilities that you are willing to pay?**

5. **If you are interested in using pay for use facility, please rate the following factors that are influencing your decision to do so.**

	Not Important	**A Little Important**	**Somewhat Important**	**Important**	**Very Important**
Cleanliness of facility	`	`	`	`	`
Helping local business	`	`	`	`	`
Ability to pay for facility	`	`	`	`	`
Safety in using this facility	`	`	`	`	`
Contribute to biogas industry	`	`	`	`	`

6. Please rate the following factors as to the level of concern you have about paying for a sanitation facility.

	No Concern	A Little Concern	Somewhat Concerned	Concerned	Very Concerned
Ability to pay	`	`	`	`	`
Energy Generation	`	`	`	`	`
Safety	`	`	`	`	`
Changes in prices	`	`	`	`	`
Regular access	`	`	`	`	`
Trusting owner	`	`	`	`	`
Other: Please list _____	`	`	`	`	`

7. How much information is currently available to you regarding the following issues?

	None	A Little	Moderate	A Lot	Not Sure
Washing Hands	`	`	`	`	`
Health Benefits of propoer sanitation	`	`	`	`	`
Location of sanitation	`	`	`	`	`
How to build sanitation structure	`	`	`	`	`
Effect of sanitation on water quality	`	`	`	`	`

8. Please provide any other comments and concerns you might have that can help to strengthen sanitation services in Haiti and comments on your willingness to pay for this service.

Defi, Opòtinite ak volonte pou peye Sanitasyon an Ayiti Sondaj

Pati 1) Kouran Sanitasyon pratik tout patisipan yo

Ranpli ti sèk yo ak yon plim nwa oswa yon kreyon.

1. Ki kote ou abitye fe twalet ?

☐☐pa gen akse nan pyes kote – twalet a te

☐☐Latrin ki pa gen degajman anle (PVC)

☐☐Latrin ki gen degajman anle (PVC)

☐☐Latrin kompostaj

☐☐Twalet ijenik

☐☐Twalet ijenik ki gen biodigester (blad sa yo)

☐☐Lòt fason: _____

2. Ki rezon ki fe w pa fe twalet yon pi bon kote

☐☐Paske pa gen yon twalet kote mwen abite

☐☐Pa gen mwayen pou fe yon latrin

☐☐Pa gen mwayen pou bati yon twalèt ijenik

☐☐Pa vle peye pou itilize twalet

☐☐Pa gen dlo pou twalèt ijenik

☐☐Pa gen espas pou bati yon latrin

☐☐Pa konnen kijan mwen dwe bati yon latrin

☐☐☐Pa gen pyes rezon

☐☐Pa gen twalet pou peye kote mwen abite☐☐☐☐☐☐☐☐

☐☐ Lot Rezon): _____

3. Pou ane (2012) la, kombyen cob li ta koute pou w bati yon twalet.

	Konbyen Goud
Latrin	
Twalèt ijenik yo	

Yon twalèt pou biznis	
Konpostaj oswa biodigester	

4. Eske ou konnen peye pou itilize yon twalet?

` ☐☐☐☐Oui

☐☐☐☐Non`

5. Eske w tá enterese peye pou itilize yon twalet chak fwa ?`

☐☐☐☐☐☐☐☐☐Pa enterese.

☐☐☐Yon ti kras enterese

☐☐☐☐☐☐☐ Antrede

☐☐☐☐☐☐☐ Entèrese anpil

☐☐☐☐☐☐☐ Mwen pa konnen

6. Nan (2014), konbyen lajan ou ta peye pou chak fwa pou ale itilize twalet

	Konbyen Goud
Latrin	
Twalèt ijenik	
Twalet kompostaj	

7. Kisa ki enpotan pou ou si wap peye itilize twalet chak fwa ? Chwazi yon ladan sa yo

	Pa enpòtan		**On tijan enpòtan**	**enpòtant**	**Trè enpòtant**
Si twalet la pwop	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐
Pou ede biznis lokal	☐☐☐	☐☐	☐☐☐	☐☐☐	☐☐☐
Si w ka peye	☐☐☐	☐	☐☐☐	☐☐☐	☐ ☐☐
Si li gen sekirite	☐☐☐	☐	☐☐☐	☐☐☐	☐☐☐
Kontribye pou fe plis gaz	☐ ☐☐☐	☐ ☐	☐ ☐☐☐	☐ ☐☐☐	☐ ☐☐☐

Lòt Rezon _____

8. Ki sa ki konséne w nan pakét kesyon sa yo ? Chwazi yon ladan sa yo

	Pa Okipe		On tijan Okipe	Mwen okipe	Okipe anpil
Si w ka peye pou itilize twalèt					
Pou fe gaz ak twalet la (biogaz)					
Sekirite					
Si yo pral chanje pri tanzantan					
Si w ap jwenn akse fasil					
Konfyans nan moun ki jere twlaet la					

Lot Rezon _____

9. Konbyen enfomasyon ki disponib pou w de bagay sa yo?

	Pyès	toupiti		Anpil	Pa konnen
Peye pou itilize twalèt					
Pwodiksyon Biogaz					
Ki Kote ki genyen yon twalet					
Kijan yo bati yon twalet					
Ki benefis yon bon twalet bay pou lasante ou					
Pou w konnen kijan twalet pral enfecte dlo ak te a					

10. Tampri di nou kijan plis informasyon te ka ede ou.

	Pa ede menm	Yon ti kras ed		Anpil ed	Pa konnen
Peye pou itilize twalet					
Pwodiksyon Biogaz					
Ki Kote ki genyen yon twalet					
Kijan yo bati yon twalet					
Ki benefis yon bon twalet bay pou lasante ou					
Pou w konnen kijan twalet pral enfecte dlo ak te a					

11. Èske ou enterese ale nan yon atelye ki pral bay infomasyon de pwodiksyon biogaz, pi bon fason pou fe twalet, epi peye pou fe twalet?

` Oui

Non

petèt

12. Nan ki laj ou ye

18-29 ane

30-49

50-64

65-75

Plis ke 75 ane

13. Ki seks ou?

Mai

Femèl

14. Ki nivo edikasyon ou: **chwazi yon sel repons**

Ou pat ale lekòl

Fini lekòl sekondè

Mwens ke 4 ane nan lekòl

Pran kou nan kèk kolèj

☐ Tèmine etid primè ☐☐☐☐☐pran seminè de fomasyon

☐☐☐☐☐☐☐☐ Frekante kèk lekòl sekondè ☐Diplome

15. Silvouplè eske ou vle ba nou plis enfomasyon sou fason moun itilize twalet an Ayiti epi peye pou sevis twalet

Consent Form Approved by the University of Maryland Institutional Review Board

Project Title	Incentivizing Sanitation with Biogas in Haiti—Stage 1 Pilot Digester Evaluation
Purpose of the Study	*This research is being conducted by* ***Dr. Stephanie Lansing*** *at the University of Maryland, College Park. We are inviting you to participate in this research project because you can help us learn more information about the state of sanitation in Haiti and willingness of participants to pay for future sanitation services. The purpose of this research project is to* validate a sustainable sanitation model for Haiti based on biogas generation from low-cost anaerobic digesters by testing digestion systems in Haiti and evaluating a pay-for-use sanitation model.
Procedures	*The procedures involve* answering a 15-minute questionnaire on your sanitation practices, importance of sanitation and your willingness to pay for improved sanitation. The questions that will be asked include: 5. Which of the following best describes your current sanitation practices? 6. What is your current interest in transitioning to a pay for use sanitation facility`
Potential Risks and Discomforts	There are no known risks associated with participating in this research project.
Potential Benefits	*There are no direct benefits from participating in this research. However, possible benefits resulting from this work* is a greater understanding about sanitation practices and willingness to pay for improved sanitation. We hope that, in the future, that other people might benefit from this study through improved understanding of sanitation practices and priorities.
Confidentiality	The questionnaire will be anonymous and will not contain information that may personally identify you. Your name will not be included on the survey. All data collected will be kept in locked filing cabinets, and on password-protected computer files, with only the Investigator, Dr. Lansing, and her assistant having access to the data. All reports or articles about this research project will protect your identity to the maximum extent possible. *Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.*

Right to Withdraw and Questions	*Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.* *If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the investigator:* Dr. Stephanie Lansing at: 1425 Animal Sciences Bldg, UMD, College Park, MD 20742, USA or slansing@umd.edu
Participant Rights	*If you have questions about your rights as a research participant or wish to report a research-related injury, please contact:* **University of Maryland College Park** **Institutional Review Board Office** **1204 Marie Mount Hall** **College Park, Maryland, 20742** **E-mail: irb@umd.edu** **Telephone: 301-405-0678** *This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.*
Statement of Consent	*If you verbally agree to participate, this indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction and you voluntarily agree to participate in this research study. You will receive a copy of this consent form.* *If you agree to participate, please state "yes, I agree to participate"*

Tit pwojè a	Nan evaliasyon sanitasyon an Haiti ak biogas-dijeste, 1-evaliasyon pilòt
Bi etid la	Rechèch saa te fèt pa Dr Stephanie Lansing nan University of Maryland, College Park. Nou envite ou yo patisipe nan pwojè sa a rechèch paske ou ka ede nou aprann plis sou eta a nan sanitasyon an Ayiti ak volonte patisipan yo 'pou peye pou sèvis sanitasyon ap vini yo. Objektif la nan sa a pwojè rechèch se valide yon modèl sanitasyon dirab pou Ayiti ki baze sou pwodiksyon an nan biogaz soti nan dijèsteur anaerobik nan sistèm ba tès pri dijesyon an Ayiti ak evalyasyon nan yon modèl sanitasyon salè travay.
pwosedi	Pwosedi enplike reponn yon kesyonè pandan15 minit sou pratik sanitasyon ou a, enpòtans ki genyen nan sanitasyon ak volonte ou pou peye pou sanitasyon amelyore. Kesyon yo mande yo se: 1. Kilès nan sa ki youn apre lòt yo ki pi byen dekri pratik aktyèl sanitas nan latrin ni twalèt regilye dirèkteman jere jere sou tè. 2 Ki sa ki se enterè ou kounye a nan tranzisyon pou peye pou sèvis sanitè
Risk potansyèl ak malèz	Pa gen ankenn risk kita pou anpeche ou patisipe nan pwojè rechèch saa
Benefis potansyèl	Pa gen okenn benefis dirèk pou moun k ap patisipe nan rechèch sa a. Men tou, benefis yo potansyèl de travay sa a se pi byen konprann sanitasyon ak volonte pou peye pou pratik ijyèn amelyore. Nou espere ke nan lavni an, lòt moun ta ka benefisye de etid sa a nan konpreyansyon pou amelyore sou pratik ak priyorite sante yo.

konfidansyalite	Kesyonè a pral anonim e li pap pral gen nenpòt enfòmasyon ki ta kapab idantifye ou pèsonèlman. Non ou pa pral dwe enkli nan sondaj la. Tout done yo kolekte yo pral kenbe fèmen nan kabinèt, dosye ki nan òdinatè ak modpas pwoteje, ak sèlman chèchè a, Dr Lansing, ak asistan li gen aksè a done yo. Nenpòt rapò oswa atik sou pwojè rechèch saa ap pwoteje idantite ou osi lwen ke posib. Ka divilge enfòmasyon ou yo ak reprezantan ki nan University of Maryland, College Park oswa otorite gouvènman si ou menm oswa yon lòt moun an danje oubyen si n ap oblije fè pa lalwa mande.
Kesyon ak dwa nan retrè	Patisipasyon w nan rechèch sa a se antyèman volontè. Ou ka chwazi pa patisipe nan tout. Si ou deside patisipe nan rechèch sa a, ou ka sispann patisipe a nenpòt ki lè. Si ou deside pa patisipe nan etid sa a oswa si ou sispann patisipe a nenpòt ki lè, yo pa pral pran okenn sanksyon kont oswa pèdi benefis ou ta ka jwenn nan pwoje saa. Si ou deside sispann fè pati nan etid la, si ou gen nenpòt kesyon, pwoblèm oswa plent, oswa si ou bezwen rapòte yon aksidan rechèch ki gen rapò ak sa, tanpri kontakte anketè a Doktè Stephanie Lansing 1425 Animal Syans Bldg, UMD, College Park, MD 20742, USA oswa slansing@umd.edu Anile Chanjman
Dwa patisipan yo	Si w gen kesyon sou dwa ou kòm yon patisipan nan rechèch sa oswa lè yo vle rapòte yon aksidan rechèch sa ki gen rapò ak, etid sa tanpri kontakte: **University of Maryland College Park** **Institutional Review Board Office** **1204 Marie Mount Hall** **College Park, Maryland, 20742** **E-mail: irb@umd.edu** **Telephone: 301-405-0678** Rechèch saa te revize daprè University of Maryland, College pwosedi IRB Park pou rechèch ki konsène sijè imen.
Deklarasyon ak konsantman	Si ou dakò pou patisipe vèbalman, li endike ke ou gen omwen 18 ane, ou te li fòm konsantman sa a ,ou te reponn kesyon yo nan satisfaksyon ou, epi ou dakò volontèman ou patisipe nan rechèch ak etid saa.ou pral resevwa yon kopi fom saa Si ou dakò ou patisipe, tanpri endike "wi, mwen dakò mwen patisipe"

Progress and Trip Reports

Progress Report: October 2013

1. First Trip Overview

The first trip to Haiti under the DIV grant ran for 9 days from Tuesday 20th – Wednesday 28th August 2013 and was attended by project implementers Dr. Stephanie Lansing (University of Maryland), Alexander Eaton (IRRI Mexico) and Rachel Smith (IRRI Mexico).

During this time the project implementers met with the USAID office in Haiti as well as holding a Learning Community Workshop in order to engage other high level stakeholders within the biodigester sector in Haiti. Additionally several pilot systems were reviewed, samples were taken for laboratory testing and other possible future systems under the DIV project were examined for their feasibility.

2. Trip Itinerary

Date	Activity
Tuesday 20th August 2013	Arrive to Haiti
	Visit and review of pilot systems (2) at Haiti Communitere, Port-Au-Prince
	Visit and review of pilot system at Episcopal Seminary, Port-Au-Prince
Wednesday 21st	Preparations for Digester Learning Community Workshop on Friday 23rd
	Investigation into local laboratory testing availability
Thursday 22nd	Meeting with USAID Haiti office
	Site visit to Islamic Relief market rehabilitation project in Croix des Bouquets to review feasibility as a possible site for Pay-Per-Use system implementation
Friday 23rd	Delivery of Digester Learning Community Workshop
	Additional tours of Haiti Communitere pilot system
	Sampling of Haiti Communitere pilot systems (2) for laboratory testing at University of Maryland
	Travel to Cange to review PIH pilot system
Saturday 24th	Review of PIH pilot system
	Meeting with PIH staff to establish a maintenance system and outreach plan
	Visit to local wetland to identify plants for secondary treatment within PIH pilot system
Sunday 25th	Training of local technicians at PIH pilot system
	Planning of biogas use at PIH pilot system
	Travel back to Port-Au-Prince
	Gas tests at Haiti Communitere pilot systems
Monday 26th	Development of stove design for households
	Travel to Aquin
	Visit to 9 recently installed household systems to review progress, use and user satisfaction (rural & peri-urban systems)
	Training of 3 CFFL / Zanmi Agrikol students as biodigester technician assistants
Tuesday 27th	Meeting with stakeholders in Aquin project
	Visit to further household systems to review progress, use and user satisfaction (peri-urban systems)

Date	Activity
	Travel back to Port-Au-Prince
Wednesday 28th August 2013	Meeting with Islamic Relief to discuss technical details for the installation of institutional system at a Port-Au-Prince school
	Final review of Haiti Communitere pilot systems (2)
	Leave Haiti

3. Meeting with USAID Haiti Office

In order to align the project with existing USAID work in the sanitation and agriculture sectors in Haiti a meeting was held on 21st August between the project actors (IRRI Mexico and University of Maryland) and key USAID staff;

Webert Jose;	Monitoring and Evaluation Advisor /Health Office (Project Oversight for the DIV project)
Elsy Salnave;	Health System Strengthening Advisor /Health Office
Gyrlande Bois;	Disability Advisor /Health Office
Katia Petion;	Maternal and Child Health Advisor /Health Office
Wenser Estime;	Public Health Advisor / Health Office
Kenold Moreau;	Agriculture Specialist /Economic Growth Office

Key points discussed included:

	Point made	Response
1)	USAID - Ensure that local presence is in place – the project should not be managed solely from USA/Mexico.	IRRI Mexico has a staffed Haitian technician to oversee its work and is working during September to train a further 4 local technicians.
2)	USAID – Charcoal availability and cost may not be the limiting factor for why families only cook once a day as the income may limit the amount of food that can be bought, which in turn limits the need to cook more than once a day.	This is a valid point and one that can be examined through the course of the project.
3)	USAID – Biogas production would need to give around 3 hours of cooking time daily as typical Haitian food takes a long time to cook.	The gas produced by smaller systems is not intended to entirely replace charcoal demand, rather add additional benefit, e.g. to cook soup or coffee in the morning or heat drinking water for purification.
4)	USAID – Larger systems need a high level of government/local actor involvement (regarding discussion of Croix-des-Bouquets site).	This is still in its early stages – the project aims to use existing structures with strong local contacts for this project activity, e.g. Islamic Relief are undertaking the Croix-des-Bouquets market rehabilitation – the project would add-on to this.
5)	USAID – Ensure that environmental compliance and best management practices are met.	Environmental compliance will be met in accordance to the plan submitted to DIV. Best management practices developed through IRRI Mexico's involvement in RedBioLAC will be followed.
6)	USAID - Value can also be added from a WASH perspective through the integration of hand	Didactic materials (kreyol) will include these points (developed from existing didactic

	Point made	Response
	washing and hygiene education.	materials used in Haiti by IRRI Mexico).
7)	USAID – Possibility for discussion with USAID shelter projects for community level latrine blocks.	Webert to coordinate contact between UMD/IRRI and USAID Shelter group.
8)	USAID - Environmental compliance workshop in October that the project should attend.	Webert to coordinate this.

Existing and relevant work and actors detailed by the USAID team included:

- USAID WASH:
  - Potable water projects
  - Health & hygiene promotion (manged by PSI)
- DPSPE – general hygiene promotion materials (didactic materials used by PSI)
- UNICEF – cholera prevention didactic materials and general hygiene promotion materials
- DINEPA – holds contacts for the Association of Latrine Emptiers
- World Bank (Spain) – existing sanitation projects
- CDC – existing sanitation projects

4. Delivery of Digester Learning Community Workshop

Entitled 'USAID Development Innovation Venture (DIV) Digester Learning Community Workshop', the first workshop of the DIV project was held on 23rd August 2013 from 9:30 AM – 1:00 PM at Haiti Communitere, 19 Rue Pelican, Clercine 4, Port-au-Prince.

The event invited actors already engaged in biodigesters implementation, or actors known to have a strong interest in implementing biodigesters, in Haiti. The event was attended by 30 attendees from Government, INGO, NGO, University and Private backgrounds including;

- University of Maryland
- IRRI Mexico
- USAID
- VivaRio
- Independent Sustainable Sanitation Consultant
- DINEPA
- MSPP Ministry of Health – DOSS
- UN MINUSTAH
- Islamic Relief
- CFFL / Zanmi Agrikol
- Universitè Quisqueya, Port-Au-Prince
- HELVETAS Swiss Intercooperation
- Food for the Poor
- Hôpital Albert Schweitzer
- PROPRE-Haiti
- USAID Improved Cooking Technology Program (Global Alliance for Clean Cookstoves / Chemonics)
- Ohio State University
- Private interest

- Builders Without Borders
- Rescue Haiti Project 2013
- Harvard University

Presentations were given from University of Maryland, IRRI Mexico, VivaRio and by independent sustainable sanitation consultants, which led into group discussion on technical, social and economic advantages and challenges regarding the use of digesters in sanitation and agriculture in Haiti. The session was run in English and Kreyol (with translation into either depending on the speaker).

The presentations were followed by a tour of the IRRI Mexico Sistema biobolsa digester system installed at Haiti Communitere, with demonstrations of the toilet, the digesters, and the biogas stove. The workshop closed with lunch and informal networking.

From the event a Google Group was created to facilitate communication and learning within the newly formed the Digester Learning Community. Full workshop minutes and the presented powerpoints were sent out to attendees and other interested parties who were unable to make the event, along with an invitation to the Google Group and an online survey for feedback on the workshop.

5. Review of pilot systems

Overall twelve pilot systems were visited and reviewed. Meetings were held with stakeholders to discuss next steps, field tests were made and samples were taken for the first round of laboratory testing at University of Maryland.

a. Port-Au-Prince, Haiti Communitere

- 2 pilot systems installed at Haiti Communitere – household sized systems, 1.8m3 with secondary aerobic treatment and final discharge to banana plant beds. Both with flushing toilets.
- Both in good condition; biogas use in main latrine system is for water heating for tea and coffee, with biogas use in second system still not yet defined.
- Operation and maintenance plan is working well with regular cleaning of latrines with appropriate materials.
- Samples and gas tests taken.

b. Cange, Partners In Health / Zanmi Lasante

- 1 pilot system installed at the External Clinic – 36m3 with secondary baffled aerobic gravel treatment train.
- Latrine block not yet open to public use, but digesters have been fenced and covered with shade-cloth.
- Meeting held with PIH staff to establish a maintenance system and outreach plan and to edefine final biogas and safety measures.
- Visit to local wetland to identify plants for use within the top level of the secondary treatment.
- Training of local technicians on biodigesters technology and up-keep.

c. Aquin, Food for the Poor

- Visit to 9 recently installed household systems to review progress, use and user satisfaction (rural & peri-urban systems).
- Training of 3 CFFL / Zanmi Agrikol students as Level 1 Biodigester Technicians.
- Meeting with stakeholders in Aquin project to discuss next steps.

- Visit to further household systems to review progress, use and user satisfaction (peri-urban systems)

d. Sampling activities at pilot systems

Haiti Communitere

Samples of digester influent and effluent were taken at both Haiti Communitere systems to be tested at University of Maryland labs for:

- Biological parameters (Total coliforms, E-coli)
- Chemical & physical parameters (TS, VS, Alkalinity, Total Nitrogen, Total Phosphorus, COD, VFAs, ammonium and orthophosphate).

On-site field tests were made for the following:

Date of Analysis	**8/23/13**						
Sample	**Time**	**Temp (C)**	**Press. (mB)**	**DO mg/L**	**Cond. mS/cm**	**pH**	**ORP (mV)**
Main Latrine Inflow Bag 1	14:00	32.5	1010.6	0.98	3.95	7.01	-186.5
Main Latrine Outflow Bag 1	15:05	32.5	1010.3	0.33	3.16	6.94	-207.2
Main Latrine Inflow Bag 2	15:30	31.7	1010.4	1.15	3.66	6.89	-191.8
Main Latrine Outflow Bag 2	15:15	31.2	1010.4	0.62	3.23	6.87	-197.5
Main Latrine Into Post-Treat	15:40	31.7	1010.5	0.93	3.24	6.97	-195.1
Front Latrine Inflow Bag 1	16:30	29.7	1010	N/A	2.26	6.81	-105.3
Front Latrine Inflow Bag 2	16:15	36.1	1010.4	0.43	3.39	6.94	-179.6
Front Latrine Outflow Bag 2	16:20	33.3	1010.4	0.8	3.54	6.9	-174.4

Biogas composition:		
Date: 8/23/2013	**Time:**	**Time:**
Parameter:	**Main latrine:**	**Front latrine:**
Methane content (%)	74.6%	71.8%
Carbon dioxide content (%)	24.3%	27.0%
Hydrogen sulfide concentration (ppm)	1060 ppm	2060 ppm

Biogas production: (Main latrine)		
Observation:	**Date: Sunday 25th Aug**	**Comments**
Starting time:	14:11 h	Gas lit, meter reading started
End time:	14:26 h	Gas metre stopped reading – pressure too low for meter
	14:47 h	Gas finished burning – pressure too low for conveyance. Digesters still containing some gas.
Time duration of flow meter reading:	15 mins	
Time gas burnt:	36 mins	
Initial gas metre reading:	1011.9 cuft	

Final gas metre reading:	1015.2 cuft	
Gas flow rate:	0.22 cuft/min = 6.229 l/min	
Gas production:	373.74 l/h	
Useful burn time:	2.68 h/m3 gas	

Toilet use frequency: (Main latrine)		
Date:	**Time:**	**Clicker count:**
Thursday 22nd Aug	09:40 h	0 (Clicker set)
Friday 23rd Aug	06:50 h	27
	06:51 h	0 (Clicker re-set)
	09:35 h	5
Sunday 25th Aug	14:10 h	61
Monday 26th Aug	08:55 h	69
Tuesday 27th Aug	18:45 h	78

Aquin (Household systems)

Biogas composition:		
Date: Tues 27th Aug 2013	**Time:** 15:05 h	**Time:** 15:09 h
Parameter:	**K-Francois (Janita):**	**K-Francois (Yvois):**
Methane content (%)	72.0	71.1
Carbon dioxide content (%)	28.0	28.7
Hydrogen sulphide concentration (ppm)	705	410

6. Site evaluation for Pay-Per-Use system

A visit was made by the project team to Croix-des-Bouquets market, Port-Au-Prince with Islamic Relief on Thursday 22nd August in order to review the site's potential for a Pay-Per-Use latrine-digester system.

Croix-des-Bouquets is a commune located 12 kms from Port-au-Prince. After the earthquake, it became the extension area of Port-au-Prince identified by the government, with almost all IDPs now relocated to the commune; population increased from 227,012 in 2009, to almost 400,000 habitants in 2013. In addition to the earthquake tragedy, Croix-des-Bouquets has been affected by the cholera epidemic. Within the market area, there are around 7,000 people attending the market on non-official market days and on Friday and Monday (the official days of the market), there are almost 227,900 people within the area.

Islamic Relief are undertaking a rehabilitation of the market area in response to the request made by the municipality of Croix-des-Bouquets for support to improve the environmental sanitation of the district in order to reduce the risk of cholera in this commune. This will include cleaning of the market area (to remove organic food waste and slaughterhouse waste), reconstruction of market halls and market administration area, and construction of new sanitation facilities.

The current latrine block provides two options: one set of latrines for no fee, but that are dirty and poorly maintained and another set of latrines that charge 5 Goudes, but that provide toilet paper and pay for a cleaning schedule. Islamic Relief wishes to replicate the pay-per-use model and are interested in the

possibility to incorporate a digester. The new facilities would not be built on the existing site, but relocated to a more central location within the market.

Other potential feedstocks for a digester include large volumes of slaughterhouse waste – blood, excrement and stomach waste – and other organic food wastes from fruit and vegetable sellers, all of which are currently dumped in the central market area (make-shift dumping site). Pigs were also seen to be roaming the rubbish dump feeding on dumped food waste – the possibility to pen them and utilize their manure within the proposed digester was discussed. Potential biogas use could be realized by food sellers (who prepare hot food) who currently spend from 100 Goudes upwards per day on charcoal.

Challenges related to the installation of a Sistema Biobolsa digester at this location were discussed and included:

- Location of biogas use close to the potential biodigester site
- Management of the latrine block – would this be a local entrepreneur/vendor within the market, or managed by the market administration
- Final discharge of effluent – there is little option for use of effluent as a fertilizer. Deep pit drainage/discharge could be an option, but an assessment of water table interaction would be required.
- Protection of the digester and prevention from damage
- Difficulty of keeping animals penned in the market as those that are slaughtered each day are brought to the market the morning of the day of slaughter. Pigs that currently roam the market are not necessarily owned by anyone.

Further discussion with Islamic Relief, as well as further examination of other potential Pay-Per-Use sites is planned to be undertaken before the project commits to this site.

7. Other activities

Other activities within the scope of the DIV project included:

1) Visit and review of pilot system at Episcopal Seminary church
    - 2m3 pilot system to treat human waste from the seminary, with possibility for expansion to other sites within the church compound.

2) Investigation into local laboratory testing availability
    - Quisqueya University; Faculty of Engineering and Architecture; Water Quality and Environment Laboratory – are currently able to test for Total Solids and Volatile Solids. Other tests will not be available until at least October as the facilities are under construction, but the laboratory contacts have stated that they will be able to test for Coliforms, physical parameters such as pH, DO and TOC and nutrients (Universitè Quisqueya; Faculté des Sciences de Génie et d'Architecture; Laboratoire de Qualité de l'Eau et de l'Environnement).
    - Ministry of Agriculture Tamarinier Veterinary Laboratory (Laboratoire vétérinaire de Tamarinier du Ministère de l'Agriculture) – team were unable to contact this laboratory.

3) Additional tours of Haiti Communitere pilot system
    - Additional tours of the HC pilot system (main latrine) were given to 3 other NGO groups outside of the programmed workshop who are interested in improving sanitation solutions in schools and churches in Haiti.

4) Development of stove design for households
    - Consideration of adaption of locally available kerosene stoves, briquette stoves and development of basic stove design from scrap metal that may be easily rendered by local metal workers.

5) Meeting with Islamic Relief to discuss technical details for the installation of institutional system at a Port-Au-Prince school.
    - Meeting with Islamic Relief staff and contractors at school site to review plans, discuss site setting out and construction phases. Installation not expected until October/November 2013.

8. Next steps and (updates)

Next steps to progress the project from the first trip will include;

1) Laboratory testing of samples taken by UMD team
    a. All laboratory sampling has been completed and data compiled for all systems tested
2) Further examination of feasible sites in Haiti for the application of a Pay-Per-Use system model;
    a. Additional site visits will be made by Alex Eaton in December
3) Guide and assist PIH technicians and management to ensure the opening and use of the Cange pilot system in the shortest time-frame possible;
    a. The PIH latrine and digester system has been opened with 150 user per week in the first few weeks of operation. The attendant is taking usage numbers and the interns get these numbers from the attendant each week. The attendant is on-site from 6am to 2pm (hours that clinic is open)
    b. 1st and 3rd digester bags are inflated fully, but the second bag is not inflated. Urinal and sink water were flowing from the T into the 3rd bag, but now that the 3rd bag is full, the urinal and sink waste are flowing into the wetlands.
    c. Infrastructure is holding up well, no problems at all so far. Attendant keeps it clean and cleans inside the fence and keeps the bags and fence clear of vegetation
    d. Cow manure, added 100 gallons over a 3-week period about a month ago for inoculum, and will be added again in the next few weeks to get the system inoculated with methane-producing organisms.
    e. Biogas is not being utilized as of yet.
4) Continued monitoring of existing pilot systems by Sistema Biobolsa, CFFL and PIH technicians and reporting to IRRI Mexico and UMD;
    a. Monitoring is o-going with more sample collection occurring in December.
5) Planning for DIV Workshop (2) around biodigester technician training, likely in conjunction with CFFL / Zanmi Agrikol;
6) Continued management of Digester Learning Community Google Group.
7) Alex will meet with USAID officials in December at the PIH digester site. Specific details will be coordinated shortly.

HAITI TRIP REPORT

DATE: Wednesday 19th February – Thursday 27th April 2014

---

1. Trip Overview

The trip to Haiti under the DIV grant ran from 19th February – 27th April 2014 and was attended by project assistant David Waters. During the trip made by the project assistant, project implementers Dr. Stephanie Lansing (University of Maryland) and Alexander Eaton (IRRI Mexico) made independent trips to Haiti to collaborate on the DIV grant project.

During this trip the project assistant visited, evaluated, and performed maintenance on the project pilot systems in Port-au-Prince and Cange. The project assistant collected waste and biogas samples from pilot biodigesters and performed in-place and laboratory testing of the wastewater and gas samples. The project assistant also took samples to Dr. Lansing's University of Maryland lab for further analyses.

The project assistant met with researchers and professors at the University of Quisqueya (UniQ) Water Quality Lab (LAQUE) in Port-au-Prince to determine the capabilities of the laboratory and to engage in discussion of future collaboration between the DIV project team and the University. The project assistant attended a later meeting between project implementer Dr. Stephanie Lansing and UniQ representatives. The project assistant also investigated the capabilities of other laboratories in Port-au-Prince for potential duplicate testing and/or supplementation of testing services that UniQ could not provide.

The project assistant aided the project impleenters in hosting a Learning Community Workshop in the Central Plateau (Corporant) during which an additional pilot system was installed. The project assistant attended a project status meeting between the project implementers and their USAID in-country grant manager, Webert Jose.

The project activities are discontinuous because the project assistant was engaged in other activities during the trip period.

2. Trip Activities

Date	Activity
20th February	Arrive to Haiti
	Visit and review of pilot systems (2) at Haiti Communitere, Port-Au-Prince
	Meeting with University of Quisqueya (UniQ) Water Quality Lab (LAQUE)
21st February	Communication w/project implementers re: UniQ meeting
	Draft and send Official Request for Services letter to UniQ for testing services
24th February	Interviews with Haiti Communitere staff and volunteers re: biodigester use
	Communication w/UniQ and project implementers
25th February	Meeting with new Haiti Communitere base manager, Laura Puts
	Maintenance of Haiti Communitere pilot systems
26th February	Travel to Cange to review PIH pilot system
27th February	Meeting with resident engineers in Cange (Clemson Engineers for Developing Countries (CEDC)) to discuss biodigester system
	Visit and review PIH pilot system

Date	Activity
	Planning of biogas use at PIH pilot system
28th February	Inventory of laboratory equipment at PIH site
	Meet with local agronomists to discuss planting of pilot system wetlands
	Biogas monitoring at PIH pilot system
1st March	Reporting and communication with project implementers
	Biogas monitoring at PIH pilot system
2nd March	Biogas monitoring at PIH pilot system
3rd March	PIH pilot system maintenance (plumbing)
	PIH pilot system wastewater and gas sampling and testing
11th March	Investigation into local laboratory testing capabilities in Port-au-Prince
	Travel to Cange to prepare for Digester Learning Community Workshop
12th March	Plant PIH pilot system wetlands
	Project implementers arrive for Digester Learning Community Workshop
	Reroute biogas from pilot system to a new kitchen in vicinity
	Commission construction of a simple cookstove adapted for biogas use
13th March	Preparations for Digester Learning Community Workshop on Friday 14th and Saturday 15th
14th March	Day 1 of biodigester installation and operation course at Centre Formation Fritz Lafontant – focusing on theory of biodigesters and site preparation
15th March	Day 2 of biodigester installation and operation course at Centre Formation Fritz Lafontant – focusing on biodigester installation and maintenance requirements
17th March	Travel to Port-au-Prince with project implementers for meetings and review of Haiti Communitere pilot systems
	Meeting with University of Quisqueya Water Quality Lab staff
	Meeting with USAID in-country project manager, Webert Jose
18th March	Travel to Cange with UniQ LAQUE staff for orientation of PIH pilot system and sampling
19th March	Maintenance on biogas piping of PIH pilot system in Cange; biodigester plumbing maintenance
24th March	Install new biogas meter on one Haiti Communitere pilot system
25th March	Travel to Cange for final system review and sampling
26th March	Sampling of Cange pilot system for laboratory testing at University of Maryland
	Final review of Cange pilot system
27th March	Sampling of Haiti Communitere pilot systems (2) for laboratory testing at University of Maryland
	Final review of Haiti Communitere pilot systems (2)
	Leave Haiti

3. **Meetings with University of Quisqueya**

On 20th February, 2014 the project assistant met with contacts from the Univeristy of Quisqueya (UniQ) Water Quality Lab (LAQUE). He met with International Relations director for the lab, Joaneson Lacour; lab manager and researcher Mrs. Elmyre Clervil; and principal researcher Dr. Ketty Accou. He subsequently met with the director of the lab, Dr. Osnick Joseph. During this meeting, the parties discussed the DIV project team's desire for testing services to be performed by the laboratory, the current testing capabilities of the lab, and potential future collaboration on biodigester projects in Haiti. Following the meeting, the DIV project team through Dr. Stephanie Lansing sent an Official

Request for Services letter to UniQ LAQUE requesting a quote for sampling and analysis of wastewater samples from the project pilot systems in Port-au-Prince and Cange. LAQUE advised that the following tests could be performed at the lab: pH, Total Solids (TS), Volatile Solids (VS), Chemical Oxygen Demand (COD), E. Coli, Total Coliforms, and Alkalinity, and Total Nitrogen and Total Phosphorus. Other desired tests could not be performed at the lab: NH4, PO4, and VFAs.

On 17th March, 2014 the project assistant and project implementer Dr. Stephanie Lansing met again with the University of Quisqueya Water Quality Lab to tour the lab, further discuss the collaboration between the DIV project team and the UniQ lab, and to establish parameters for the relationship between the parties. They met with the same four representatives from the previous meeting and were joined by a professor from the Faculty of Agriculture. The primary objective was to establish the laboratory testing services LAQUE could provide. The secondary objective was to discuss the possibilities for broader and more comprehensive collaboration between the two parties for the development of anaerobic digestion systems and economic models for the implementation of these systems. There was discussion about a potential partnership between the parties for future USAID DIV grant applications. There was further discussion about a direct partnership between the University of Maryland and the University of Quisqueya for the purpose of skill sharing and collaborative development of in-country capabilities.

Between these two meetings, a relationship was established between the DIV project team and the Univeristy of Quisqueya Water Quality Lab for the lab to provide wastewater testing services for the DIV project team.

4. Investigation of local wastewater testing capabilities

An investigation into the testing capabilities of laboratories in Port-au-Prince was conducted. The following labs were visited and their testing capabilities determined:

- Office of Jedco Services S.A. – Jedco is one of Haiti's largest sanitation services companies.
    - An engineer in their headquarters office, Enaillo Nonez, said that Jedco has no wastewater testing capabilities. They deliver their waste to treatment sites run by the national government.
- DINEPA – National Directorate of Potable Water and Sanitation (Direction Nationale de l'Eau Potable et de l'Assainissement) – Water Quality Lab (Unité de Laboratoire et Contrôle de la Qualite de l'Eau
    - The lab can perform only water quality testing. The lab management said they could test the fully treated effluent from a digester system.
    - The lab can perform the following analyses: Bacteriological Exam including Total Coliforms, E. Coli, and others; and Physiochemical Exam including pH, Conductivity, Alkalinity, and Total Dissolved Solids (TDS).
- National Public Health Laboratory – Laboratoire de la Sante Publique
    - It was determined that this lab does not perform wastewater analyses. They perform only water quality testing. They offer free coliform and E. Coli testing.

- Laboratory for the National Faculty of Agriculture – Tamarinier
    - It was determined that this lab does not perform wastewater anayses. They perform only water quality testing.
- Titanyen Sewage Treatment Plant – to the northwest of Port-au-Prince on National Route 1 on the coast towards St. Marc. Unknown who operates the site. Built in 2012 with international funding.
    - Staff did not know of any wastewater testing procedures and suggested a meeting with the site engineer. They did not have contact information for the engineer. No meeting was had.

The following laboratory was not investigated, but was suggested as a place of inquiry:

- Laboratory for the National Faculty of Sciences

5. Meeting with USAID Haiti Office

In order to continue to align the project with existing USAID work in the sanitation and agriculture sectors in Haiti a meeting was held on 17th March between the project implementers, project assistant, and the USAID project grant manager, Webert Jose. Meeting minutes were taken and can be found in "DIV-TripReport-Mar2014."

In summary, the project team met with Webert Jose to update him on the status of the project and discuss how the team was meeting its project deliverables. The project team addressed questions from Mr. Jose and discussed the next round of grant funding from USAID DIV.

6. Delivery of Digester Learning Community Workshop

Entitled 'USAID Development Innovation Venture (DIV) Digester Workshop', the second workshop of the DIV project was held on 14th and 15th March 2014 from 10:00 AM – 4:00 PM at Centre Formation Fritz Lafontant, Corporant, Route National 3, Near Mirebalais.

The event invited actors already engaged in biodigesters implementation, or actors known to have a strong interest in implementing biodigesters, in Haiti. The event was attended by over 15 attendees from Government, INGO, NGO, University and Private backgrounds including;

- University of Maryland
- IRRI Mexico
- CFFL / Zanmi Agrikol
- Partners in Health
- Universitè Quisqueya
- Hôpital Albert Schweitzer
- Food for the Poor

Presentations were given from University of Maryland, IRRI Mexico and CFFL on biodigesters and their design, anaerobic digestion and installation and maintenance of biodigester systems. The session was run in English and Kreyol (with translation).

The presentations were followed by a tour of the Partners in Health installed biobolsa digester system installed at the Clinique Externe in Cange, with demonstrations of the toilet, the digesters, and the biogas stove, and an installation of the projects 2nd biodigester system at the CFFL campus.

7. Capacity-building initiatives

The project team assessed the capabilities of the laboratory at the Centre Formation Fritz Lafontant (CFFL), the site of the biodigester workshop. Dr. Lansing supplemented the laboratory with equipment she brought from her lab at the University of Maryland. Dr. Lansing performed wastewater analyses at the lab and planned for a future workshop for students of CFFL to learn to perform field analyses on biodigesters.

8. Review of pilot systems

The pilot systems in Cange at the Partners in Health hospital and at Haiti Communitere in Port-au-Prince were visited and reviewed. A new pilot system was built in Corporant at a farm owned by Partners in Health. Meetings were held with stakeholders to discuss system status and next steps, field tests were performed and samples were taken for the second and subsequent rounds of laboratory testing at University of Maryland.

a. Port-Au-Prince, Haiti Communitere

- 2 pilot systems installed at Haiti Communitere – household sized systems, 1.8m3 with secondary aerobic treatment and final discharge to banana plant beds. Both with flushing toilets.
- A use survey of Haiti Communitere staff and volunteers was conducted.
- Normal maintenance was done on the toilets and the biodigester plumbing and gas lines for both systems.
- Both systems in good condition; biogas for the main latrine system is actively being used for water heating for tea and coffee.
- A new biogas meter was installed for the main latrine system.
- A click system is used in the main latrine to record the number of toilet flushes. The biogas meter readings are used in combination with the record of the number of flushes to determine the biogas production per flush.
- A new point of contact was established at Haiti Communitere – new base manager Laura Puts.
- Operation and maintenance plan is working well with regular cleaning of latrines with appropriate materials.
- Wastewater and gas samples taken. In-site tests performed and samples brought to University of Maryland lab for further testing.

b. Cange, Partners In Health / Zanmi Lasante

- 1 pilot system installed at the External Clinic – 36m3 with secondary baffled aerobic gravel treatment train.
- A use survey of latrine users and hospital staff was conducted.
- Normal maintenance was done on the toilets and the biodigester plumbing and gas lines for both systems.
- Meeting held with Cange resident engineers (Clemson Engineers for Developing Countries (CEDC)) to discuss system use and maintenance.
- The system is functioning well, effectively treating waste and producing biogas.
- Biogas pipeline was installed to provide gas to the guesthouse restaurant. A small biogas-adapted cookstove was built for the restaurant.
- A new biogas meter was installed.
- The secondary treatment was planted with local wetlands plants. There is further need for planting.
- Operation and maintenance plan is working well with regular cleaning of latrines with appropriate materials.
- Wastewater and gas samples taken. In-site tests performed and samples brought to University of Maryland lab for further testing.

c. Corporant, Centre Formation Fritz Lafontant

- New system installed during the Learning Community workshop. New latrine construction for the system had begun when the project assistant left Haiti. Future construction of a pig sty for the system to occur in the coming weeks.
- System was installed at the biodigester workshop on 14th and 15th March.
- System is a dual stage reactor system 1.8m3 capacity, connected to a latrine with the ability to also be connected to a pig pen in order to increase biogas reduction through use of pig waste in combination with human waste.

d. Sampling activities at pilot systems

Samples of digester influent and effluent were taken at both Haiti Communitere and Partners in Health systems to be tested at University of Maryland labs for:

- Biological parameters (Total coliforms, E-coli)
- Chemical & physical parameters (TS, VS, Alkalinity, Total Nitrogen, Total Phosphorus, COD, VFAs, ammonium and orthophosphate).

In-site and field testing were performed on biodigester systems at Haiti Communitere and Partners in Health. These results will be made available in a separate document.

9. Next steps

Next steps to progress the project from this trip will include:

- Final visit s to Haiti by the team to finish project components.
- Preparation and submission of the final reports.
- Preparation of Phase 2 proposal.

HAITI TRIP REPORT (2)

DATE: Tuesday 11th – Thursday 20th March 2014

---

9. Trip Overview

The second trip to Haiti under the DIV grant ran for 10 days from Tuesday 11th – Thursday 20th March 2014 and was attended by project implementers Dr. Stephanie Lansing (University of Maryland) and Alexander Eaton (IRRI Mexico). IRRI Mexico attended the trip from Tuesday 11th – Tuesday 18th March.

During this time the project implementers met with the USAID office in Haiti and held a practical workshop on the implementation of biodigesters in Haiti. Additionally several pilot systems were reviewed, samples were taken for laboratory testing and other possible future systems under the DIV project were examined for their feasibility.

10. Trip Itinerary

Date	Activity
Tues 11th March 2014	Arrive to Haiti Communitere.and review latrine systems installed
	Organize materials for installation of latrine system at Centre Formation Fritz Lafontant
Weds 12th	Meetings with other stakeholder groups Food for the Poor and Islamic Relief regarding additional digester installations
Thurs 13th	Travel to Cange, review biodigester Partners in Health biodigester system
	Prepare for biodigester installation and operation course at Centre Formation Fritz Lafontant
Fri 14th	Day 1 of biodigester installation and operation course at Centre Formation Fritz Lafontant – focusing on theory of biodigesters and site preparation
Sat 15th	Day 2 of biodigester installation and operation course at Centre Formation Fritz Lafontant – focusing on biodigester installation and maintenance requirements
Sun 16th	Visit Mirebalais market and make a case study assessment for a biodigester site
	Laboratory testing at Partners in Health biodigester
	Maintenance of wetland system
Mon 17th	Meeting with USAID staff in Port-Au Prince to discuss progress and EMPR for installation
	Meeting with Universite Quisqueya regarding laboratory testing
	Meeting with USAID team in Port-Au-Prince
Tues 18th	Test the field laboratory testing kit
	Final preparations

11. Meeting with USAID Haiti Office

In order to continue to align the project with existing USAID work in the sanitation and agriculture sectors in Haiti a meeting was held on 17th March. The following minutes were taken:

March 17, 2014 - 4pm
Attending: Webert Jose (USAID grant manager), Alex Eaton (Sistema Biobolsa), Stephanie Lansing (UMD), David Waters (UMD)

Info from Webert Jose - 3 USAID representatives from Washington, D.C. will be in Haiti from March 29 to April 5, 2014. They have a visit scheduled to a USAID project in the north of Haiti on April 1. They are interested to visit other USAID grantee projects during this trip and have an open schedule.

Brief to USAID

1. Mid-May delivery date to include:
   a. Haiti Communitere
   b. Cange
   c. Corporant, if sample data is available
2. Project deliverables discussed

. Characterization of digester system at PIH in Cange
   a. Implementation of a new system at Corporant
      i. Update - digester installed, toilet to be completed within 2 weeks
   b. Creation of a pay-per-use business model for biodigesters in Haiti
      . Sanitation surveys, including willingness to pay, are being performed to determine economic viability
   c. Creation of a digestion community in Haiti to include local resource development through: digestion workshops; creation/capacity building of digestion labs; and creation and testing of a digestion field testing kit

3. Lessons learned evaluation from successful and failed projects in Haiti to be included in reporting
4. Deliverables updates:

. Field kit has been tested. We have notes we will evaluate for a 2nd generation field kit.
   a. We are creating a digestion laboratory at CFFL vocational center in Corporant
   b. We are building the capacity of a water quality lab at University of Quisqueya to be able to perform digestion analyses
   c. Sanitation questionnaires in progress
      . Performed in rural area as per grant proposal - 200 surveys in Cange
   d. Survey scope expanded to include not only rural area survey (Cange), but also mid-size urban (Mirebalais), and high-density urban (Port-au-Prince)
      . Total number of surveys increases from 200 to 600-700
   e. Model for pay per use digester business being developed
      . Using data from: digester installations re: tangible benefits, such as biogas and liquid fertilizer (effluent); and data from sanitation questionnaires re: demand and willingness to pay

f. Creating a business model through market analysis - i.e. costs per system size, fees necessary to make a profit, etc.
g. Exploring funding mechanisms
h. Digestion community updates
. 60 members including from recent workshop
i. It has been decided that informational materials should be in 3 languages: English, French, and Kreyol.

12. Delivery of Digester Learning Community Workshop

Entitled 'USAID Development Innovation Venture (DIV) Digester Workshop', the second workshop of the DIV project was held on 14th and 15th March 2014 from 10:00 AM – 4:00 PM at Centre Formation Fritz Lafontant, Corporant, Route National 3, Near Mirebalais.

The event invited actors already engaged in biodigesters implementation, or actors known to have a strong interest in implementing biodigesters, in Haiti. The event was attended by over 15 attendees from Government, INGO, NGO, University and Private backgrounds including;

- University of Maryland
- IRRI Mexico
- CFFL / Zanmi Agrikol
- Partners in Health
- Universitè Quisqueya
- Hôpital Albert Schweitzer
- Food for the Poor

Presentations were given from University of Maryland, IRRI Mexico and CFFL on biodigesters and their design, anaerobic digestion and installation and maintenance of biodigester systems. The session was run in English and Kreyol (with translation).

The presentations were followed by a tour of the Partners in Health installed biobolsa digester system installed at the Clinique Externe in Cange, with demonstrations of the toilet, the digesters, and the biogas stove, and an installation of the projects 2nd biodigester system at the CFFL campus.

13. Review of pilot systems

Overall twelve pilot systems were visited and reviewed. Meetings were held with stakeholders to discuss next steps, field tests were made and samples were taken for the second and subsequent rounds of laboratory testing at University of Maryland.

a. Port-Au-Prince, Haiti Communitere

- Systems functioning well.
- Biogas is in use for heating water for hot drinks by the guests

- New staff were trained in the operation and maintenance
- Samples and gas tests taken.

b. Cange, Partners In Health / Zanmi Lasante

- System is functioning well.
- Biogas line installed to provide gas to guest house restaurant.
- Wetland needs to be planted with more plants.
- Samples and gas tests taken.

c. Corporant, Centre Formation Fritz Lafontant

- New system installed with new latrine construction to be carried out over the coming weeks.
- System was installed at the biodigester workshop on 14th and 15th March.
- System is a dual stage reactor system 1.8m3 capacity, connected to a latrine with the ability to also be connected to a pig pen in order to increase biogas reduction through use of pig waste in combination with human waste.

d. Sampling activities at pilot systems

Samples of digester influent and effluent were taken at both Haiti Communitere and Partners in Health systems to be tested at University of Maryland labs for:

- Biological parameters (Total coliforms, E-coli)
- Chemical & physical parameters (TS, VS, Alkalinity, Total Nitrogen, Total Phosphorus, COD, VFAs, ammonium and orthophosphate).

Results are not yet available.

14. Next steps

Next steps to progress the project from this trip will include;

1. Final visits to Haiti by the team to finish project components.
2. Preparation and submission of the final reports.
3. Preparation of Phase 2 proposal.

Approved Environmental Mitigation Plan & Report Narrative

1. Background, Rationale and Outputs/Results Expected:

This project provides a technological solution for two of the most critical needs faced in Haiti—the need for effective wastewater treatment and the need for decentralized, low-cost energy sources. The ongoing cholera epidemic has added further urgency to the implementation and evaluation of sanitation solutions appropriate for the Haitian context. This project proposes the validation of a sustainable sanitation model for rural Haiti based on biogas generation from low-cost anaerobic digesters. Anaerobic digestion (AD) treats wastewater while exploiting the large energy content of human waste, providing biogas as a clean burning, renewable energy source, as well as an enriched fertilizer/soil amendment. The production of these value-added products through waste treatment provides incentives for proper treatment of human excreta in a cash-limited economy.

The proposal is broken into **four main activities**: **(1)** Characterization and testing of a previously constructed digestion system treating wastewater at the Partners in Health (PIH) complex in Cange, Haiti; **(2)** Implementation and evaluation of one additional, community-scale Sanitation Center in Haiti treating only latrine waste, **(3)** Evaluation of a pay-for-use business model that integrates sanitation, energy production and soil amendments; **(4)** Creation of digestion learned community through digester operator workshops, creation of a digestion laboratory, and field digestion test kits.

At both digestion sites, technical digester performance and community acceptance will be evaluated as success metrics. The feasibility of a 'pay for use' business model will also be evaluated, with the goal of incentivizing system maintenance and providing entrepreneurship opportunities. Capacity/willingness of community members to pay for access to improved latrine facilities, as well as the resulting biogas (for cooking, lighting) and liquid fertilizer (for agricultural uses) will be evaluated to determine future scale-up strategies. Furthermore, water, soil, pathogen and energy parameters will be quantified to provide the basis for a model to quantify impacts of increasing digesters usage countrywide.

The evaluation will provide economic, agricultural, and sustainability impacts, thus providing evidence for the need of a more inclusive perspective in addressing food security by integrating sanitation with energy production, soil amendments, and entrepreneurship. Successful scaling and adoption of AD technology throughout Haiti would have notable impacts on (1) public health (intercept fecal-oral route transmission), (2) environment (improve soil fertility; eliminate raw sewage discharge to water bodies), and local economies (offset cooking/lighting costs; improve agricultural productivity; entrepreneurship activities).

2. Activity Description:

The characterization and testing of the digestion system at the previously constructed waste treatment system at the Partners in Health (PIH) complex in Cange, Haiti will begin in September 2013 to determine the water quality of the final effluent, its availability for agriculture, and the effectiveness of the subsurface constructed wetlands for wastewater

polishing. The parameters tested will be total coliforms, E. Coli, solids, and nutrients in the treated water. See attached photo of the wastewater digestion system.

The evaluation of the proper location for the second system currently being conducted as part of the proposed work in the USAID funded grant. A visit to a potential site on Thursday, August 22nd, 2013 in order to review the site's potential for a Pay-Per-Use latrine-digester system. Additional site visits will be made in the coming months before determing the exact location.

Gender plays a large role in the project in that the creation of restroom/latrine buildings will provide a safe location for women to use the restroom. Women are the most vulnerable group in terms of safety when using latrines and need for privacy when using restroom facilities, which are not currently available to many of the women in Haiti. It is estimated that only 33% of the population have access to improved sanitation with the remainder practiced open defecation. The testing of these biodigesters models will improve women's safety to providing them safe, secure access to sanitation, while producing biogas for cooking. The biogas will replace charcoal, which disproportionately affect women's health, especially in terms of asthma rates and cardiovascular health due to their proximity to particles and fumes associated with cooking from charcoal. The goal of the improvement of WASH is specifically focused on women and they will be the largest beneficiaries of the improved sanitation and access to clean burning renewable energy. The restroom buildings will include a monitor/cleaner and the sides of the restroom facilities are divided by sex to increase the feeling of safety and security for women.

A map is not included at this time, as this site has not been finalized. When the pay-for-use site is finalized, the exact location will be given. Once a site is selected, specific details on ancillary development activities that are required to build or operate the facility will be included. Once a site is selected, the permitting and the oversight of the construction will be in conjunction with our partners, Partner in Health, and DINEPA.

In March 2013 (with funds outside of this USAID-funded project), co-PI Alex Eaton installed a double reactor digestion system in Port-au-Prince at Haiti Communitere, a community demonstration and resource center in order to provide a demonstration of anaerobic digestion as an option to provide clean, modern sanitation services at both the institutional and individual family level in Haiti. In Aquin, 40 household-scale digesters were installed. In addition, we are in the process of confirming the installation of a digester at a school in Port-au-Prince that serves 800 children. Again, the installation of these digesters are outside the scope of this USAID-grant, but the testing of the water quality could be included in this project to increase the number of systems characterized. The testing and characterization of the existing digestion systems will not include any ancillary development activities. Water and biogas samples will be taken and analyzed on-site or in the laboratory after collection.

3. Environmental Baseline:

The baseline information for the PIH site does not exist for the anaerobic digestion system, as the stated goal of this USAID grant is to collect outflow data and assess the baseline production (biogas and treatment quality) of this site. In addition, as other digesters have been built by our project team with outside funding, these systems can be included in the environmental analyses in order to have more replicates and increase the strength of the collected

data set and provide more baseline data for digestion-sanitation projects at a variety of scales in Haiti.

Monitoring & evaluation (M&E) of the digesters will be conducted both by the managers and project researchers and will include rigorous environmental characterization of digester influent/effluent (e.g. solids, pH, nutrients, and fecal coliforms) and biogas production, based on established USEPA methods. The collected data will provide a number of public health, safety, and water quality indicators. An economic analysis, using a cash-flow methodology, will also be conducted at the end of the project to evaluate willingness to pay and project payback period.

In addition, training is an integral part of the process, and not only training in constructing digesters but also sustained training in operation and use. From our experience with design of the PIH system and correspondence with other sanitation groups, successful implementation and acceptance of new sanitation methods requires a minimum of 6 months to one year of operator training, as well as near continual community education and input. There are many examples of failed sanitation initiatives across Haiti—ill-used or abandoned latrines, septic tanks dug on high water tables, or housing projects constructed without sanitation infrastructure. Further, there is limited collective Haitian knowledge/experience with the design and operation of advanced sanitation technology. In addition to these factors, biodigesters are a relatively un-tested concept in Haiti, making success of pilot systems vital for any future expansion. Our aim for the initial phase of this project is thus to focus on successful construction and operation of two integrated biodigester systems, as well as capacity building, education, and empowerment as crucial elements for properly functioning systems.

Our workshop on August 23rd, 2013 entitled, "USAID Development Innovation Venture (DIV) Digester Learning Community Workshop" was the first step in the development of a digester community to assist in training, sharing of information and creating a baseline database of digester projects throughout the country of Haiti. The agenda to the meeting is attached.

While the site of the second system has not been finalized, the state of the current sanitation system can be seen as the baseline. As you can see from attached photographs, the baseline environmental impacts of no sanitation facilities are quite large including open defecation. The baseline environmental conditions are not acceptable, and the restroom facilities with digestion treatment will be a vast improvement on the baseline conditions.

4. **Evaluation of Environmental Impact Potential of Activities (Table 2):**

No construction has begun, nor has a site been selected. Once a site is selected, the evaluation of the environmental impact potential of the activities can be described in more detail. The overall impact of building a sanitation facility has been evaluated in Table 2, but not for a specific location.

5. Environmental Mitigation Actions (Tables 2 & 3):

Site selection is part of the project, and thus construction has not begun. Once construction has begun, environmental mitigation actions will be documented.

6. GENDER

Integrating gender considerations into all stages of planning, programming, and implementation of development assistance is not only a priority for USAID, but also an essential part of effective and sustainable development. The Automated Directive System (ADS) 201 sets out specific requirements to help ensure that appropriate consideration is given to gender as a factor in development planning at the Assistance Objective and the Intermediate Results level of Assistance Objectives all the way down to the activity level. This programming policy includes clear guidance on the procedures for gender integration where determined to be appropriate. In this regard, gender issues must be addressed in procurement documents and evaluation criteria. Gender equality is a USG-wide priority, and USAID has and will continue to a take a lead role in that effort. For example, USAID/Environmental Protection Program monitors how men and women will be involved in the process of improving the Dominican Republic's Environmental impact assessment procedures. The Program is documenting gender participation in all of its activities. Whenever possible, gender based differences in roles, attitudes and concerns should also be documented.

As stated before, gender plays a large role in our project in that the creation of restroom/latrine buildings will provide a safe location for women to use the restroom. Women are the most vulnerable group in terms of safety when using latrines and need for privacy when using restroom facilities, which are not currently available to many of the women in Haiti. It is estimated that only 33% of the population have access to improved sanitation with the remainder practiced open defecation. The testing of these biodigesters models will improve women's safety to providing them safe, secure access to sanitation, while producing biogas for cooking. The biogas will replace charcoal, which disproportionately affect women's health, especially in terms of asthma rates and cardiovascular health due to their proximity to particles and fumes associated with cooking from charcoal. The goal of the improvement of WASH is specifically focused on women and they will be the largest beneficiaries of the improved sanitation and access to clean burning renewable energy. The restroom buildings will include a monitor/cleaner and the sides of the restroom facilities are divided by sex to increase the feeling of safety and security for women.

Figure 1: Partners in Health Digestion and Sanitation Building with the new latrine building, 3 digestion cells and post-treatment wetlands.

Figure 2: State of sanitation and health in the Croix-des-Bouquets district market (photo by Islamic Relief of Haiti from their Concept Note on "Improving Livelihood and Sanitation of the Croix-des-Bouquets district" from 2013.