



# **University of Oklahoma International WaTER Conference**

**Sept. 23-25, 2013  
Norman, Okla., USA**

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# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Studies on the Role of WASH in Livelihood Security: Challenges and Opportunities in the Case of Bora Woreda
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<b>Primary Author Name *</b>	Bekele Abaire
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**Abstract Body \***

This study was conducted to assess the role of water, sanitation and hygiene in livelihood security of communities in the Bora woreda (state) in the Oromia region of Ethiopia, located about 100 kilometers south of south of Addis Ababa.

Both primary and secondary sources were used for the study. Primary data was collected using focus group discussions, household surveys, the observation method, and key-informant interviews. Household surveys were conducted in three kebeles (districts) in which 100 heads of household (43% women and 57% men) were interviewed. Three focus group discussions were held with water committee members, elders, health extension workers, development agencies and kebele administration officials.

About 36% of respondents asserted that they experienced changes in livelihood following water supply interventions (22% claimed increased income and 14% increased livestock productivity). Similarly, about 57% asserted that the health of family members significantly improved after they began using an improved water supply system. The findings from focus group discussions, key informants and personal observation agreed with the household survey results. Furthermore, these sources and a literature review showed that high fluoride in groundwater is a major concern and requires further consideration.

The study indicated that improved water and sanitation had a significant impact on people's wellbeing as well as the management of water supply systems through involvement of the community during planning, implementation and monitoring. Impacts observed included significant improvements in household income and livelihood security, increased school attendance with better child care, social and cultural benefits such as reductions in stress levels, increased status and self-esteem, better family and community relations, and increased ability to observe religious rites and customs.

Involving community members in planning, monitoring and management of the projects brought new insights into long term sustainability of water supply and sanitation systems. Understanding the potential that water supply and sanitation projects can have on poor people's lives underlines the fact that access to safe water and sanitation is a precursor to any form of sustainable development. Additionally, the study identified areas that need further intervention and research, including institutional capacity building, maintenance and operation, strengthening of community involvement, selection of appropriate technology, water quality and rainwater harvesting.

availability of cash within local economies to continue to pay for WASH services and infrastructures yet addressing the other livelihood challenges in these communities.

## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The Arborloo: Breaking Sanitation Challenges in Ethiopia
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### **Abstract Body \***

The concept of the Arborloo latrine was introduced to Catholic Relief Services in Ethiopia in early 2005 as a pilot project to test whether Ethiopian families would accept the design. In the prior six years, CRS had achieved about 6,000 conventional pit latrines, but there was little replication at community level due to high cost. The Arborloo had the potential of solving many of the problems faced by the CRS Ethiopia sanitation program, yet program implementers had doubts about acceptability. The pilot project involved asking 30 rural families to build Arborloos in three culturally different program areas and to evaluate results. Families were to be given SanPlat slabs valued at \$5. At the end of 2005, 3000 Arborloos had been constructed and demand was high for slabs. CRS partner organizations had set up slab workshops to meet demand. By the end of 2012, CRS programs had achieved over 70,000 Arborloos in various cultural areas and several communities became officially Open Defecation Free. Some partner organizations used PHAST to promote sanitation, while other only gave information on the Arborloo. This has taught us that, in sanitation uptake, technology matters. The simplicity of the Arborloo suits many rural Ethiopian households. As provision of free slabs is not the way forward, CRS is helping local entrepreneurs to set up slab production workshops so future demand can be met by the private sector.



## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	THE CROSSPATH OF DISEASE INCIDENCE AND DOMESTIC WATER ACCESS AMONG WOMEN IN A SLUM AREA OF NIGERIA
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### Abstract Body \*

#### Abstract

Poor sanitation and the consumption of deficient water in the midst of in-sanitary conditions explain the prevalence of water and sanitation related but preventable diseases. This study examines the relationship between poor quality water, inadequate quantity and incidence of disease among women in a slum neighborhood of Lokoja. This is because women perform a myriad of domestic chores; making them to bear disproportionate share of survival burden. Using the case study approach, the study covers Lokoja urban system of Kogi State in central Nigeria. Data was collected from both primary and secondary sources. Data collected relates to Sub-national Government expenditure and budgetary allocation to the health sector vis-a-vis; health related environmental sectors like sanitation and water. Data was also sourced on trend of prevalent diseases, especially in slum and low income areas. Analysis included the use of simple correlation statistics. Findings show poor water access both in quantity and quality as well as a glaring mismatch in disease trend, type and expenditure; as well as neighbourhood decline in the slum areas. The implications on the health of women was x-rayed., modalities for proactive repositioning of government effort were outlined. This includes a paradigm shift towards brown issues capable of addressing environmentally induced but preventable diseases which will have a direct benefit to women.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	THE NEGLECTED PATH; DENIED REALITY; RETARDED PROGRESS AND A MISSING LINK
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	and PROFESSOR RHODA MUNDI PhD <a href="mailto:rmundi@yahoo.com">rmundi@yahoo.com</a> Department of Geography and Environmental Planning, University of Abuja, FCT and SOLOMON JIYA N. PhD <a href="mailto:solojiya@yahoo.com">solojiya@yahoo.com</a> Department of Geography, Ibrahim Badamasi Babangida University Lapai, Nigeria

## Abstract Body \*

### Abstract

School water and sanitation coverage is one area where the battle of water and sanitation within the frame of the Millennium Development Goal appears to be neglected and is capable of retarding progress. In the struggle for the attainment of the Millennium Development Goals (MDGs) in Nigeria effort has been directed at community water supply. The component of community water supply does not appear to focus on institutional bodies like the school system. Yet the child spends more active time in school than home. In the MDGs water and sanitation sector, is this a neglected path or denied reality, does it retard progress? This research attempts to ventilate this aspect of community water and sanitation coverage within the fame of the MDGs. Data was collected through primary and secondary sources. Selected schools in urban and rural areas of Kogi and Niger states were sampled for the study. The water infrastructure in each school was examined while school children were interviewed on sanitation behavior. The curriculum of the schools was also examined to assess the extent to which sanitation constitute a teaching item. Several government documents were also reviewed to identify the status of regulations and standard on school component infrastructure. Findings show mis-match in water coverage between public and private schools, just as disparity existed between urban and rural schools. Hygiene and Sanitation content of the schools was also considered to be inadequate. There was however a positive correlation between age of children, level of study and sanitation awareness. The implications of the findings as it relates to water and sanitation policy as well as the school system were outlined in the paper.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Water Isn't just for drinking: how water, sanitation and hygiene conditions affect girls' use of menstrual cups & sanitary pads in primary school in Kenya
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## Abstract Body \*

A number of studies cite the importance of improved WASH facilities at school for female students in terms of attendance, comfort and privacy during their monthly period (Bolt et al. 2006; Jasper et al. 2012; Njuguna et al. 2009; Redhouse 2004). There is also growing evidence that WASH may impact school attendance and drop-out, resulting in early marriage, pregnancy, and adverse reproductive outcomes (Bastien 2008; Fentiman et al. 2001; Hargreaves et al. 2008; Lloyd and Mensch 2008; Sommer 2011). Our study looks at the influence of menstrual hygiene supplies, puberty education, and WASH on girls' attendance and comfort at school and their health risks outside of the school environment.

Thirty primary schools in western Kenya are involved in the 18 month study (May 2012 –November 2013). All schools are located within the health and demographic surveillance system (HDSS) of the KEMRI/CDC Research and Public Health Collaboration (Odhiambo et al. 2012). Schools were randomly allocated to one of two intervention arms or a control group; with ten schools in each arm. Students in one intervention arm received standard disposable sanitary pads for menstrual management and students in the other arm received long-lasting, reusable menstrual cups. Girls in each arm received puberty education and monthly visits with a school nurse. Focus group discussions were held in twelve schools during the course of the project to understand the challenges and viewpoints of girls in terms of puberty and menstruation. WASH conditions at the homes of enrolled girls were observed during unannounced visits over the study period. WASH spot-checks in schools were completed every two months during unannounced visits. Spot-checks included student roll-call along with observed and reported indicators of WASH conditions. Key variables included: presence of handwashing water and soap, latrine quantity, and latrine quality including privacy and cleanliness. Latrine to pupil ratios were calculated per school and compared against government standards. Data were also collected on WASH contributions to the school from supporting organizations such as community, governmental and non-governmental partners in order to compare WASH conditions of schools with and without significant support from organizations.

Preliminary results of this on-going study are expected by September. We will be able to report on girls' use of pads and menstrual cups and the conditions, and effects, of WASH in the school and home environments. This will compliment existing data on school and home WASH conditions, student attendance patterns, familial socio-economic status, and the challenges and perceptions of girls' experiences with the various menstrual management technologies.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Improving service delivery of water, sanitation, and hygiene in primary schools: a cluster-randomized trial
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## **Abstract Body \***

Water, sanitation, and hygiene (WASH) programs in schools have been shown to improve health and reduce absence. In resource-poor settings, barriers such as inadequate budgets, lack of oversight, and competing priorities limit effective and sustained WASH service delivery in schools.

We employed a cluster-randomized trial to examine if schools could improve WASH conditions within existing administrative and operational structures. Seventy schools were recruited and assigned to one of three intervention groups and a control group. All intervention schools received increased monetary support for purchasing WASH-related items. A second intervention groups received additional funds to hire a janitor (or WASH attendant) and for making additional repairs to existing WASH infrastructure. A final intervention group was given the guidelines and tools for supporting local monitoring and prioritizing WASH in schools in addition to financial supports.

All intervention schools made significant improvements in provision of soap and handwashing water, treated drinking water, and clean latrines compared to controls. Although qualitative interviews suggest that teachers perceived significant benefits from the additional funds for repairs and hiring a janitor and from expanded monitoring tools, observational data did not suggest that expanded intervention out-performed budget-only interventions.

Providing schools with budgets for WASH operational costs improved access to necessary supplies in schools but did not guarantee consistent provision of services. Further work is needed to clarify how schools can maintain WASH services on a daily basis in order for school WASH to achieve its full benefits.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Fluoride Contamination in the Bongo District of Ghana, West Africa: Geochemical and Cultural Complexities
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## Abstract Body \*

While almost half of the world's population faces a scarcity of water, 1.6 billion people experience this shortage as an economic water scarcity--where water is naturally available in the environment but access is limited by human, institutional, and economic capital. Geogenic contaminants place economic and development based stress on the provision of potable water beyond simply providing access to groundwater sources.

The primary objectives of this research were to investigate the extent of the fluoride contamination in the Bongo District of Ghana and the relationship of this contamination to precipitation and geological patterns in the area. A secondary objective was to study the social and cultural attitudes towards water and any age and gender divisions inherent in water usage and water demand patterns. Taken together, this information would allow us to quantify, for a rural African village, input parameters that would be needed to treat fluoride-contaminated water and to ensure community acceptance of possible treatment.

The local Community Water and Sanitation Agency (CWSA) adheres to the WHO guideline of 1.5 mg/L maximum contamination limit for fluoride. Lacking an established method of defluoridation, the agency caps drilled wells in violation of the standard, thus rendering them unusable. Capping water sources directly affects the community members who, collectively, invested 5% of the total capital costs for borehole construction. The capping of a well means that the people lose not only the water source but also the money invested. Reports by the CWSA list only 32 boreholes as capped, with most of these being in the District's peripheral communities. Of the 278 functioning boreholes tested in this study, 46% were in violation of the 1.5 mg/L fluoride limit. If the CWSA continues its current protocol of capping all boreholes exceeding regulated limits, many areas of Bongo will be without any improved water sources. Water treatment to reduce fluoride concentrations is needed for the area, and such treatment would require monitoring.

Unique to this geologic configuration, high fluoride levels in Bongo are geographically confined to one geologic formation. The fluoride variation studies tracking concentrations over eight months reflected a link to local precipitation patterns, correlating a decreased concentration of fluoride to diminished rains as the seasons change from rainy to dry. Comparing the results from this research to past studies conducted in the Bongo District, the levels of fluoride measured in the area by this research are higher than those measured in past studies. Changing land cover and climate patterns in the area are of extreme importance as long-term water treatment solutions are defined.

Finally, understanding the demographics of water fetching and the roles of borehole committees will allow for the majority group of users to be targeted for design consideration and treatment acceptance. During demographic studies, teenage females were determined to be the primary water collection community yet they are not integrated into the structure of local water committees. The repercussions of this exclusion are reflected by local attitudes concerning water.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Aluminium–fluoride chemical interactions during alum coagulation and associated effects on drinking water treatment
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## Abstract Body \*

The primary goal of this research is to elucidate the impact of fluoride on aluminium–based drinking water treatment systems. Coagulation is considered a common treatment technique for contaminants from small–scale treatment (i.e., the Nalgonda Technique developed by NEERI) to large–scale conventional treatment. Many drinking water treatment plants in developed countries use aluminium sulphate (alum) or polyaluminium chloride (PACl) as coagulants in the removal of both particles (turbidity) and natural organic matter (NOM). It is also anticipated that the USEPA will reduce the fluoride MCL (currently 4.0 mg/L) in coming years to reflect the standards of the rest of the world (1.5 mg/L F guideline set by the WHO). As a result, the US will join utilities worldwide in striving to simultaneously meet fluoride standards and produce high quality water free of residual contaminants.

Fluoride has a high reactivity with aluminium; however, the interactions between fluoride and aluminium in complex waters are not adequately understood. Experimental results suggest that high doses of alum can achieve high fluoride removal efficiencies; however, residual aluminium concentrations and the solids precipitated during treatment complicate simply dosing more chemical coagulant. Furthermore, in resource limited areas, the costs associated with increased chemical dosing remove this approach as a viable option. Many experiments previously conducted to look at single and dual ligand adsorption on preformed aluminium precipitants use aluminium chloride to form the precipitant (1, 2) and not alum. The few researchers forming precipitants in the presence of ligands use timescales irrelevant to the detention times of treatment plants (3, 4). As a result, little research has looked at the efficiency of removing both fluoride and organics from the perspective of the precipitation process at environmentally relevant concentrations and timescales applicable to treatment practices.

This research explored the effects of varying ligands on the precipitation of aluminium. Looking at the pH effects on the solubility of aluminium precipitation in the presence of a complex NOM and fluoride, it is revealed that the complexation of fluoride and aluminium determine the amount of precipitant formed. The solubility curve of residual aluminium and respective precipitation of aluminium in the fluoride and NOM system corresponds more closely to the curve when fluoride is the lone constituent than when NOM is the constituent. The shifting solubility can influence residual aluminium concentrations in treated water if treatment plants are not cognizant of the effects of fluoride on the aluminium precipitation process. Paired with spectroscopic results from this research, it is confirmed that fluoride is disrupting the crystalline growth of aluminium hydroxide precipitants due to a co–precipitant being formed.

Macro– and microscopic understanding of the solubility effects of various ligands on aluminium and microscopic analysis of the precipitant are necessary to achieve an understanding of the formed precipitant and the resulting influence on treatment.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	The Desert Research Institute's WASH Capacity Building Efforts over the last 20 years in West Africa
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## **Abstract Body \***

Developing nations face obstacles in achieving goals related to improving health and socioeconomic benefits while sustainably managing environmental resources, especially water. Achieving these goals will contribute to reduced poverty, increased access to water, and improved basic sanitation. Factors such as increasing population, poor water quality, and global climate change, however, pose new constraints to sustainable development. Insufficient human resource capacity across disciplines related to these fields continues to be a barrier to providing services. It is becoming increasingly critical to bridge gaps between scientific research and applied problem-solving in the context of developing nations to ensure that optimal solutions are discovered and applied.

The Desert Research Institute (DRI) has been involved in providing technical capacity building to water project staff in Ghana, Mali, and Niger. DRI's work began in the early 1990s and provided technical support and capacity building of staff in 1) the use of appropriate groundwater exploration methods and techniques to increase the success rate of water well drilling; 2) water quality analysis and interpretation of results; 3) investigation the use of local geomaterials to treat contaminated water; 4) assistance with the development and use of hydrogeological and water quality data management systems; and 5) the training of staff through short courses at DRI and graduate degree programs at the University of Nevada, Reno. With a recent grant from the Conrad N. Hilton Foundation, DRI is establishing a Center on International Water and Sustainability (CIWAS) with the goal of capitalizing on DRI's vast expertise to address gaps in knowledge, research, and human resource capacity that persist in developing countries and assist in reducing health related issues and the design of sustainable water, sanitation, and hygiene (WASH) programs.

This presentation will provide information about DRI's international WASH work during the past 20 years. The paper will also discuss the strategies that have been used, and the achievements and lessons learned from DRI's work in West Africa. An outline will be presented for the ongoing and planned future work that will be accomplished through CIWAS and how this aligns with the goals and objectives of the U.S. Universities WASH Consortium.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The Impact of Climate Change adaptation Efforts on Water Resources in Ethiopia.
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## Abstract Body \*

By 2025, between 75 and 250 million people of Africa are projected to be exposed to an increase of water stress due to climate change (IPCC, 2007). In 2002 alone, 14 African countries experienced water stress as the result of water scarcity, leading to increasing conflict over water use, a decline in water services, crop failure, and food insecurity. In the future, increased temperatures and variable rainfall could put additional pressure on water availability and demand in certain regions of Africa. Africa's water resources are still too low in terms of the water its people require for domestic use, agriculture, energy production, navigation, recreation, and manufacturing (World Water Assessment Program, 2006). Many of these uses put pressure on water resources and stresses that are likely to be exacerbated by climate change. In many areas, climate change is likely to increase water demand while shrinking water supplies. This shifting balance would challenge water providers to simultaneously meet the needs of growing communities, sensitive ecosystems, farmers, energy producers and manufacturers.

In Ethiopia also reports indicate climate change has been affecting certain components of the hydrological cycle, especially precipitation and runoff coupled with temperature rise, altering the spatial and temporal availability of water resources as well as water quality. Drying of lakes & springs and drying and/or seasonal fluctuation of rivers observed mainly during the last two to three decades. Climate change is not a future possibility for Ethiopia, it is a present reality. That is why it is imperative that we start now to protect our people and our environment, while at

the same time building a green economy that will help to realize the ambitions set out in the Growth and Transformation Plan (Ethiopia's vision for a climate resilient green economy).

This paper on the impact of climate change adaptation efforts on water resources is designed to highlight the World Vision Ethiopia's (WVE) integrated development observed impacts at few of WVE operational areas such as Astbi, Saessei Tseada Emba & Wukuro (Northern Ethiopia) as well as Humbo and Sodo (South Western Ethiopia) Area Development Programs (ADPs). At indicated Northern Ethiopia ADPs, observed positive changes such as better water infiltration and soil accumulation in the trench, raised water table and its discharge, manual and motorized irrigation systems enabled because of the improved discharge, change in farmers cropping system and frequency of planting per year, apiculture practice development, arresting expansion of gullies on grazing land of down stream, better feed type and amount for livestock mainly through cut and carry system; and as result income of households get diversified and improved. The main approach WVE used and is being using is community based programming and implementation with full participation of local Government staff. Likewise, at indicated South Western ADPs one of the community development bottlenecks was watershed degradation due to over exploitation.

In one of the intervention areas mentioned above, Sodo, particularly Mt. Damot, some three decades back it was covered with thick indigenous forest and was serving as the home for several wild animals and endemic



bird species. The mountain was also the source of thirty-one springs and was the tower of water for hundreds of thousands of communities dwelling around the mountain. Later, as the settlement around the mountain increased and the population pressure swelled, people started clearing the forest for agriculture, grazing, settlement and fuel purposes. For some the forest became the source of bread. This practice left the surface of the mountain degraded and barren. People were farming up to 80% of the slope of the mountain. The deforestation left the majority springs dry. Few of the springs flow but their discharge significantly reduced. Drinking water became scarce and people had to waste hours looking for water. In a bid to avert the aforementioned hazardous effect, World Vision initiated rehabilitation of the communal forest site via adopting participatory management method. It began through awareness creation campaign in 2006 on how to restore the devastated forest, area enclosure of 503 hectare of land, project demarcation, development plan and formation of five legal cooperatives.

The relentless effort of reforesting the devastated forest has resulted in fruitful outcomes, says Mr. Mulatu Tadesse, the South Nations Nationality Peoples' Regional State Environment protection Head. "The springs are recharged, improving water shortages. Soil erosion is greatly reduced resulting in productivity boost. The lost forest is recovered improving the biodiversity of the area. The migrated wild animals returned to the forest," he happily explained. The communities around the mountain are grateful to World Vision for this illustrious initiative. The forest restoration has brought about a number of co benefits for us, says Begejo Melebo, one of the cooperative members. "Our land is no more eroded. Our production has increased two folds. We are able to access water both for ourselves and our livestock from the rehabilitated springs." Further, the lessons and experiences gained from these model interventions with incredible impacts stimulated the Ethiopian Government to develop climate resilient green economy policy and strategy. At present massive afforestation, natural regeneration and physical conservation works are underway nationally. However, this is the beginning to an end.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Effective behavior change starts with the user journey.
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## **Abstract Body \***

Sanitation improvement, at its core, is about behavior change—getting people to change their behavior from open defecation to consistent use of hygienic latrines. One helpful framework to assess a person's readiness to act is the Transtheoretical Model of Behavior Change, which maps out the user journey of change according to the user's readiness to act, from pre-contemplation all the way through to maintenance of behavior change. By mapping out the user journey, one can identify the barriers, motivators, influencers, and accelerators of behavior change present at every stage that is either preventing or driving the user from moving forward along the path.

This presentation will use case studies from iDE's Global WASH Initiative experience to show how starting with the user journey instead of a pre-determined technological or methodological solution allows all initiatives to target the specific drivers and barriers affecting users. Behavior change initiatives, therefore, are no longer siloed according to method (e.g.: CLTS/SanMark/BCC/PHAST/etc.) or technology (e.g: sanitation ladder), but grounded in the user experience.

Moreover, using case studies, the presentation will demonstrate the role the market can play in either driving or preventing people from moving along the behavior change path. As the market is comprised of both supply AND demand, WASH behavior change initiatives need to consider the role of the market not only product development and supply chain optimization, but also promotions and sales.

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# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Effective WASH Technologies put the the user, not the technology, at the center.
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**Abstract Body \***

Technology can transform lives, but a technical solution alone is insufficient for large-scale, sustained behavior change. The most technically efficient solution is not necessarily the most effective.

This presentation will discuss to develop effective technical solutions the user, not the technology, needs to be at the center of the design process. With the user at the center, solutions then need to be evaluated, prototyped, and developed through the three lenses of desirability, feasibility, and viability to ensure they will be adopted by the end user and, where appropriate, the market. This presentation will also discuss how affordability is not the most important element to ensure end user adoption but rather the design process needs to find the 'sweet spot' between affordability, accessibility, and aspiration.

Case studies from iDE's Global WASH Initiative experience in product design in Cambodia (the Easy Latrine, the Hydrologic Super Tunsai, and a newly designed handwashing station) will be used to illustrate the confluence of feasibility, desirability, and viability and affordability, accessibility, and aspiration.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Behavior Adaptations to the Climatic Variability in the Use of Water for Drinking and Sanitation in the Dry Region of Sri Lanka
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<b>Primary Author Name *</b>	Prof.G.M.Bandaranayake
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## Abstract Body \*

One of the most urgent challenges facing the world today is ensuring an adequate supply and quality of water for the people. In addition to growing demand on water, climatic variability has intensified the problem. But there are still major gaps in our basic understanding of water availability, quality and dynamics, and the impact of changing climate, and human activity. In this sense, the understanding of the behavior pattern of the people in response to climatic variations will be an essential need when panning community water development projects in regions where water is a scarce resource

It has been understood that Sri Lanka also experiences remarkable climate variations. It is also apparent that these changes are preliminary affecting rainfall pattern, runoff in river basins , surface water, water storages and ground waters. As a result, a large population of rural communities living in the Dry region of Sri Lanka is suffering from water problems. Apart from land use changes, the people's behavior patterns, attitude and perceptions on water, and water utilization techniques have dramatically been changed. These changes clearly indicate some significant adaptations to the climatic variation that provide a good insight into the field of community development planning not only Sri Lanka itself but for the regions similar in the world .

Present paper from a sociological perspective, deals with how people's behavior patterns in the se of water for farming, drinking and sanitation have been changed over the time of past 30 years. The paper first analyses the climatic variability using meteorological dada recorded in the past 30 years. Based on information collected by field investigation the paper discusses how their adaptations were set during the period of concerned. It was revealed that traditional perceptions on water are being evolved towards the new activities such as Rainwater Harvesting, Mechanical Ground Water Pumping and Pipe born water. This paper highlights the practical experiences of these methods which will be more useful to share with an international dialog.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	The Impact of Fluorosis on Education in the Ethiopian Rift Valley: The Case of Wonji/Shoa Area
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<b>Primary Author Name *</b>	Paulos Beyene
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**Abstract Body \***

Abstract:

Health problems related to high fluorine concentrations in drinking water are widespread in the East African rift system including the Ethiopian Rift Valley. A total of 160 students aged 14 – 28 years have completed questionnaires administered in the two school compounds residing for long period in three villages. The villages are namely, Village A, Village O and Village K were selected purposively out of the 15 villages with high (16mg/l F<sup>-1</sup>), medium (8 mg/l F<sup>-1</sup>) and low fluoride concentrations (1.3mg/l F<sup>-1</sup>) respectively are considered to compare and contrast the impact of fluorosis on education of students of Wonji/Shoa secondary school and preparatory school. As fluorosis is a long term impact, the research purposely chooses to take students of secondary school and preparatory school than primary school because the impact is no longer pronounced at the early age. The study indicated that there is a major problem of fluorosis in the areas studied. The prevalence of severe fluorosis was significantly higher in the high fluoride area than in the area with medium and low fluoride concentration in the water. Both sexes were equally affected by dental fluorosis in the Wonji/Shoa. Unlike the problem of dental fluorosis among the students, male students were affected more than the females by skeletal fluorosis. This is because the males are more exposed to hard work and they also consume more water than their female counterparts in the area. Based on the findings from the study, the physical pain associated with fluorosis leads to poor personal hygiene. The victims also fail to maintain relationship with friends and are more prone to violence. Additionally, students who develop fluorosis related behavioural problems are disruptive in school and under achievement in academic performance. They also become absent from school regularly, exhibit weak participation in class activity and high dropout rates.

## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Two years in Kasiisi: lessons learned building biogas digesters in Western Uganda
<b>Primary Author Name *</b>	Bonny Bradway
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Adam Brady, ENV PV, Instructor, Department of Geography and Environmental Engineering (USMA) Jeffrey Starke, PhD, PE, Assistant Professor, Department of Geography and Environmental Engineering (USMA)

### Abstract Body \*

Over the past two years cadets and faculty from the United States Military Academy have traveled to Kasiisi, Uganda to build anaerobic biogas digesters. Sponsored by the Center for the Study of Civil and Military Operations, these trips afforded the cadets the opportunity to learn about renewable energy and sanitation in the developing world. The digesters created a source of renewable energy (methane) and a soil amendment (biosolids) while improving the sanitation conditions in the area through the control of organic wastes. During their stay in Uganda the cadets participated in the construction process. The sites were both on property owned by the Kasiisi Project, a non-profit organization that operates 10 primary schools focused on conservation education in western Uganda. This region, within five kilometers of the Kibale National Park, is reliant on a forest-based economy. Outside of the park, the primary source of wood for cooking fuel has been diminished due to deforestation caused by population growth. The Kasiisi Primary School, one of the only schools in the country that provides a lunch meal to students, chose biogas digesters as a sustainable solution to meet their cooking fuel needs while providing improved sanitation to their 1,000 students. The first digester, built at Kasiisi Primary School in 2012, included three latrines to supplement the school's existing pit latrines. In addition to human waste, organic kitchen waste from the school's guesthouse and a local research station, and animal waste from the organization's farm is added to the digester. The methane created is used for cooking in the guesthouse and the school kitchen. The second digester, built on the organization's demonstration farm in 2013, was a smaller version of the previous design. This digester, sized solely to use the animal and human waste from the farm, will be used to heat chicken coops to an optimal temperature for egg production. The outcomes achieved were consistent with the intent of the project. Organic waste, normally disposed of without viable reuse, is being utilized to produce methane and a soil amendment. Lessons learned from the first digester helped improve the planning and design of the second digester. For example, the students at Kasiisi School often opted not to use the new latrines because they were experiencing "splash back". This led the engineer to redesign the latrines on the second digester and retrofit those on the first to eliminate this problem. These digesters have been a large success in Kasiisi. Cadet participation in the construction of these digesters was also a large success. Cadets learned about many topics, both culturally and academically, that will benefit them in their Army careers. Cadets learned about construction practices in developing countries, as well as conservation practices of valuable resources and the extreme impacts human activity can have on the different ecosystems of the country. The experience also sparked several cadet research and design projects.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Optimizing Filtration Materials for Fluoride Removal from Drinking Water
<b>Primary Author Name *</b>	Laura R. Brunson
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Peter Everest –University of Oklahoma; David.A. Sabatini – University of Oklahoma

## Abstract Body \*

Lack of access to safe drinking water is a global issue of concern as the World Health Organization and UNICEF estimate that over 780 million people still lack access to an improved drinking water source (WHO and UNICEF, 2012). This number does not take into account the approximately 200 million people who may be consuming groundwater that contains elevated concentrations of fluoride (Amini et al., 2008). The health issues resulting from inadequate safe drinking water contribute to many additional concerns such as education, maternal health and economic development. Further troubling is the fact that approximately 2.6 billion people are living on less than \$2.00 (US) per day (The World Bank, 2008). Therefore, solutions to increase access to safe drinking water must be inexpensive and sustainable.

While the most significant issue contributing to a lack of safe drinking water is pathogens, fluoride is reportedly the next largest issue limiting access to safe water. The World Health Organization has suggested a fluoride limit in drinking water of 1.5 mg/L – this number should be assessed in individual locations based on local climate, amount of fluoride consumed through food, etc. Fluoride is naturally occurring in the drinking water sources of many areas of the world, including the Rift Valley of Africa. The health effects of fluoride include dental and skeletal fluorosis. Dental fluorosis can cause social issues and skeletal fluorosis causes bones to become deformed or stiff to the point where mobility is limited and/or painful, which is particularly problematic in rural areas where people depend on their physical labor in order to farm or earn a living.

This presentation will share results of experimental work done to optimize existing and novel fluoride removal technologies. Bone char has been used for years as a fluoride removal filtration media, but in some areas bone char is not an appropriate technology due to cultural or religious reasons or availability of animal bones. Therefore, wood char and other activated carbon based materials with similar properties have also been studied. Since our preliminary work showed that wood char was not as effective for fluoride removal as bone char, we looked for ways to amend the wood char, for example by adding aluminum oxide or iron oxide to the media through various coating or impregnation processes, to improve fluoride removal efficiency. Additionally, this work investigated the possibility of pretreating the char with oxidizing agents to improve the aluminum or iron uptake capacity of the media to facilitate higher fluoride removal. Results of these amendment methods from batch tests will be shared and discussed along with media characterization metrics such as specific surface area, point of zero charge, and metal loading.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	DECENTRALIZED WATER KIOSKS: DEVELOPING MODELS FOR SUSTAINABLE AND ACCESSIBLE DELIVERY OF SAFE WATER SERVICES IN RWANDA
<b>Primary Author Name *</b>	Laura R. Brunson
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	G. Chapeau <sup>2</sup> , A. Huttinger <sup>2</sup> , R. Dreibelbis <sup>1,2</sup> , C. Moe <sup>2</sup>  1 CEES; 202 W. Boyd St.; Room 334; Norman, OK 73019, 405-255-9622  2 Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, GA,

## **Abstract Body \***

Market-based approaches to delivery of water supply services are increasingly proposed as a key strategy for expanding access to safe water in under-served populations. Market-based approaches utilize private sector business models to sell safe water or maintenance of existing water sources and treatment systems. This approach, while not appropriate in all circumstances, has many benefits including: sustained cash flows without the necessity of donor or government funding in the long-term, fostering enhancement or creation of supply chains and repair networks required for long-term viability of a safe water source, and new revenue sources for business operators.

Together with the Rwanda Ministry of Health and Access Project Rwanda, the General Electric Foundation has partnered with Emory University to assess the feasibility and sustainability of membrane-filtration devices as a source of safe drinking water for health centers in Rwanda. In addition, the partnership plans to assess the potential to expand community-access to safe drinking water through the development, operation, and support of safe drinking water kiosks which will sell treated drinking water to community members in the vicinity of each health clinic.

This presentation will outline the development and implementation of the kiosk delivery model within the context of Rwanda. Community assessments of existing water sources, water source prices, and collection patterns were used to inform the development of a pricing, business, and branding strategy for the kiosks. Collaborative meetings were held with members of the Ministry of Health, health clinics, and local community members to gain insight into local priorities, kiosk placement, and price-points. Preliminary results suggest several of the health clinics and communities are highly receptive to the idea of a local safe water kiosk and purchasing water that not only has been treated but also contains a small chlorine residual to protect during transport and storage. The business model strategy incorporates a branding and marketing campaign that will be initially tested in two of the ten kiosk locations. Branding of the kiosk will be complemented by behavior change communication strategies incorporated into existing health mobilization and education campaigns operated by the Ministry of Health, local health clinics, and community health volunteers.

Several kiosks are expected to be fully operational by summer 2013, and preliminary data on kiosk operation, pricing strategy, community health education, branding campaign, and community responses from the first implemented kiosks will be shared.



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Application of "Asset-Based" Development Methodologies to Water Projects
<b>Primary Author Name *</b>	Lauren M Butler
<b>Primary Author Affiliation *</b>	Engineers In Action
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## Abstract Body \*

Development programs often mistakenly take the "aid approach" of matching the needs of a community with the resources of outsiders. By not harnessing and further developing local capacity, these programs miss out on opportunities to make projects more sustainable and to have greater impact on the community.

Many consider asset-based approaches to be current best practices in development, but most literature and organizations focus on organizational, educational, and economic development, rather than water or other technology and infrastructure development.

This presentation will give an overview some asset-based methodologies: Asset-Based Community Development, Appreciative Inquiry, Participatory Development, and Positive Deviance. Then I assess how asset-based approaches are already used in many water projects, such as using local materials, building upon local knowledge, and relying on local organizations. Engineers In Action in Bolivia is given as an example of relying heavily on local resources to make projects sustainable.

Opportunities will be shared for using asset-based methods in water projects, e.g. how they can help avoid creating unrealistic expectations. Also included is a critical examination of applying these approaches to technology and infrastructure. For example, necessary resources often must come from outside the community. The Asset-Based Community Development Institute does suggest establishing connections between the community and outside resources (McKnight), but I contend that this is necessary even more in technology/infrastructure projects. Also, it has been found that "increased community participation in project decisions has a positive effect on maintenance for non-technical decisions but a negative effect for technical decisions" (Khwaja).

Example water projects in Guatemala and Bolivia demonstrate the impact of an asset-based approach. In Guatemala, a ram-pump project that started with Appreciative Inquiry had more community acceptance and involvement than a rainwater system that used the traditional approach of primarily outsiders trying to solve the need. In a water well and distribution project in Bolivia, an asset-based mindset has created a supporting network of indigenous groups and organizations. By relying on local resources the project advanced more quickly and encountered creative and culturally-acceptable solutions, especially for system administration and maintenance.

No tool is a golden-ticket solution, but using and building local resources offers outsiders the opportunity to help find specific, locally-connected solutions to each unique problem. Doing not only a good needs assessment but also a resource assessment can uncover previously unknown resources. I conclude that asset-based tools are useful in the front and rear end, and the socio-cultural side, of a water project. Specific tools are less applicable for the design of a large technical solution, but an asset-based mindset is still helpful. And because water projects often fail for social, cultural, or political influences on maintenance or community acceptance, rather than a technical mistake, asset-based approaches can significantly improve the provision of safe, abundant water worldwide.

# 2013 OU WaTER Conference Abstract Submittal Form

**Abstract Title \*** Evolution of a Potable Water Partnership in Omoa, Honduras

**Primary Author Name \*** Michael E. Campana

**Primary Author Affiliation \*** Ann Campana Judge Foundation

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**Secondary (Co-) Author(s) and Affiliation(s)**

## **Abstract Body \***

Many rural communities in the rugged Sierra de Omoa of northwestern Honduras have been without reliable, safe potable water supplies for their entire existence. The reasons for this are generally twofold: the region is 1) rugged and difficult to access; and 2) sparsely populated with little political power. Few politicians and agencies find it worth their while to help the residents; NGOs find the rugged topography and limited access challenging with a high risk of project failure – anathema to their donors.

The author has worked in the area since 2001 assisting Hondureños Rolando López, Alex del Cid Vásquez, and local villagers construct five community water systems in the Municipalidad (similar to a county) de Omoa. University of New Mexico graduate and undergraduate students worked in this area with the author from 2001 through 2005. Descriptions of these trips can be found in Water Resources IMPACT (<http://bit.ly/9ColgZ>) and the Journal of Contemporary Water Research and Education (<http://is.gd/Xgml38>).

More recently, the Ann Campana Judge Foundation has partnered with Omoa and its mayor, Prof. Ricardo Alvarado, to bring potable water to two communities, Brisas de Rio Cuyamel and Los Mejias. Rolando López and Alex del Cid Vásquez continue to play major roles: the former as a manager and facilitator and the latter as the project engineer and Omoa municipal councilor. Prof. Alvarado has marshalled the forces of the municipal government to provide transportation, road maintenance, human power, and assistance with other jurisdictions.

The successful work in the aforementioned villages has prompted Omoa and the ACJF to continue their collaboration. Six more villages in Sierra de Omoa region of Omoa have been identified as potential candidates for potable water systems. Each village must request a system and exhibit strong support for same; no village is forced to accept a water system nor will a village receive one without overwhelming community support. Before a project is started or even designed, the community's residents are organized, a junta de agua (water committee) formed with tasks, training, financing, and responsibilities identified. At that point, SANAA, the Honduran government agency responsible for rural water supply, must approve each project and agree to provide support after the project's completion.

Simple gravity flow systems are constructed using a small dam and reservoir, ferroconcrete tank with a chlorinator, and PVC and/or GI (galvanized iron) piping to provide each residence with a tap. Water is to be used for household use only; irrigation using project water is proscribed.

The partnership provides benefits beyond potable water. For example, road maintenance needed for equipment access assists villagers in getting their products to market; students traveling to school; and transportation and commerce in general. Politicians benefit by acquiring political capital. In particular, they are seen helping their constituents obtain one of the necessities of life – a reliable supply of potable water.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Hydrogeologists Without Borders: Integrating Groundwater with International Development
<b>Primary Author Name *</b>	Michael E. Campana
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## Abstract Body \*

The nonprofit hydrophilanthropic organization, Hydrogeologists Without Borders (HWB; <http://www.hwbwater.org>), recently reorganized, seeks to connect hydrogeology and its practitioners to the international development community. It will assist the world's marginalized people as they seek access to water, sanitation, and sound water resources development and management. Hydrogeology is a key development component as groundwater has become an important source of water in much of the developing world, a trend expected to continue due to population pressures, limitations of surface water supplies, and climate change impacts. HWB was incorporated in Canada in 2008, registered as a Canadian Charity in 2010, formed a Board of Directors in 2011, and is actively seeking to establish chapters outside Canada. HWB's mandate is to strengthen developing countries' capacity in hydrogeology, as well as that of the many water organizations involved in water projects. The primary types of water projects undertaken by such agencies – water supply and sanitation (WatSan) – have suffered as they frequently have not employed sound hydrogeologic principles in the construction of water wells and latrines, climate change impact assessments, and watershed management. Initial HWB efforts employ a two-pronged approach: 1) supporting longer-term capacity development; and 2) addressing more immediate needs for hydrogeologic assistance. As opposed to a project management lead, HWB's niche will be that of a technical support organization to ensure sound hydrogeology is incorporated into projects so that organizations will be strengthened in their ability to plan and implement water projects more effectively and with greater benefit. HWB will support development of new appropriate hydrogeologic technologies for developing countries and help build hydrogeologic capacity in developing countries by supporting graduate programs, students, faculty and staff in developing countries. Our presentation will include HWB's newly developed (2012) mandate and mission statement and serve to introduce HWB to the international WatSan/WaSH communities and seek partnerships with same.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Capacity Building for the Improvement of Water and Sanitation Facilities in Metro Manila
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<b>Primary Author Name *</b>	Maria Rebecca Campos
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<b>Primary Author Affiliation *</b>	University of the Philippines Open University
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## **Abstract Body \***

The Manila Third Sewerage Project (MTSP) was conceived with the following aims: to increase the coverage and effectiveness of sewerage service delivery in participating areas of Metro Manila where majority of the Philippines' urban poor reside through an integrated approach involving septage management, sewage management, and heightened consumer awareness of water pollution problems and their solutions; and to establish the financial and technical viability of new approaches for sewage management in Metro Manila. The components of the project are: Sewage Management which includes construction of 10 sewage treatment plants, upgrading of two communal septic tanks to secondary treatment, rehabilitation and construction of collection networks; Septage Management which covers vehicles for pumping-out septage from septic tanks (fecal tankers), two septage treatment plants (SPTPs), and safe disposal of treated septage; and Institutional Strengthening for (a) the carrying out of a public information campaign on the benefits of sewerage and sanitation services, and on the best practices of proper disposal of sewage, and (b) assistance in preparation of follow-up programs for wastewater and sanitation improvements. This wastewater project is expected to serve about 3.3 million people within its concession area in eastern Metro Manila by the year 2014 through a loan from the World Bank. MTSP is the biggest wastewater project in the country. The project will increase sewerage coverage from about 8% to 30%, and sanitation services from around 1.5% to 100% in the East concession area. Additional benefits of the project include: (a) reduction in total domestic BOD load in Manila Water concession area by about 15,400 to 37,700 tons/year; (b) improvements in public health and well-being The risks of the community coming into contact with raw wastewater are lessened, and the resultant benefit has been estimated at about PhP 300,000 per 1,000 persons/year. The reduced risk benefit of people coming in contact with raw wastewater from overflowing septic tanks has been estimated at PhP 150,000 per 1,000 persons/year avoided health costs due to loss indirect income and medical costs; (c) improvement in soil condition and crop yields in lahar-affected areas, where treated septage will be applied; and (d) information on the viability of new approaches for sewage management in Metro Manila. Institutional benefits through improved approaches on sewage management is also expected. The project is the first of two pilots on the use of combined sewers for sewerage systems in the country. Lessons learned from the project will help improve the design of subsequent investments on sewerage and sanitation that are more socially, economically and politically acceptable.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	"I couldn't urinate at our toilet ... there's no water... I might see blood on the bowl": A formative investigation of Menstruation and school WASH in four countries
<b>Primary Author Name *</b>	Bethany A. Caruso
<b>Primary Author Affiliation *</b>	Behavioral Science and Health Education, Emory University
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## **Abstract Body \***

### Introduction

Educating girls through the secondary level has implications for development, poverty alleviation, civic engagement, and health. The onset of menstruations may put girls' learning potential at risk. Robust research on the education and health impacts related to menstruation is scarce. There is increasing attention to menstruation in the WASH-sector and a need for evidence-based interventions. In partnership with UNICEF, we systematically investigated adolescent schoolgirls' menstruation-related challenges and the resultant education and health impacts in four geographically and culturally distinct countries: Bolivia, the Philippines, Rwanda and Sierra Leone. We explored the determinants of these challenges and impacts, with attention to water, sanitation and hygiene (WASH), in order to make evidence-based recommendations.

### Methods

Research activities took place in partnership with UNICEF country offices and local partners in all locations. We used the Socio-Ecological Model to develop methods to understand challenges from multiple levels of influence. We conducted focus group discussions, in-depth and key informant interviews with girls, boys, mothers, teachers, government officials, and NGO partners, and carried out structured school observations. All activities were conducted in the local language, recorded, transcribed, and translated verbatim by trained research assistants. Thirty-nine schools were visited, 244 activities were completed, and 610 participants were engaged. Data was analyzed using MaxQDA software. Areas of intervention potential were systematically identified by mapping challenges and impacts with associated determinants. Comparisons were made across countries to identify similarities and differences in challenges, impacts, determinants, and recommended areas of intervention.

### Results

Girls faced challenges at school during their period. Girls acknowledged absenteeism and also reported distraction, an inability to concentrate, reduced classroom and extra-curricular participation, and poor performance during menstruation. While no physical health impacts were explicitly reported, girls discussed potentially harmful behaviors: avoiding bathing, refraining from urination, and using improvised and unclean materials. Mental and social health issues, like stress, anxiety, teasing and isolation were discussed. Inappropriate school WASH facilities, a lack of understanding of menstruation and how to manage it, and inability to access absorbent materials all contributed to girls' challenges. Girls knowledgeable about menstruation with access to materials could not manage without WASH facilities. All schools had sanitation facilities, though none suited girls' needs due to insufficient privacy, water access, and disposal. Needing to ask for keys to use facilities, being restricted to use at designated times, and simply not knowing how to use the facilities during menstruation were noted.

## Conclusions

Water and sanitation structures need to suit the girls' needs. Those constructing facilities need to consider menstruation when proposing designs and should consult girls in the process. WASH practitioners need to create programs that teach girls how to use facilities appropriately and effectively, and need to consider school management of facilities as a part of programming. School rules and systems can either enable or disempower use. Finally, considering menstruation requires WASH sector actors to partner with education, reproductive and adolescent health, and behavior change specialists to create enabling environments for girls'. Strategies need to be evaluated for impact and for suitability from girls' perspectives.

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# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Water Supply Options in Arsenic-Affected Regions of Cambodia: Targeting the Bottom Billion
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<b>Primary Author Name *</b>	Jim F. Chamberlain
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## **Abstract Body \***

Of the nearly 900 million people globally who still rely upon unimproved water sources, many live on less than \$2 per day and thus have limited income to purchase clean water or to support water systems. Deep tube wells often deliver water with elevated arsenic or fluoride, leading to chronic arsenicosis or fluorosis. Alternatively, potable water taken from surface water sources tends to contain pathogens, increasing the risk of diarrheal and other water-borne diseases. A suite of water supply options often represents a wide range of social equity in terms of both benefits and costs. A great challenge for a community is to evaluate and choose optimal drinking water solutions that are sustainable across the life cycle and are characterized by reasonable costs, high rates of adoption, and social equity regarding populations served and contributing.

The objective of this research is to use a life-cycle cost approach (LCCA) to compare and select the optimal drinking water source and delivery system(s) for arsenic-impacted communities in Cambodia. Quantifiable inputs into the evaluation include capital cost expenditures, as well as recurrent expenditures such as capital maintenance, operation and maintenance, and the costs of securing capital.

We provide a comparison of three traditional and one emerging (novel) technology:

(1) Rainwater harvesting and storage – it is estimated that 6300 liters of storage are required for a Cambodian family of 5 to meet their water needs during the dry season.

(2) Purchase of water from a water vendor on an as-needed basis, water likely contaminated with fecal coliform.

(3) Village-level treatment and distribution of piped water – surface water is treated for biological contaminants at or near the source and piped to households in a village.

(4) Reduction of geogenic arsenic / fluoride from well water – imported or locally-produced media is used to mitigate geogenic contaminants via adsorption and/or ion exchange. Current research for both arsenic and fluoride removal are focused on developing media with high surface area, removal effectiveness, and longevity or ability to regenerate. Presently, costs for adsorption media can range from \$0.50/kg bone char to \$1.94–\$4.20/kg activated alumina and \$2.50/kg Bayoxide. Each of these media has different effectiveness levels, lifetimes, and maintenance needs.

Preliminary field data was collected and used to verify the findings of an earlier report on household preferences and practices, water supply options, and willingness-to-pay. This data was then used to compare water source options during the dry season, a time of greatest water stress, and to optimize water supply options for the bottom three income quintiles in the country. This also results in a “need-to-reach” cost level for optimal mitigation of geogenic contaminants using community-level adsorption technologies. In future work, the method will be applied to fluoride mitigation in the Rift Valley of Ethiopia.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Potters for Peace: Scaling Up as the Gatekeeper
<b>Primary Author Name *</b>	Peter Chartrand
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	

## **Abstract Body \***

The US based nonprofit Potters for Peace (PFP) is arguably the foremost promoter and its consultants the most experienced hands-on technical workers of the ceramic pot water filter. We have worked to start production at some 40 facilities in over 25 countries. In this position we sometimes act as the default "gatekeeper" for the technology and as such also have to sometimes answer for failings in the technology when quality falters with producers.

Because PFP does not operate or have any financial interest in the filter shops we have limited input after the training and set up work we are contracted to carry out with our partners.

PFP is approached every week by parties interested in starting a ceramic filter production facility. Through a process involving extensive email exchanges wherein we provide verbal coaching and documents illustrating what will be needed, then an onsite, pre-startup feasibility study, the inquiry can become reality

The majority of these inquiries however never go beyond the initial exchanges. Although some of these are clearly due to mistaken ideas about what is involved in quality filter production we at PFP have to wonder if there is any way we can scale up the technology at the start-up phase.

In the interests of strengthening our ability to have a voice in quality control issues we encourage all producers to stay in contact with us after starting production and thereby participate in any sharing of knowledge which becomes available. To further facilitate this part of our work we produced a Best Practices Manual in 2011. We also make use of the RDI Cambodia ceramic filter production manual, especially at the inquiry stage. Although there are minor differences between the PFP and RDI techniques the manual is very useful to give the uninitiated a realistic idea of how to do it.

In my presentation I will address the issues of scaling up at the start-up phase of a project as well as uses of our Best Practices document.

A poster presentation will illustrate the entire Potters for Peace production start-up process.



# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Ceramic Water Filters for Rural China: Research Results and Resulting Filter Pot Redesign
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<b>Primary Author Name *</b>	Derek E Chitwood
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**Abstract Body \***

About 1.1 billion people worldwide and 242 million people in China lack access to improved drinking water supplies and use unsafe surface and groundwater sources. However, even people who have access to "improved" water supplies such as household connections, public standpipes, and wells may not have microbiologically safe water. In rural China, improved supplies are often contaminated with pathogens causing infectious diseases such as giardiasis, cholera, enteric fever, and dysentery. Village studies conducted over the past 10 years in Southwest China show that over 95% of the approximately 300 village drinking water sources tested have E. coli concentration exceeding the Chinese national standards and are not biologically safe.

In an effort to help rural Chinese have access to biologically safe water in their homes, Rural Development Partners International (RDPI), based in Kunming, Yunnan, China has been manufacturing and distributing ceramic water filters, in particular to rural villages in China.

Through funding from the local district government's technology bureau, a series of tests were completed to help improve the quality and reduce the manufacturing cost of the filters. Testing parameters including application methods of silver, species of silver added, burnout material sieve size, amount of burnout material in the clay mixture, and filter wall thickness. Each of these parameters were varied and the resulting impact on the removal of E. coli was investigated. The affect of sieve size and amount of burnout material on filter strength was also investigated.

As a result of this research, a computational flow model developed for ceramic water filters, and customer requests, RDPI redesigned our filter pot to be narrower and deeper, changed the species of silver used as a chemical disinfectant, and method of silver addition. The results of this research and the new design of filter will be discussed in this presentation.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	An Approach Using Portable Rock Drills for Water Wells in Remote Areas on Mountains
<b>Primary Author Name *</b>	John Cherry
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## **Abstract Body \***

There are more than a billion people who live in mountains on bedrock or on plains on bedrock and many of these billion have inadequate water supplies. Most of these mountain people derive their drinking water from groundwater discharging from the bedrock at springs and seeps. Many of these water supplies are problematic because of bacterial contamination from human and animal wastes and/ or inadequate flow rates or the water is located far from the village or farm. The main option to solve these problems is the drilling of wells to tap the water in the fracture networks at depth in the rock where the contamination is absent or minimal. We are developing methods to create water wells in bedrock by means of three types of portable rock core drills used globally in the mineral exploration industry. These small gasoline or diesel engine drills are most suitable for drilling in terrain without roads so that portability is a key attribute of the drills. These portable drills range in size from one that drills two inch diameter holes and fits into a back pack and drills to 10–20 m depth and costs 6K US dollars to the largest that requires several people to transport and that fully equipped costs about 130 K US. This drill can penetrate to 300–400 m depth creating two inch holes or 40–80 m making a three inch hole. Methods have been developed so that the wells, made of standard PVC pipe, are properly sealed in the holes using natural clay and simple sealing and well installation methods. These methods for creating small-diameter bedrock wells using the portable drills have been refined and demonstrated at sites on sedimentary bedrock in mountain and plains terrain in Canada and the United States where the wells are used for monitoring of groundwater quality. Generally, the water is artesian or nearly so and therefore methods for pumping are not difficult. This program of testing the drills and demonstrating well designs and performance has evolved to the point where the next stage is to try them out for creating of small flow-rate water supply wells in developing countries, primarily in mountainous regions where other approaches for obtaining clean water supply are not feasible or effective.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Sustainability Happens?
<b>Primary Author Name *</b>	Christopher Cotner
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## **Abstract Body \***

Sustainability is a buzzword seemingly on the lips of every major and minor water organization. However, it is not a magic word and simply saying it does not mean that Sustainability Happens.

The Water4 Foundation is a 501(c)3 nonprofit organization based in Oklahoma City, Oklahoma. We are focused on bringing hand-drilling and hand-pump technology to rural communities in developing countries. As we bring the technology and training, our primary goal is to empower national-led drilling teams. These teams can run a well-drilling business while simultaneously working towards eradicating the water problems in their region with a benefit of helping to increase universal access.

As Water4 works towards empowering national-owned and led drilling teams, we have attempted to overcome the "sustainability" issue by (a) suggesting, but not requiring, that our partners pursue a "business based" model, and (b) creating tool and pump designs that can be made from universally available material, steel and PVC.

Through our partners we have experienced varying degrees of success over the last four years, but we have identified three primary roadblocks to meeting the goals of sustainability: (1) personnel; (2) creation and establishment of a supply chain; and (3) the affordability of the wells.

As a result of our experiences, we are pursuing a revised model with our partners that focuses on (1) training and raising up leaders who understand future thinking; (2) using resources to also focus on the macro by establishing locally based "operating centers" that will have the economic power to create and establish a supply chain for quality materials, and (3) working through our partners to pre-qualify communities by focusing on the long term, based around current perceived needs, on-going maintenance costs and potential future water system installation opportunities, rather than a narrow focus related to the up-front cost for drilling a well and installing a pump.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Collaborative learning for collaborative impact in the Millennium Water Alliance
<b>Primary Author Name *</b>	Susan Davis
<b>Primary Author Affiliation *</b>	Improve International
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Susan Dundon, Millennium Water Alliance

## Abstract Body \*

The global water crisis is too big for any one organization to solve alone, and we all recognize that business as usual isn't achieving the goal of safe water and sanitation services for all fast enough. Working in partnerships, when done purposefully, can promote inter-organizational learning and program improvement to more effectively achieve safe water and sanitation services for all.

Partnerships of various types have developed in recent years but there hasn't been much rigorous evaluation of the effectiveness of working in collaboration vs. working alone. In 2012, Improve International performed a Collective Impact evaluation of the Millennium Water Alliance (MWA) partnership, through the lens of its oldest and most complex program in Ethiopia. This evaluation surfaced some surprising benefits in terms of inter-organizational knowledge transfer which was applied for innovation and program improvements. This evaluation also helped MWA further develop the concept of its role in the sector and its theory of change. The authors will share the specific lessons learned, examples of how the knowledge was applied to programming or planning, and the methods used, with the purpose of helping the sector learn more efficiently and work more effectively.

Some examples of these knowledge transfer topics are:

- Solar Powered Pumps
- Community Management
- Mapping and Monitoring
- Water Source Protection
- Sanitation – CLTS & Flag System
- Ecological Sanitation
- Inclusive Design for Handicapped & Elderly
- Administrative & Regulatory Compliance Support

The Collective Impact report recommended that methods and outcomes of learning should be better planned and documented, and that MWA should purposefully share this powerful evidence – for example, at sector conferences or in publications – to advocate for the power of partnership. MWA has now included a formal Learning Agenda as part of its new Latin America Program.

Expected outcomes:

- attendees will understand practical methods for promoting and documenting knowledge transfer within and between organizations
- attendees will understand the potential value added and challenges of working in partnership

## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	"Construction of an Anaerobic Digester in Rural Uganda"
<b>Primary Author Name *</b>	Ethan Dewart, LEED Green Assoc., ENV PV
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Adam Brady, ENV PV, Instructor, Department of Geography and Environmental Engineering (USMA) Jeffrey Starke, PhD, PE, Assistant Professor, Department of Geography and Environmental Engineering (USMA)

### Abstract Body \*

Engineers use the available tools, resources, and capacity to develop and implement innovative solutions. In Uganda, cadets from the United States Military Academy at West Point (USMA) saw that manifested each day in the work of Vianney Tumwesige and his company Green Heat Ltd. Green Heat's mission is: "To create alternative sources of fuel through recycling of waste and impart the urge of environmental conservation to mankind." The company focuses on creating energy from waste through the use of biogas digesters. This presentation highlights the construction materials and techniques used to build two digesters in western Uganda.

The primary construction methods used were all manually powered. From the making of bricks, the mixing of cement, and the building of the digester dome, all tasks were completed by hand. This contrasts with much of the engineering work we do in the United States, where electronic measurements and gas- or electric-powered tools are ubiquitous.

The digesters are built in phases. The site was excavated and the cement foundation completed prior to the cadets arrival. Upon the completion of the initial phase, bricks are used to create the anaerobic digester dome. Using counterweights, keystones, and two identical saplings which rotated around a central bolt, a perfectly formed dome was created. Upon completion of the dome construction, the sealing/finishing phase began. Using a wet trowel and board, a specific mortar is used to create a gas tight seal, keeping oxygen out while keeping the methane created by the system in.

The design of the digester is innovative in that it has no moving parts or need for electricity. Gravity and the pressure created by the methane gas produced supply everything needed for the system to operate.

The process of building the dome began with the roughly four-foot-tall foundation. Bricks, made locally from clay and dried in forms and of slightly different sizes and weights, are laid on their edges horizontally. Each brick layer is completed, including the insertion of two "keystones", prior to the next layer being built. The common radius was kept throughout construction with two identical saplings which rotated around a central bolt in the ground. Eventually counterweights are employed on the exterior of the dome to ensure it did not collapse in.

The secondary dome, intake valve, outtake valve, and latrine were constructed from the same materials.

Innovation occurred, whether through the use of water seals to ensure the gas lines are air tight to wrapping the gas lines in water bottles to minimizing the lines being cut.

Vianney and his team effectively made use of their resources to produce a product that immediately bettered the quality of life for Ugandans in the surrounding area. This is the focus of engineers and can be a model for any project in the future.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The Social Marketing of Household Toilets among the Bai, Yunnan Province, China
<b>Primary Author Name *</b>	Mary Dickey
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## Abstract Body \*

The effectiveness of a social marketing campaign to increase the number and use of household toilets among the Bai in Eryuan County, Yunnan Province, China is being studied in a three-year research project (January, 2011–December, 2013). The villages studied were found at baseline to have about 25% sanitation coverage. Sanitation coverage refers to the percentage of homes with sanitation facilities which adequately separate human excreta from human contact. Any sanitation facility that allowed easy and immediate access to raw feces such as a bucket placed in concrete or a toilet that emptied into an open pit was not accepted as providing sanitation coverage. This study first sought to understand how the Bai perceive the costs and benefits of household toilets. A door-to-door survey, participatory rural assessments, focus groups, and interviews were used in four villages to gather the formative research data needed in the development of a social marketing campaign to promote household toilets among the Bai. The social marketing campaign was offered to two villages while the other two served as a control group.

After analysis of the formative research data, a three-chamber septic system design with the addition of an inexpensive additive was selected for promotion. The system has three anaerobic chambers which are connected by PVC pipe. Anaerobic conditions, the proper placement of PVC pipe as well as time in each chamber ensure that waste passing from one chamber to the next will result in waste in the last chamber being safe for use as fertilizer. The toilet additive is first introduced into the system after six months of usage and yearly thereafter. The toilet additive uses harmless bacteria to kill dangerous bacteria and parasites increasing the safety of the three-chamber toilet system. The additive also reduces smell and liquefies waste increasing the efficiency of the system by preventing clogging in the PVC pipes.

Local builders in the villages help design and build each household toilet according to household preference. A local building supervisor (resident of one of the intervention villages) was selected to work with local builders to ensure that each design follows criteria necessary to ensure safety of the three chamber system. Researchers also inspect all toilets built.

Four demonstration toilets were built in March, 2012 in the two intervention villages. A kick-off "fair" was held in June, 2012 with about 600 residents attending. During this first promotion event, over 100 of the 357 households in the intervention villages without a toilet signed up to build three-chamber toilets. Building could not begin again until October 2012 due to the rainy season. To date (mid-March 2013) about 50 household toilets have been built. Promotion efforts are ongoing.

prices would become prohibitive in terms of access to sanitation for the poorest. When unregulated, sanitation services may be affordable but the quality of service would decrease to an unacceptable level. A better understanding of this paradox can help in developing pricing and tariffs systems for improved access to affordable and sustainable services for the urban poor while generating profits for business operators. In many economic and sectorial environments, there is a need for financial sustainability, allocative efficiency, productive efficiency, price sensitivity and equity;

- ☐ Financial sustainability: revenues are adequate to cover costs to ensure the continued financial viability of an efficient service provider.

- ☐ Allocative efficiency: customer prices are kept as close as possible to the cost incurred in serving the customers.

- ☐ Productive efficiency: goods and services are produced as cheaply as possible at required standards.

- ☐ Price sensitivity: operators and consumers have the incentive to expand supply/demand, if demanded/supplied.

- ☐ Equity: fair and impartial allocation of services at standardized rates.

Creating a sanitation model which deals with these principles and components within a unified framework ensures consistency among the different variables involved in the process. Such a model, when developed allows the quantification of impact that the various changes in variables have on the different actors (entrepreneurs, consumers/users, and the government) in the process.

WSA working with economic and financial experts are working on testing an Economic and Financial model for sanitation service delivery in an urban setting.

The conceptual frame of the model is based on four major components: supply, demand, institutional/regulatory context, and environmental sustainability. The frame revolves around the Demand and Supply (DS) components operating within effective and efficient Financial, Economic, Environmental and Social/institutional (FEES) environment. An agglomeration of these acronyms provides a brand name for the conceptual model known as DS-FEES model.

This paper examines the challenges with achieving sanitation service delivery at scale in an urban environment and suggests a conceptual framework for an Economic and Financial model for pricing and setting sanitation tariffs for affordable services.

## 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Water Tower in Belize by Arkansas Engineers Abroad
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<b>Primary Author Name *</b>	Jenny Doyle
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### **Abstract Body \***

Arkansas Engineers Abroad (AEA) is a group of engineering students at the University of Arkansas dedicated to international humanitarian projects which employ their developing knowledge in engineering. We would like to present our Water Tower Project in More Tomorrow, Belize and our success as a student organization at the 2013 OU International WaTER Conference. As a group, we have been active in our local community by participating in stream clean ups and designing a water collection and irrigation system for a small urban community farm. Also, AEA has been invited to the Clinton Global Initiative University conference in April 2013 because of our project that will ensure public health in the village of More Tomorrow, Belize by 2015. Clean water is an issue in More Tomorrow, where AEA found the three wells of the village contaminated with E. coli, fecal coliform, and Staphylococcus during its trip on December 18–24, 2011 which sent 13 students from six different departments. With the lack of education and safe water in the village, villagers are not only sick, but not getting better. Luckily, the village has a local ministry led by Randy Gaither, an AEA partner, and the Belizean government has funded a small public school for the village. The water tower will be constructed in a lot within a half mile of these safe havens. AEA will travel to Belize on three occasions before 2015 to lay a foundation, to dig a new well, to educate the villagers of More Tomorrow, and to survey symptoms. In May of 2013, with the funds already raised, AEA will travel to Belize, to lay the foundation of the water tower, dig the well, and survey the symptoms of the villagers. After symptoms of diarrhea, stomachache, fever, vomiting, and skin infections have been surveyed, AEA will return to Arkansas while Randy Gaither and many villagers within More Tomorrow construct the water tower on our behalf. By the end of 2013, AEA will return to monitor the water tower, making sure it is functional and clean. Chlorine tablets will be provided to take care of any potential pathogens in the water. AEA will then conduct lessons to the villagers on water sanitation and general health precautions, such as hand washing. Finally, in 2014, AEA will return to More Tomorrow to conduct the survey again and make sure that the symptoms of E. coli and Staphylococcus infections have diminished.



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	What factors affect sustained adoption of clean water and sanitation technologies? A systematic review
<b>Primary Author Name *</b>	Robert Dreibelbis
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## **Abstract Body \***

The provision or promotion of low-cost technologies at the individual, household, or community level – coupled with interpersonal or mass communication – is a key strategy for improving coverage of safe drinking water and adequate sanitation in low- and middle-income countries. Examples include point-of-use water treatment technologies, improved household latrines, well pumps, rainwater harvesting infrastructure, and handwashing stations. These technologies require an initial adoption by the target population coupled with necessary changes in personal behaviors, and adoption and behavior change must be sustained over time in order to achieve potential health and development gains.

This presentation will discuss the result of an on-going systematic review of literature on the factors that influence initial adoption and sustained behavior change associated with water, sanitation, and hygiene technologies.

The forthcoming Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) will be used to guide a framework-analysis approach to the review and synthesis of existing literature. Articles included in the review will be coded to reflect a range of behavioral determinants that influence the sustained adoption of specific WASH technologies.

The review will proceed in two phases. In the first, a systematic mapping of existing published and grey literature on WASH technology adoption will provide a snapshot of the current approaches, definitions, and understandings of sustained behavior change. Results from this mapping will be used to identify literature for detailed synthesis. In the detailed synthesis stage, specific analyses will assess the role of each of the three main dimensions of the IBM-WASH framework: contextual factors associated with sustained behavior change, psychosocial factors associated with sustained behavior changes, and technological factors associated with sustained behavior change. A second analysis will compare difference in behavioral determinants that foster sustained adoption for individual- or household-level technologies and community-based technologies, and between domestic versus institution-based interventions.

Expected results of this on-going systematic review (final results in August, 2013) include: describing current research gaps and opportunities related to the sustained adoption of WASH technologies, assess the extent to which current implementation and promotional strategies have resulted in successful sustained behavior change, and the identification of programmatic and policy factors that encourage the sustained adoption of WASH technologies.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Feasibility and sustainability of advanced membrane filtration devices for improved water quality in health centers in Rwanda.
<b>Primary Author Name *</b>	Robert Dreibelbis
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Alexandra Huttinger, Emory University; Leodomir Mfura, Access Project – Rwanda; Shadi Saboori, Emory University, Christine Moe, Emory University

## **Abstract Body \***

Improvements in water quality at community health centers have the potential to reduce disease by reducing exposures within the institutional setting, serving as a barrier to the public transmission of pathogens, and fostering improved practices or access in associated communities. Advanced filtration systems, such as membrane filtration technologies, are increasingly targeted at low- and middle- income countries, yet few studies have assessed their long-term feasibility in resource poor settings. Emory University and the General Electric Foundation, in partnership with the Rwandan Ministry of Health, are assessing the programmatic, organizational, and contextual factors that influence the feasibility and sustainability of membrane filtration systems in health centers in Rwanda.

Pilot membrane filtration systems were installed in 10 selected community health centers in Rwanda during 2012. Project staff complete monthly observations of facility conditions and conduct weekly-unannounced visits to assess on-going maintenance and daily operation and use of the filtration system. Water filtration systems have been successfully adopted and maintained in 8 of the 10 participating health centers – pumps are backwashed on daily basis and chlorine residual logged on a weekly basis. Water availability in participating health centers has increased significantly.

Thus far, the greatest determinant of membrane filtration feasibility has been access to water at sufficient pressures to allow the technology to function. Of the 25 health facilities included in an initial rapid assessment, only 17 had sufficient water quantity and pressure to make membrane filtration systems viable. In eight participating facilities, installation required extensive modifications to existing water distribution systems (additional piping or pumps for rainwater tanks, etc.). Seasonal variations in rainwater have also resulted in periods where health centers needed to supplement water with untreated sources. Another contextual factor that has influenced adoption is a recent increase in tariffs for both piped water and electricity, resulting in large perceived increases in the operating costs of membrane filtration systems.

Organizational determinants of feasibility and adoption include the technical capacity of local staff to monitor rainwater storage systems and traditional “lock-and-key” approaches to facility management, where access to treated water is highly regulated and rarely available to patients.

At the programmatic-level, integrating health center leadership into training, planning, and construction resulted in more frequent maintenance and improved performance. Including a basic set of tools for repairing and maintaining infrastructure was necessary, as facilities management staff at rural health centers often lack this rudimentary equipment.

Membrane filtration systems present a viable solution for improving water quality in some health centers, however, their application is limited to those areas with sufficient water quantity and distribution systems. Engaging local staff in planning and training is critical to the success of interventions, and interventions must address on-site limitations in terms of equipment and capacity in order to ensure maintenance. Systems also represent a significant cost to

health centers, though this cost may be offset by selling excess water to local communities.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Synthesis of low cost aluminum-based sorbents: Effects of solution composition and temperature on fluoride removal performance
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Elizabeth C. Butler, School of CEES, The University of Oklahoma; David A. Sabatini, School of CEES, The University of Oklahoma

## **Abstract Body \***

Fluoride in drinking water can cause severe health problems at levels above the World Health Organization drinking water standard of 1.5 mg/L. Therefore it is imperative to find efficient water treatment technologies for fluoride removal. Among potential technologies for fluoride removal, adsorption is efficient, economical, and suitable for household use. While activated alumina is a widely used defluoridation adsorbent, its high manufacturing cost limits its application in less developed regions. Therefore, the objective of this study was to develop low cost synthesis methods for Al-based adsorbents that can be prepared with low cost materials, and using technologies--such as kilns--that are available even in rural areas of developing regions.

Aluminum (hydr)oxides were prepared by adding ligands (sulfate and citrate) and varying temperature (25 °C and 200 °C) in order to influence the degree of crystallinity. Based on initial adsorption results, selected aluminum (hydr)oxides were coated with metals (magnesium, manganese, or iron), based on the hypothesis that these amendments might affect surface charge and therefore adsorption efficiency. Mg-Al layered double hydroxides were also synthesized for comparison to the aluminum hydr(oxides). Then, the fluoride adsorption capacity of the different sorbents was tested for a range of initial fluoride concentrations.

For the aluminum (hydr)oxides, metal coating did not improve the fluoride adsorption capacity, and increased synthesis temperature had a negative impact on fluoride adsorption capacity. X-ray diffraction analysis and scanning electron microscopy showed that the samples aged at 25 °C had lower crystallinity and a smoother surface than those aged at 200 °C. The addition of excess sulfate during aluminum (hydr)oxide precipitation led to the highest fluoride adsorption capacity of  $40.0 \pm 2.4$  mg/g. Aluminum (hydr)oxides prepared with sulfate were the most amorphous compared to those prepared with citrate and with no excess ligands. Accelerated nucleation, more compact aggregation of small colloidal particles, and the formation of basaluminite on the surface might account for the good performance of the aluminum (hydr)oxide prepared with excess sulfate.

The fluoride adsorption capacity of Al (hydr)oxides and the best performing Al-Mg layered double hydroxide were compared. While the Langmuir model predicted a higher adsorption capacity for the Mg-Al layered double hydroxide at equilibrium dissolved fluoride concentrations much higher than those tested in this study (and thus higher than of interest in ground water in developing countries), the Al hydr(oxides) performed better at dissolved equilibrium fluoride concentrations in the range of the WHO standard of 1.5 mg/L. Together, these results indicate that effective sorbents for fluoride removal can be synthesized using low cost materials and technologies that are available in developing regions.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Lessons Learned in the Development of U.S. Environmental Laws
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<b>Primary Author Name *</b>	Findlay G. Edwards, PhD, PE, BCEE
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**Abstract Body \***

Environmental laws in the United States have evolved to be some of the most stringent in the world. But, the road to development of these laws has been long and complicated. With increases in population and industry, public awareness of environmental degradation and the subsequent impact on the quality of life in the U.S. also increased. The first U.S. environmental laws were written in the late 1800's during the Progressive Era. Seminal events have caused increases in public awareness and involvement, which has driven legislation of each addition to the environmental laws in the U.S. The same process can be observed currently in the developing countries around the World. The citizens of these developing countries can learn from the road that the United States has travelled to expedite the development and enforcement of environmental laws in their countries.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Entrepreneurial Tools for the Developing World
<b>Primary Author Name *</b>	Tim Elliott
<b>Primary Author Affiliation *</b>	PATH
<b>Primary Author Email *</b>	<a href="mailto:timothy@path.org">timothy@path.org</a>
<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Part of our presentation will include a discussion of our collaboration on Sanitation Financing in Cambodia with Tamara Baker of iDE.

## **Abstract Body \***

Diarrheal disease is the most common cause of illness and the second leading cause of death in children under five in the world . For the past six years PATH has been addressing a primary cause of this critical health issue by developing market-based approaches for improving access to effective water and sanitation products and services for low-income households. A core component of this program has been to support social entrepreneurs in low-resource settings by developing commercial tools and approaches that support the viability, scalability and sustainability of these businesses, while simultaneously having a positive health impact on local populations.

PATH proposes an Oral Presentation highlighting the best practices and successful application of the approaches and tools offered to our entrepreneurial partners.

- Cambodia: PATH's assistance in the recruitment, training and management of a sales team helped a manufacturer of water filters quadruple the sales per salesperson (40 filters/month to 160), while doubling closing rates (23% to 49%).

- Kenya: PATH's partner used our financial analysis tools to optimize product sourcing and pricing to create a sustainable model for filter distribution.

- India and Cambodia: PATH helped local MFIs develop consumer water filter financing programs, under which nearly 100,000 loans have currently been made.

- Cambodia: PATH extended the success in water filter distribution and financing into sanitation – working with International Development Enterprises (iDE) and Cambodian MFIs to develop a latrine financing program that has made thousands of loans in the pilot stage and is now being scaled up to new provinces throughout Cambodia.

Results are presented from pilots in four countries and represent data captured through third-party qualitative and quantitative household surveys and commercial data reported by our partners.

We will also share approaches and tools for applying commercial skills to address water and sanitation issues. These tools have been posted online in PATH's Commercialization Toolkit at <http://sites.path.org/commercializationtoolkit/>.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Sooners Without Borders: Capacity Building for Flood Prediction in Africa
<b>Primary Author Name *</b>	Zachary Flamig
<b>Primary Author Affiliation *</b>	OU/ARRC & NOAA/NSSL
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## Abstract Body \*

The OU Hydrometeorology and Remote Sensing Laboratory supports the NASA and US AID SERVIR joint venture to build capacity in flood prediction and monitoring over the East Africa region. The OU and NASA developed Coupled Routing and Excess Storage (CREST) hydrologic model has been deployed in an operational capacity over the Lake Victoria region with support from the Regional Center for Mapping of Resources for Development (RCMRD) and Kenyan Meteorological Department (KMD). The operational system integrates quantitative precipitation forecasts from KMD to provide flood prediction over the Lake Victoria region. A web portal is available for visualization, and verification purposes for all users in East Africa. In addition, Intensive, week-long training courses on the CREST hydrologic model have also been provided to RCMRD and the Rwandan Integrated Water Resources Department. These courses teach end users how to setup, run and visualize outputs from the hydrologic model as well interpret the outputs in terms of impact magnitude. Understanding of the hydrologic model strengthens the hydrometeorological abilities of the end users and gives them further faith in predictions made by the operational system. Future courses and follow up training is planned to further the capacity building efforts across the entire region.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Sustainable Development Extension Model Empower communities to achieve sustainable self sufficiency.
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<b>Primary Author Name *</b>	Stephen Forbes
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<b>Primary Author Affiliation *</b>	SuDeX
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## **Abstract Body \***

The basic essential needs are access to health care, water and sanitation, food and shelter, to which is added the basic need of opportunity to build capacity—access to information, education and training, financial resources, jobs and business prospects, as well good governance and ability to retain earnings. Technology is necessary to provide basic essential needs—otherwise people die, but without opportunity the needs cannot be self sustained.

The Sustainable Development Extension Model (SuDeX) extends reliable credible information, formal education, vocational training, and technical assistance to ensure that all impoverished countries around the world are empowered to be their own agents of progress so that they can self determine and proactively seek the ways and means to meet primary basic needs and gain access to opportunities to sustain themselves, family and community. This is a bottom up approach. The intent is not to thwart the top down approach, but to ensure the communities gain access to it and use the benefits to their own best interest.

The SuDeX is a collaborative alliance with the community which prepares a strategic plan that defines problems, assesses the causes, identifies solutions, studies obstacles and how to resolve them, and sets priorities. Ultimate intended outcome: Community becomes self sufficient with the reliable capacity to meet its own basic needs and providing opportunity to ensure the capacity is sustained, and then sharing the knowledge gained with neighboring communities, becoming mentors and extension agents themselves.

The premise of SuDeX is to empower communities with the capacity to identify and assess appropriate solutions and self-determine and proactively seek ways and means to escape poverty and achieve sustainable self-sufficiency. SuDeX provides information and guidance; the communities become their own agents of progress. The obstacles are many and diverse; progress is slow but measurable as we learn collectively and confidence grows, scaling up by passing on the lessons learned.



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	EMPOWERING LOCAL VILLAGERS FROM WEST BENGAL TO UNDERSTAND THE EXTENT OF ARSENIC CONTAMINATION AND LOCATE ALTERNATIVE SOLUTIONS
<b>Primary Author Name *</b>	Sophia Ford
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## Abstract Body \*

Arsenic (As) contamination in drinking water poses a threat to more than 75 million people in the Bengal Delta. In an area of illiteracy, poverty and neglect, this mass contamination of drinking water makes up one of the worst environmental mass-poisoning in human history. In January 2012, water from tube wells, irrigation wells, ponds and shallow aquifer sediment samples were collected from four villages in Murshidabad, West Bengal, India. The aim of the study was to examine the relationship between sediment and water chemistry to understand the extent of As contamination in the groundwater in these four villages. Our objectives were to identify future drilling sites of low As, and educate local villagers about arsenic contamination. High As is associated with gray, reduced sediments, whereas low As is associated with orange-brown, oxidized sands. Color identification and grain size is a simple test to teach locals how to identify high or low As bearing sediments. The platform of the tube wells is stained red where high As groundwater is present. Data was collected on household size, source of drinking water, number of tubewells, age and depth of tube well, proximity of tubewells to ponds and sewage outputs from households from on-site interviews as well as India census records. Using onsite test kits, we identified areas of high As, warned owners in their villages of the As concentration and recommended alternative locations for safer drinking water. We trained drillers to detect As and test water quality parameters in order to identify As in newly-drilled wells. Through Census data collected and on-site observation, it is observed that the majority of villagers are without waste-water infrastructure. Waste-water carries pathogenic bacteria and viruses, which contribute to increasing levels of As by mobilizing As and other oxyanions in the subsurface. Along with scientific research in the area, we are empowering adults and children in the villages to become knowledgeable about arsenic contamination and the steps they can take to avoid the situation on their own.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	A multi-component toolkit for effective integration of relevant NTD control activities into current WASH programs
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<b>Primary Author Name *</b>	Matthew C Freeman
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<b>Primary Author Affiliation *</b>	Emory University
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Stephanie Ogden, Taskforce for Global Health
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## **Abstract Body \***

Together, the diseases known as the "neglected tropical diseases" (NTDs) undermine the health and nutritional status of more than 800 million people worldwide. While current control and elimination strategies for NTDs, such as trachoma and soil transmitted helminths (STH), rely heavily on Mass Drug Administration (MDA) for the treatment of current infections, there is an awareness that in highly endemic areas, successfully addressing these diseases is not possible without improvement to the WASH related environmental factors that contribute to transmission.

Because of the high cost of implementing WASH infrastructure, NTD control programs are largely unable to affect WASH access and drive environmental change at a large scale. The most effective routes to creating the large scale environmental change upon which the reduction of NTD transmission depends include: 1) utilizing WASH sector expertise, further enabling WASH organizations to conduct targeted interventions in NTD endemic areas, and 2) integrating compatible NTD control activities into ongoing WASH sector work.

The project's main activity is the development of a toolkit to facilitate the integration of NTD control activities into existing WASH programming at a national and international level. The toolkit includea the following components: 1) printed manuals for the integration of NTD control activities into ongoing WASH programming, 2) customizable online manuals and modules based on the known endemicity of NTDs in the geographic area of WASH intervention, 3) an online certificate course in "Integrating WASH and NTD Control," administered by Emory University, and 4) a website that houses online materials and links to related resources.

The direct beneficiaries of this proposed project are WASH sector practitioners and organizations who will benefit from the availability of increased information, as well as joint monitoring and advocacy tools. Online materials and the online course are intended to be openly and permanently accessible, though targeted to staff of WASH organizations, multi-lateral development organizations implementing WASH activities, and government officials in countries affected by NTDs. An online, self-administered short course will be made permanently available after the completion of a facilitated pilot course.

The purpose of this talk will be to introduce practitioners to the manual and explain the utility of integration of NTD control into WASH programs. This project is a collaboration between the International Trachoma Initiative (ITI), Children Without Worms (CWW), and the Emory Center for Global Safe Water (CGSW).

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	ONSITE WASTEWATER NATURAL TREATMENT AND EFFLUENT REUSE SYSTEM AT THE OMNILIFE SOCCER STADIUM IN GUADALAJARA, MEXICO
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Michael Ogden/Biohabitats; Pete Munoz/Biohabitats; and Erin English/Biohabitats.

## Abstract Body \*

An onsite wastewater natural system was designed and built to treat high strength wastewater generated at the new Omnilife soccer stadium at Guadalajara, Mexico. The elevated expected concentrations of ammonia (NH<sub>3</sub>) in the wastewater put at risk the health of the surrounding ecology where this effluent might be discharged. The wastewater treatment facility in the stadium has been designed to reduce biochemical oxygen demand (BOD), total suspended solids (TSS), total nitrogen (TN) to concentrations below 10 mg/L to meet international standards for toilet flushing and irrigation. Fecal coliform was another important parameter reduced to meet effluent quality for reuse. The stadium has over 46,000 seats, restaurants, museums, offices, and other facilities that employ 4,000 people. The stadium was built from May 2007 to July 2010 with sustainable features and technology. 575 m<sup>3</sup> of wastewater are generated from the stadium after a game or event with full occupancy. The high strength wastewater concentrations generated at the stadium were estimated to be 250 mg/L NH<sub>3</sub>, 160 mg/L BOD and 90 mg/L TSS. The treatment system units include primary treatment and equalization system, bio-filters, trickling filters, constructed wetlands, recirculating sand filters, mechanical filtration, and UV disinfection. The designed public domain technology met the following engineering design criteria: reliable and easy to construct, operate and maintain. After disinfection, a water quality test determined that the effluent exceeded tertiary treatment water quality and reuse standards as defined by the United States Environmental Protection Agency (USEPA), with concentrations <10 mg/L BOD, <10 mg/L SST, <10 mg/L TN, and <4 counts/100 mL fecal coliforms. The effluent is reused at the stadium for toilet flushing, irrigation and washing down. This presentation describes design and performance data for each treatment unit used to reclaim wastewater at the Omnilife soccer stadium as well as advantages and disadvantages compared with other technologies. It also discusses the challenges found in the last 2.5 years of operation and maintenance of this onsite natural wastewater treatment system.

composition, and  $\text{pH} > \sim 8$  lead to adsorption-desorption relationships with Fe-oxides and consequently groundwater contamination by oxyanion-forming elements. These geochemical conditions characterize groundwater along the Eastern African Rift and thus constitute a potential threat to the quality of groundwater in larger areas of Eastern Africa.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Hand Pump Attachable Iron Removal Plant for Field Implication in Rural Areas
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Subhash P. Andey

## Abstract Body \*

More than half of the world's population depends on Groundwater as a source of drinking water for survival. Geogenic contaminants such as Arsenic, Fluoride and Iron are emerging as an endemic public health issues in many nations around globe. As per Ministry of Drinking Water and Sanitation (MDWS), Government of India more than 50,000 rural habitations in more than 25 states in India are affected due to excess Iron in groundwater. Iron is not considered to be hazardous to the health; however excess concentration may cause digestive disorders, skin diseases and dental problems. Moreover, people switch over to unsafe water sources due to colour and taste imparted by iron. When the level of iron in water exceeds the 0.3 mg/l limit; red, brown, or yellow staining of laundry, glassware, dishes, and household fixtures such as bathtubs and sinks. The water may also have a metallic taste and an offensive odour. Water system piping and fixtures also become restricted or clogged.

The removal of iron from water is sought by various methods. If it is present in soluble form, it can only occur as protoxide, in combination with a soluble acid. As soon as an opportunity offers to transform the protoxide, by encouraging the absorption of oxygen into an insoluble oxide, it becomes possible, by effecting the removal of the latter, to accomplish the purpose. In the purification of water containing iron, some chemical process is necessary.

The hand-pump attachable iron removal plant developed by NEERI, Nagpur is a low-cost, natural system with the principle of KISS (Keep It Sweet, Simple). NEERI has developed a simple technology and installed several such plants in Madhya Pradesh and Maharashtra states of India. Oxidation followed by sedimentation and filtration is a basis for designing of hand pump attachable Iron Removal Plant. Sedimentation is a physical water treatment process used to settle out suspended solids in water under the influence of gravity. Based on this process CSIR-NEERI has designed hand pump attachable Iron Removal Plant with 1 m<sup>3</sup> per hour hydraulic loading. All the treatment processes like aeration, sedimentation and filtration are incorporated in a single unit which is attached to an existing Hand-pump. The system treats the water with Iron content in the range of 1 – 30 mg//L. The treated water is with iron content less than the drinking water standard (BIS: 10500: 2012) of 0.3 mg/L.

The plant is suitable for 250 persons with 40 lpcd and 10 hours of operation. The plant is either constructed of Reinforced Concrete (RCC) or pre-fabricated using Fibre-glass Reinforced Plastic (FRP) as per required situations. The major cost is involved in construction of the system which works out to be USD 1000 for RCC structure and USD 1800 for FRP structure.

Advantages of the System include:

- Simple technology and can be constructed in rural area
- Low-cost natural treatment system without addition of any chemical
- High efficiency
- No need of skilled operator, electric power and mechanical parts
- Easy to operate, negligible operational and very low maintenance cost.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Removing coliforms and E. coli in contaminated drinking water using biosand filtration
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<b>Primary Author Name *</b>	Michelle Henry
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<b>Primary Author Affiliation *</b>	Harding University
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Dr. Ed Wilson, Harding University Professor; Dr. Steve Moore, Harding University Professor
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**Abstract Body \***

Biosand filters are cost effective and are designed to provide clean drinking water for small families. They can be made with local materials: sand and gravel in a concrete container that work like an aquifer to remove bacteria, parasites and some viruses. This research consisted of building the filters, making modifications to the layers, and testing the water for various contaminants. The research questions were: Do biosand filters effectively remove harmful coliforms and E. coli? How do biosand filters effect pH and turbidity of creek water? Does adding additional layers of charcoal and iron oxide improve effectiveness?

The main contaminants tested were E. coli and coliform because they are indicator organisms. When ingested, they will likely cause dehydration induced by diarrhea, the second leading cause of death worldwide in children under age 5. The filters removed an average of 97.06% of coliforms and 97.68% of E. coli. The turbidity improved and the flow rate averaged 150.2 mL per minute. The filter that removed the bacteria the best and had the fastest flow rate was the original design. The results of this research could be used to improve water quality and health status of people living in developing countries.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Water, Society, and Health Research Experience for Undergraduates
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<b>Primary Author Name *</b>	Courtney Hill
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<b>Primary Author Affiliation *</b>	University of Arkansas
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	James Smith, University of Virginia
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**Abstract Body \***

The Water and Health in Limpopo (WHIL) Program and the Center for Global Health at the University of Virginia and PureMadi is conducting an NSF-funded Research Experiences for Undergraduates (REU) summer 2013.

Students who participate in this program will conduct research over an 8-week period at the University of Venda and surrounding communities in Limpopo Province, South Africa. A small number of students may also conduct research at the University of Virginia over this same period. Students will learn to work at the interface between water, societal, and human health disciplines, participate in research in a developing-world region on the African continent, and experience community-based research opportunities on appropriate environmental technologies and systems for water supply and treatment to improve human health. Students will also benefit from a strong, 5-year-old partnership between the University of Virginia, the University of Venda, and the rural African communities of Ha-Mashamba, Tshibvumo, and Tshapasha.

WaSH Scholars have begun their programs in March, 2013 through weekly participation in video conference calls with program faculty. These weekly virtual meetings will engage them into ongoing research, introduce them to WHIL faculty, graduate students, and companion WaSH Scholars, and prepare them for their summer research experience in S. Africa. Research topics include water quality related to malnutrition and enteric disease, point-of-use water treatment, agent-based modeling and nano-disinfection of Cryptosporidia.

# 2013 OU WaTER Conference Abstract Submittal Form

## Abstract Title \*

Designing a handwashing station for low-income communities in Bangladesh using the Integrated Behavioural Model for Water, Sanitation and Hygiene Interventions (IBM-WASH)

## Primary Author Name \*

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## Abstract Body \*

### BACKGROUND

In Bangladesh diarrheal disease and respiratory infections contribute significantly to morbidity and mortality. Handwashing with soap reduces the risk of infection; however, handwashing rates remain low. Evidence suggests that having a dedicated location for handwashing where both soap and water are present improves handwashing behaviors and reduces disease risk. We tested seven handwashing station designs in rural and urban Bangladesh to inform the development of a locally acceptable handwashing station.

### METHODS

Formative research approaches – including extended household trials, in-depth interviews, and focus group discussions – were used to identify handwashing stations that facilitate frequent handwashing in settings without frequent access to running water in the household. We used the Integrated Behavioural Model for Water, Sanitation and Hygiene (IBM-WASH) to guide qualitative data analysis. The IBM-WASH framework suggests that a range of factors influence sustained behaviour change and technology adoption: contextual factors, psychosocial factors, and technological factors.

### RESULTS

In testing handwashing stations in both urban and rural households, we found several behavioral factors that were shared across different handwashing station designs. These included factors such as ease of use and convenience of location for frequent access. Some factors were technology specific and determined whether a handwashing station was acceptable and feasible in urban or rural sites. Influential contextual factors – such as geography and sociodemographics – included household size, which determined the necessary capacity of the water reservoir and living conditions, which influenced the location of the handwashing station for frequent use and safe keeping. Households with younger children also preferred reservoirs that were easier to use by children. Technologies too reminiscent of anal cleansing water containers were rejected by most participants due to feelings of disgust and were



rejected for uses other than after defecation. Technological factors that influenced adoption include water storage capacity, quality of materials, and visual appeal of handwashing station. Based on our analysis, we selected a handwashing system with a large bucket and tap with a stand, basin and a soapy water bottle made with inexpensive detergent powder for pilot testing as part of two randomized controlled trials.

#### CONCLUSIONS

Handwashing stations may facilitate improved handwashing practices, yet there is little guidance on their design and acceptability in households. Our theory-driven analysis helped identify technologies that were acceptable to local populations. Results demonstrate how even low-cost WASH technologies can benefit from rigorous assessment and evaluation.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Arsenic removal by Electrocoagulation–A socially sustainable water treatment technology.
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## Abstract Body \*

Worldwide the sources of fresh and safe drinking water are decreasing. Groundwater traditionally was considered as a major and safe source of water in developing countries. However, due to subsurface characteristics and anthropogenic activities the groundwater is contaminated. The concentration of natural contaminants like arsenic, fluoride and nitrate is above the permissible limit as stated by WHO standards which poses a potential risk. Arsenic is a carcinogen with a maximum permissible concentration of  $10\mu\text{g l}^{-1}$ . This Study Evaluates use of electrocoagulation for removal of arsenic from drinking water. Electrocoagulation is an electrolytic method of treating water whereby sacrificial anodes corrode to release active coagulant precursors (usually aluminium or iron cations) into solution. Batch experiments were carried out using monopolar iron electrode at ambient temperatures ranging from  $26^{\circ}\text{C}$ – $28^{\circ}\text{C}$  to check the efficiency of arsenic removal. The experiments were carried out at different operating conditions such as pH (3–9), Current density ( $0.5$ – $1.25\text{mA cm}^{-2}$ ), initial concentration ( $75$ – $500\mu\text{g l}^{-1}$ ) and operating time (0–20 min) to assess the arsenic removal efficiency. The higher removal efficiencies were obtained at pH 6.5 with current density of  $0.5\text{mA cm}^{-2}$ . Arsenic removal at pH 3 and 9 was slower; the results show that the operating parameter is pH as the process is efficient in the range 6–8. The best operating conditions determined are reaction time of 20 min. and pH 6.5 with 99.9% removal efficiency. Electrocoagulation is found to be the robust technology as it lowers down the arsenic concentration below  $10\mu\text{g l}^{-1}$ . It is an effective community based chemical mitigation technique when combined with solar power as an electricity generation source.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The A3U strategy, for ensuring that communities have access to safe water for consumption
<b>Primary Author Name *</b>	Dr. Ravi I. Jayakaran
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	MAP International

## Abstract Body \*

In today's world there is no shortage of technology for purifying water to make it safe for drinking. However, at the marginalized user end interface level, technology fails to have impact because of the low energy utilization in the area that makes it inappropriate for the area. As a Relief & Development agency MAP International ([www.map.org](http://www.map.org)) therefore has to continuously be in search of new, low cost appropriate technology that can easily be transferred and adopted at the village in poor areas. This technology has to be cheap, require minimum technological capacities for maintenance, be easily adoptable by the poor and marginalized and be able to show dramatic results. MAP International thus explored various options according to local contexts till it zeroed in on the 'point-one-micron' filter which met all these criteria, and introduced them in the village development programs. MAP International's strategy for safe water is similar to the food security assessment strategy, that is called the "A3U strategy" or the AAU strategy. The AAU, stands for the following:

- ☐ Availability of water (natural water points and sources/wells -open and bore/ etc.)
- ☐ Access to safe water (through filtration: BSF/Point-one-micron filters/etcetera) to ensure it is potable)
- ☐ Asset creation through surplus water (where safe water can be used to generate income like a business)
- ☐ Utilization of water (& safe water practices and behavior around it, including CLTS (Community Lead Total Sanitation)and ZOD(Zero Open Defecation)

When MAP chooses an area for the THV (Total Health Village) it starts exploring to see if water is available in the area that is free from contamination. Most communities already live around a water source such as a river, or pond or lake. These sources are often contaminated (with bacteria, protozoa, soil transmitted helminthes etcetera) and result in gastro intestinal problems. However, as long as there is no poisonous material causing contamination, this water can easily be filtered using the point one micron filter. In some cases, especially resettled communities, there is no easy availability of water and villagers have to travel long distances to procure water, a task that often gets delegated to the women and teenage girls in the household. In such cases, MAP looks at either establishing a bore well in the area or rehabilitates one that is already there. MAP is also exploring other soil and water conservation techniques such as micro-water shed development and the construction of sand dams. Once Water becomes available, safe access to it and ensuring that it is safe becomes the next greatest concern. Where water is not extremely turbid or muddy, the BSF-Bio Sand Filter works very well, but in areas where there is muddy water with high contamination, the Point One Micron Water filter (Hollow fiber technology similar to the one used for Kidney Dialysis) is used. MAP International has had very good response in using these filters in Indonesia, Kenya, Uganda, Cote d'Ivoire, Ghana, Liberia, Bolivia, Ecuador and Honduras. In detailed studies conducted in Ecuador, MAP found a 60-70% reduction in the disease burden, with a saving of close to 30-40 USD per month in medical expenses. MAP is currently exploring options of how water filter users can also get into the business of selling safe water so that those who have surplus water can use it to generate income and make 'safe water'

an asset creating venture. A lot of contamination of water takes place around storage and utilization and this calls for training for behavior change. MAP has thus launched the CLTS (Community Lead Total Sanitation) program as part of its WASH strategy.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Evaluation of microbial contamination in drinking water during chemical intervention of geogenic contaminant removal in India
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Dr. Pranav Nagarnaik; Dr. Pawan Labhasetwar National Environmental Engineering Research Institute

## **Abstract Body \***

Groundwater with geogenic contaminants has affected millions of people across the world. Due to limited availability of fresh, pure and safe drinking water sources, contaminated sources are used for drinking and irrigation purposes. It is estimated that 66 million people in India are at risk due to consumption of drinking water contaminated with fluoride. Appropriate Chemical intervention for defluoridation is required to reduce the potential risk of fluorosis due to consumption of fluoride contaminated water. Chemo-defluoridation units were provided to all households in the small community village of 25 households (Chickkautha, India) in central India where the drinking water source was contaminated with Fluoride. Socio economic and sanitary surveys were conducted within the community. The periodic review was conducted on the social and sanitary conditions of the community. The information related to demographics, water consumption, storage and sanitation was collected. Water samples were collected periodically to assess the effectiveness of the chemical intervention technology along with understanding the microbial contamination. Water sample were analysed from the source, pre and post treatment and from the storage. The Thermotolerant Coliform (TTC) count was used as an indicator for the microbial contamination in the sample water. Initial analysis of the data showed a correlation between the level of contamination and sanitary risks, in particular to risks associated with the usage of the treated water. The implementation of the chemical intervention techniques changes the social practices and the lifestyle of local people. These changes increase the potential risk of microbial contamination. These chemical interventions also increase the retention time of water within the household. The microbial contamination due to storing and handling condition has always been the primary reason for recontamination in the temperate climatic conditions. The failure of intervention techniques due to improper maintenance also increases the risk of water contamination due to stagnation leading into potential water borne diseases.

The (73%) collected samples were found to be contaminated with microbial growth. The correlation of microbial contamination with social and economic factors, storage and handling conditions were studied. The Pearson's correlation analysis between the TTC count & fluoride concentration was calculated ( $r = 0.44$ ). A Covariance of +12.21 was obtained that shows a weak yet positive relationship between the two variables. Hence, sustainability of any chemical intervention to purify water cannot be achieved if there is a risk substitution by increase in the microbial contamination.

## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Removal of selected heavy metals from polluted water with sand filtration technique
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### Abstract Body \*

Abstract: In recent times pollution of the environment by heavy metals, which are known to be toxic and non-biodegradable, has become a serious issue. Attention has been directed towards development of alternative treatment methodologies. The removal of selected heavy metals viz. chromium, copper, manganese and zinc from synthetic wastewater with economically feasible materials with adsorption was investigated. Adsorption isotherms are obtained for selected heavy metal from batch experiments. Experiments were also carried out in fixed beds using the sand as adsorbent for the different solutes. Solutions of varying concentrations of selected heavy metals of chromium and copper (2–20 ppm), manganese (2–10 ppm) and zinc 15–85 ppm were prepared and passed through sand filter. Leachate samples were analyzed for concentration of these elements by flame atomic absorption spectrophotometer. The removal efficiency of heavy metals increased with increasing pH while it decreased with increasing metals concentration and injection rate. The removal efficiency was quite high for chromium 99.4–95%, followed by copper 98.6–94.8%, manganese 74.3–64.6%, and zinc 97.1–78.1%. The proposed method is efficient and cost effective and can successfully be used for heavy metal removal from water and wastewater.

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# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Montmorillonite K 10: A scavenger for fluoride from aqueous solution
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Mr. Prakash Patni, National Environmental Engineering Research Institute, Nagpur; Dr. Pawan Labhasetwar, National Environmental Engineering Research Institute, Nagpur.

## Abstract Body \*

The objective of the present work is to assess the defluoridation capacity of montmorillonite K10. It involves batch adsorption experiments to investigate the effects of adsorbent dose, initial concentration, pH, interfering ions, adsorption kinetics, adsorption isotherms etc. Among the competing ions, sulphate, chloride and nitrate have shown little or negligible effect while carbonate and bicarbonate ions have significantly affected the fluoride removal over the range of concentrations studied. The optimum fluoride removal was observed between a pH range of 4 – 7. The Freundlich, Langmuir and Dubinin–Raduskevich models were applied to describe the adsorption isotherms and their isotherms constants were also calculated. The Freundlich and Dubinin–Raduskevich model ( $R^2 = 0.99$ ) offered better fit to the equilibrium data than the Langmuir model. The mean adsorption energy (2.83 KJ/mol) calculated from Dubinin–Raduskevich (D–R) isotherm indicates that fluoride removal takes place mostly by physisorption. The kinetic sorption data were analyzed using pseudo–first–order, pseudo–second–order and intraparticle diffusion model. The kinetic sorption data offered excellent fit to pseudo–second–order model with a high correlation coefficient value ( $R^2 = 0.99$ ). Intraparticle diffusion studies suggest that, it is not only the rate – limiting step but other kinetic factors may also control the rate of adsorption, in addition to some degree of boundary layer control. XRD and EDAX studies were carried out in order to get better insight into the mechanism of adsorption process. It also suggests that fluoride removal by this adsorbent mostly takes place through surface adsorption or physisorption. The performance of the adsorbent has been tested for the field sample collected from fluoride affected areas of Dhar, Madhya Pradesh, Central India. These results demonstrate the effectiveness and feasibility of Montmorillonite K10 for the removal of fluoride from water.

## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Treatment wetlands for water and sanitation provision and improving people's livelihoods in remote areas of Uganda
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### Abstract Body \*

In Uganda wetlands cover 13 % of the surface area. These wetlands are dominated by *Cyperus papyrus* vegetation which is either emergent or floating. In developing countries like Uganda wetlands provide water and other products like reeds, fish, clay and fuel wood. Approximately five million people in rural areas of Uganda get daily fresh water supply from wetlands. Wetlands also attenuate floods and remove nutrients and pathogens from wastewater and runoff from population centres, agricultural areas in rural communities. This results into benefits for the wetland itself, for surrounding ecosystems and economic benefits for the local and regional communities. The services provided by a given wetland depend on its functioning which is controlled by vegetative structure of the wetland, the type of wetland vegetation and processes that take place as the water interacts with the root rhizome complex of the wetland vegetation. Not all wetlands perform all functions nor do they perform functions equally well. Despite the services provided by these wetlands, wetland degradation in developing countries and Uganda in particular is an increasing problem, as these ecosystems are degraded by agricultural encroachment and settlements including urbanisation. This could be because the environmental services that wetlands provide are usually not well understood by local communities and policy makers or are simply taken for granted. As we strive to provide water and sanitation services to vulnerable communities in remote areas of developing countries, we should think of sustainable use of wetlands resources so that they can contribute to this vision. Efforts should be made to invest in restoration of degraded wetlands and encouragement of sustainable use of functional ones. This could include supporting local communities to engage in alternative livelihoods in addition to sustainably using wetland resources. Awareness and sensitization of local communities should be carried out so that these wetlands resources can be sustainably used by the current and future generations.



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The Health Effects of Fluorosis in the Ethiopian Rift Valley
<b>Primary Author Name *</b>	Anne Kroeger
<b>Primary Author Affiliation *</b>	The University of Oklahoma – Department of Anthropology
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## **Abstract Body \***

Global access to safe water is a key issue as approximately 900 million people lack access to safe water (Schuster-Wallace et al., 2008). It is estimated that over two hundred million people globally are drinking water from sources with fluoride concentrations above the World Health Organization (WHO) recommended level of 1.5 mg/L, most of whom are living within 25 countries across Asia and Africa (Amini et al., 2008; Reddy, 2009). Specifically in the Ethiopian Rift Valley, conservative estimates state that approximately 8 million people are affected by high levels of fluoride (Rango et al., 2012). Consistent exposure to elevated levels of fluoride results in the development of fluorosis, a chronic metabolic disorder, which can manifest as dental or skeletal fluorosis. Typically most individuals who develop skeletal fluorosis also have some degree of dental fluorosis; however, this is not always the case as dental fluorosis merely indicates an individual's exposure before the eruption of permanent dentition, whereas skeletal fluorosis reflects an individual's chronic exposure during any period of their life (Tamer et al., 2007). Unfortunately, the relationship between fluoride exposure and skeletal fluorosis is not clear, as there are many confounding factors, including: climate, physical activity, diet, and possibly genetics (Tamer et al., 2007; Reddy, 2009).

This presentation will summarize the current scientific evidence regarding health effects of fluoride consumption, as well as review the present gaps in this field of research. This will be helpful for researchers to have a clear understanding of what is known and what needs to be rigorously studied in order to build a stronger global case for integrated fluorosis risk management.

One key area of research needing further study is conclusive diagnoses of skeletal fluorosis. To help fill this gap, preliminary research conducted in the Rift Valley of Ethiopia will be presented. This research was conducted in two kebeles, Sori Dollessa and Korke Aldi, which have (rainy season) fluoride concentrations of approximately 6.7 mg/L and >10 mg/L, respectively. For this preliminary study women were interviewed about their health status, pain and pain management, perception of the causes of pain, and perception of the quality of the drinking water source. Additionally, women were asked to perform a series of small exercises to gauge their perception of pain versus their actual abilities and glean information regarding key areas of health concern that should be studied in more depth. Some key findings of this work will be presented. Based on the data collected, future goals will also be outlined. The primary goal of this work is to gain a more substantial set of evidence regarding what skeletal effects consumption of fluoride does or does not cause and then develop a conclusive test for diagnosing skeletal fluorosis. A discussion of the complications of this type of study and the ability to definitively diagnose skeletal fluorosis due to the many confounding factors will be included. This presentation will outline these challenges and the multitude of criteria researchers have used to diagnose skeletal fluorosis in the past.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	A Practical Approach for the Solar Disinfection of Water Using Photocatalysis
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<b>Primary Author Name *</b>	Deepika Kurup
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**Abstract Body \***

One of the major causes of drinking water contamination comes from harmful bacteria such as Escherichia coli and Salmonella. Current water purification methods for removing or destroying bacteria include filtration, chlorination, ozonation and ultraviolet C radiation (wavelength 100–280 nm). In recent years, solar disinfection (SODIS) has been used to purify water infected by pathogens. Most of the UV-C radiation from sunlight is blocked by the ozone layer of the earth's atmosphere. Solar disinfection (SODIS) that uses primarily UV-A radiation (315–400 nm) has been used to purify water infected by pathogens; however SODIS by itself is very slow.

In an attempt to accelerate SODIS, photocatalysts such as Titanium Dioxide (TiO<sub>2</sub>) and Zinc Oxide (ZnO) are currently used. When UV-A radiation from the sun strikes these photocatalysts, electrons from the valence band are energized into the conduction band thereby leaving holes (positive charges) in the valence band. The electrons and holes combine with oxygen and water to create super oxides, hydroxyl radicals and hydrogen peroxide. These reactive species are responsible for the photo-killing of bacteria. In existing TiO<sub>2</sub> enhanced photocatalytic SODIS methods of water purification, TiO<sub>2</sub> is coated on the inner surface of polyethylene terephthalate (PET) water bottles. The primary drawback of this method is that the TiO<sub>2</sub> coatings block UV radiation which diminishes photocatalytic activity. Another drawback of this method is that the TiO<sub>2</sub> coatings are not uniform and often wash off after repeated use.

In this study, a novel, light weight photocatalytic composite comprised of TiO<sub>2</sub>, ZnO, hollow glass bubbles, and a hydraulic cementing binder was developed. This composite was deployed without blocking UV radiation in several different ways such as such as a cylindrical rod to be placed in water bottles, a model water tank for long term storage, photocatalytic spheres, and a photocatalytic water purification panel. The composite was found to be effective in killing bacteria when exposed to sunlight for less than eight hours. This study highlights the potential of a sustainable, cost effective and eco-friendly way of purifying contaminated water.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	An Electronic Tongue for Detecting Heavy Metals in Groundwater
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<b>Primary Author Name *</b>	Dr. Pradeep Kurup
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Seth Robertson; Dr. Ramaswamy Nagarajan
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**Abstract Body \***

Heavy metals such as zinc, cadmium, lead, arsenic and mercury in groundwater are toxic when consumed by humans and many living species. Long-term exposures to these contaminants could damage the kidney, liver, skin, gastrointestinal tract and the central nervous system. Detecting and delineating these contaminants in the subsurface is a challenging task and generally involves sampling groundwater followed by detailed laboratory analysis. The standard analytical methods, such as inductively coupled plasma mass spectroscopy, atomic absorption/emission spectroscopy, optical spectroscopy, and x-ray fluorescence are expensive, time-consuming, and laborious.

In this study a novel device referred to as the electronic tongue (E-Tongue) was developed for intelligent detection of heavy metals in groundwater. The E-Tongue is a device that mimics the human gustatory system using an array of broadly selective electrodes coupled with powerful machine learning tools for classification and quantification of heavy metals in aqueous media. The electrode array used in this research consisted of carbon fiber, silver, gold, and platinum electrodes. Square wave anodic stripping voltammetry was used as the primary analytical technique, which provided predictions in less than three minutes. Hybrid techniques, such as the incorporation of electrical conductivity along with voltammetry measurements, were found to improve the E-Tongue sensitivity to several toxic metals. Multivariate data processing techniques were used to obtain highly accurate predictions of low part-per-million levels for zinc, lead, cadmium, arsenic and mercury in water. This study demonstrated the feasibility for qualitative and quantitative analysis of heavy metals in groundwater. The E-Tongue is faster, safer, minimally invasive, cost effective and easier to use compared with traditional analytical methods.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Community Level Solar Energy Based Electrolytic Defluoridation Plant installations by CSIR-NEERI in India
<b>Primary Author Name *</b>	Dr. Pawan Kumar Labhasetwar
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Er. Subhash Andey; Ms. Poonam Gwala; Mr.Prashant Pal and Mr. Prashant Deshmukh; CSIR-National Environmental Engineering Research Institute, (CSIR-NEERI), Nagpur (India)

## Abstract Body \*

About 62 million people including 6 million children are affected with fluoride related health diseases. Defluoridation technique based on electrolysis has been developed in CSIR- NEERI, India . The process is based on the principle of electrolysis by passing Direct Current (DC) obtained from solar photovoltaic cells through aluminium electrodes in fluoride containing water. Fformation of polyhydroxy aluminium species in the process removes fluoride in water by complex formation followed by adsorption and removal by settling. The fluoride concentration is brought down to desired level by changing the reaction time and current. During the electrolysis nascent chlorine is evolved which also reduces the microbial contamination of water. Electrolytic defluoridation plant produces the treated water with fluoride less than 1 mg/L and 90 – 99% reduction in bacterial load from the raw water with the fluoride in the range 2 – 10 mg/L and total coliform and fecal coliform counts in the range 120-630 CFU/100ml and 70-100 CFU/100 ml respectively. Reduction in hardness and nitrate is also observed in treated water. Solar power based electrolytic defluoridation demonstration units were successfully installed at many places in India in the fluoride affected villages The performance of these plants indicates that the system provides a technically sound, cost-effective and reliable community drinking water defluoridation system for supplying drinking water, which meets the guideline value of the World Health Organization (WHO) for fluoride. It is well suited for the situations in which the electric supply is not available for longer duration, the operators and maintenance workers are not highly trained technicians, such as in rural or remote locations. Treatment cost is Rs.12 per 1000 L (1 USD per 4000 liter).

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Simulation of Bone Charring Process in a Kiln
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## **Abstract Body \***

Previous studies have shown that the quality of bone char largely depends on the temperature of the charring process. They have also shown that the duration of the process maintaining at an optimal temperature is critical for the increase in both yield and quality of bone char. In this study, a numerical model has been developed to simulate the bone charring process in a kiln. The kiln model is developed using a commercial code ANSYS and is based on the one currently in use in Mojo, Ethiopia. Through simulations, it is aimed at achieving and maintaining the optimal charring condition (for both temperature and duration) by controlling process parameters such as air flow rate and bone packing density. The numerical results are first validated against the field data collected. After validation, process modifications are made to achieve the set goal. It is expected that the model thus developed will not only improve the quality and yield of bone char, but also will provide design improvements for the second kiln which is currently under planning for better energy utilization and waste reduction.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Hydro-social cooperation through developing regional knowledge networks
<b>Primary Author Name *</b>	Melinda Laituri
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## Secondary (Co-) Author(s) and Affiliation(s)

### Abstract Body \*

Innovative solutions are needed to address water issues where specific outcomes and activities are identified. Collaborative regional networks are essential to complementing ongoing local and global processes and programs. Sharing experiences across geographic and cultural settings are needed to target local responses to water security for knowledge-based strategies of land and water rights integrated with gender and environmental equity. Built upon the tenets of Integrated Water Resource Management (IWRM), and recommendations of the Sixth World water Forum in Marseilles (2013) this paper will present and discuss ways to develop global intellectual capacity for resolving water management problems through innovative training and education approaches. Developing regional knowledge networks will identify the characteristics of locales and regions across intersecting scales of policies, economic markets, ecological gradients, and cultural practice. Operationalizing "the triple bottom line" through science, education, and policymaking is the critical challenge that will be discussed in this workshop.

The key objectives of this paper include:

- Identifying the intellectual capacity needed to address water security in specific regions.
- Determining the structure of regional knowledge networks .
- Fostering collaboration between ICIWaRM, partners and stakeholders.
- Ensuring representative stakeholder involvement in developing intellectual capacity.
- Developing a suite of action items to facilitate educational activities and outcomes

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The Effect of Influent Organic Content on Biosand Filtration Efficiency and Construction
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## **Abstract Body \***

Biosand technology is becoming more widespread as a popular point of use water quality device in developing countries. Implementations of biosand filters (BSF) have been conducted all over the world, from African deserts to Asian jungles. Based on the assumption that a biolayer can and will develop in any situation, BSFs have a track record of successful integration into the lives of many people living in different conditions, using widely varying qualities of water. However, not every attempt at using BSFs has been a resounding success. One problem behind the technology is the "one-size-fits-all" assumption when implementing the filter. Because the filters rely on a biological component for filtration, effective operation of the BSF relies on understanding and predicting biological growth requirements. By analyzing the effect of organic carbon content of the contaminated water on BSF performance, a predictable model can be developed to ensure filters operate as efficiently as possible. This information, along with new methods of construction, could mean new engineering methods for BSFs to reach those without reliable access to clean water.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Contribution of low cost appropriate drilling technology for improved access to safe water at inaccessible places (The case of Hulla ADP)
<b>Primary Author Name *</b>	Robel Lambisso
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Abraham Asmare, East Africa Region WASH Learning Center Advisor

## Abstract Body \*

### Introduction

Hulla Area Development Programme(ADP) is located in Hulla Woreda, Sidama Zone of Southern Nations Nationalities & Peoples Region of Ethiopia. It is found at 365 km to the south of Addis Ababa and 90 km from Hawassa, the capital of the region to the South. The population of the woreda is estimated at 144,200(52,779 are female). A survey of the land in this Woreda shows that 59.6% is arable or cultivable, 36.2% pasture, 2.3% forest, and the remaining 1.8% is considered swampy, degraded or otherwise unusable. The estimated area of the district is 583.7Km<sup>2</sup>

### Problem Statement

Approximately 300 million people in rural Africa live without access to safe water supplies, in areas that could be appropriately supplied with hand-pumped boreholes (JMP, 2010)

Out of the total district population of Hulla, nearly 100,000 did not have access to potable water supply when the project implementation starts. This is partly due to the fact that some of the villages are inaccessible to heavy duty rigs.

The lack of potable water supply resulted in the prevalence of different water borne diseases and poor personal and environmental sanitation.

Use of appropriate low cost technology like manual drilling is seen to have resulted in reducing the cost of drilling & giving solution to access road problems.

### Project Implementation

World Vision Ethiopia piloted manual drilling technology in 4 ADPs at which the ground water table is located at shallow depths. Hulla ADP is one of those ADPs.

Local artisans were trained in manual drilling technology and they have also been organized & accredited by the local government. After attending robust practical training, they then started to drill wells at the various villages of the ADP.

### Results & Outputs

In year 2012, a total of 20 shallow wells have been drilled at inaccessible places of Hulla ADP and fitted with hand pumps. They have started benefiting estimated 5000(M=2400I, F=2600) communities in the localities.

This technology has also helped to generate income as the local drilling team members are organized as small scale entrepreneurs and are earning income from the work they do. They were able to save Birr 12000(\$ 650) in the local Bank found in the district. Prior to that, they had been earning little income from their daily wages as daily laborers.

### Conclusion & Recommendations

- Manual drilling technology has an advantage compared to hand dug wells in terms of cost of intervention, ease of implementation & sustainability. However, it requires relatively softer formations and shallower water table depths.
- The fact that it is low cost & lucid also enables local manufacturing of parts & the entire tool. This in turn can enable achieving the UAP target by addressing in-accessible places.



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Chlorine Dispensers: Establishing Impact in Emergencies
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	E. Armitage; Innovations for Poverty Action, New Haven, CT

## Abstract Body \*

Introduction. The Chlorine Dispenser System ("Dispensers") is a point-of-source treatment option that includes: 1) the Dispenser hardware installed next to communal water sources; 2) community education, including a local promoter to encourage Dispenser use; and, 3) a bulk supply of chlorine to refill the Dispenser over time. In rural Kenya in the development context, 55–60% of households had sustained detectable chlorine levels in household drinking water during unannounced visits 3–6, 18, and 30 months after Dispenser installation, compared to less than 10% with access only to the retail chlorine model. The Dispenser hardware, its location, the fact users do not pay for the chlorine, and local promotion are all critical components to encourage sustained behavior change by addressing key behavioral barriers to the adoption of chlorine.

It is currently unknown whether Dispensers will be more, less, or equally as successful in the emergency context. This project aims to complete three goals: 1) validate Dispensers in the emergency and post-emergency context; 2) investigate sustained post-emergency Dispenser use, and 3) distill and disseminate recommendations to organizations implementing programs in emergencies based on lessons learned. To achieve these goals, the project, funded by the Bill & Melinda Gates Foundation focuses on six activities: 1) Continuing and evaluating the pre-existing cholera-response Oxfam America Dispenser program in Haiti; 2) Working in collaboration with four emergency response organizations (Oxfam America, Oxfam Great Britain, IRC, and IFRC) to pre-position Dispensers, implementation manuals, and training materials in central stocks; 3) Implementing Dispensers in four to-be determined emergencies with high diarrheal disease risk; 4) Evaluating uptake and effective use of Dispensers in these four emergencies; 5) Developing and distributing implementation guidelines for Dispensers in emergencies; and, 6) Evaluating sustained use of Dispensers in two post-emergency contexts.

Methods. Innovations for Poverty Action (IPA) was responsible for the evaluation component of this grant. To evaluate each projects, a mixed-methods monitoring and evaluation general protocol was developed including five components: 1) randomized household surveys; 2) water quality testing of free chlorine residual and microbiological indicators in untreated and treated water pairs at the household level; 3) qualitative interviews with responders; 4) focus groups and semi-structured household interviews with beneficiaries; and 5) cost analysis.

To complete these evaluations, we: 1) modified the survey to be specific for the actual emergency context, hired and trained independent enumerators for the survey, designed a sampling methodology based on the geographic distribution of Dispensers, and conducted between 200–400 household-level surveys; 2) trained enumerators to measure free chlorine residual using a quantitative portable testing kit and test treated and untreated water at the household level during the survey, and also to collect a sterile sample that was stored on ice that we analyzed for quantitative microbiological contamination using membrane filtration with *E. coli*

as the indicator within eight hours of collection; 3) conducted qualitative interviews with the partner organization and any of its local implementation partner to assess perception around Dispensers as an emergency response intervention; 4) conducted focus groups with beneficiaries to assess water knowledge, attitudes, and practices, as well as perceptions around Dispenser use; and 5) retrospectively, talked with the partner organizations about the cost of implementation in the particular emergency evaluated and the estimated cost for future potential emergencies.

Results and discussion. To date, four of the planned seven evaluations have been completed or are in progress, including: 1) the evaluation of the existing Oxfam/America program; 2) two acute emergency evaluations of the Oxfam America program in Senegal and the IRC program in Sierra Leone; and, 3) one sustained use evaluation of the Oxfam America program in Senegal that is currently in progress as of writing this abstract. The remaining three evaluations are planned for during 2012. Overall, the results have been quite varied.

In the existing Oxfam/America program in Haiti, there was quite low adoption of the Dispensers. We interviewed 298 families in 10 communities where Dispensers had been installed as part of cholera-response activities. While 55% of families reported they had ever used the Dispenser, only 26% reported they used the Dispenser the last time they collected water, and only 27 (9.1%) had free chlorine residual in their drinking water at the time of the unannounced survey visits. This low adoption was attributed to placing the Dispensers at decentralized sources where few people collected water, lack of training in the community, and incorrect chlorine concentrations in the Dispensers themselves due to problems with mixing the chlorine solution. Based on this evaluation, a set of criteria were developed for installing Dispensers in emergencies, including: point sources (wells, springs, open wells), a sufficient population density around each source, a sufficient source density for 50–100 Dispensers, a minimum chlorine acceptability, access for evaluators, and an emergency in a developing country with high diarrheal disease risk.

The results from the Senegal evaluation showed quite high adoption of Dispensers. We interviewed 277 families in 10 communities where Dispensers had been installed as part of food insecurity response. The vast majority of respondents reported using the Dispenser the last time they collected water (92%), and 220 (79.4%) had free chlorine residual in their drinking water at the time of the unannounced survey visits. This high adoption was attributed to placing the Dispensers at centralized sources where people collected water, training in the community including high-quality promoters, and a well-organized project. The results from the follow-up evaluation, which is currently ongoing, continue to show this high adoption.

The results from Sierra Leone, which have not yet been fully analyzed, show quite low adoption of <10% due to lack of knowledge and training in the community and the fact that Dispensers were installed at sources on private property, which led community members to question whether they had the right to use the Dispenser.

Recommendations. As data collection is ongoing, our recommendations are preliminary. However, it does appear that Dispensers can be, but are not always, an appropriate emergency response tool. Dispensers are appropriate where there are centralized sources that people travel to, the appropriate materials to manufacture chlorine solution, and sufficient training and education for the recipients.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Rainwater Harvesting First-Flush Research and Implementation of Results in Sierra Leone
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## **Abstract Body \***

In 2010, 87% of Sierra Leone's urban population had access to improved drinking water (as defined by the United Nations in the Millennium Development Goals) compared to only 35% of its rural population. Sierra Leone experiences a 6 month wet season, where rainfall can reach up to 541 mm during the month of August and an average of 2,000 to 5,000 mm annually, depending on the region. These high rainfall amounts make Sierra Leone an ideal candidate for utilizing rooftop rainwater harvesting technology to meet daily water consumption needs throughout the year.

During a storm event, the majority of a roof's contaminants and debris are washed away during the initial part of the storm, a phenomena known as the "first flush". The objective of this research was to quantify a first flush in rainwater harvesting for old and new metal-roofed buildings in both the urban and rural areas of Sierra Leone based on water-quality analysis. Water samples were collected from sites located in Waterloo (urban), Jui (urban), and Mokonde (rural) and analyzed for the presence of total coliforms and E. coli in the initial runoff and turbidity, pH, and conductivity measurements were also recorded. Results suggest diverting the first 1.5 mm of runoff from buildings with new metal roofing (i.e. no rust present) and 2.0 mm of runoff from buildings with old metal roofing (i.e. rust present).

Based on the results, a rainwater harvesting system consisting of three 5,000 L tanks constructed from cement blocks was built at the Mokonde research site, a primary school serving 400 students, and first-flush diverters were included in the system. The system was constructed using local labor, locally available materials, and the entire two month project was more affordable than purchasing three 5,000 L plastic tanks alone. Students and teachers from the primary school were actively involved throughout the entire project in supplying materials and labor, helping ensure the sustainability and longevity of the system.

The purpose of this presentation is to not only share the water-quality data, but to also share the techniques used and knowledge gained from applying the research to a real-life project in a developing country, especially in regards to cultural and social challenges faced during the construction project. This research was conducted under a 2012-2013 U.S. Student Fulbright grant to Sierra Leone.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The Sol-Char Toilet: Reinventing human waste management
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## Abstract Body \*

The global sanitation crisis presents the challenge of providing over 2.5 billion people – or 40% of the world's population – with the means to safely dispose of their human excreta. Recognizing that sanitation underpins economic growth and development, in 2002, a target to halve the number of people lacking sustainable access to basic sanitation by 2015, using 1990 as a baseline, was added to the Millennium Development Goals (MDG). To date, despite over ten years of effort, achieving real gains in sanitation has proven to be slow – too slow to reach the MDG sanitation target in many developing countries. Although globally 1.8 billion people have achieved access to basic sanitation since 1990, the number of un-served people has actually grown due, in part, to population growth, urbanization and poverty.

The sanitation crisis is particularly challenging in urban slums where off-site sanitation options are not financially viable but uptake of on-site sanitation systems, at scale, has been slow to take hold. Many low cost on-site sanitation options do not meet the users' aspirations or needs. Households and communities may lack incentives to either purchase, use, or maintain a sanitation system. Additional barriers to increasing sanitation coverage include hydrological and geological profiles, cultural norms, available resources, community structure, and funding sources.

To pick up the pace of reaching the sanitation MDG, the Bill & Melinda Gates Foundation has established the "Reinventing the Toilet Challenge" to which we have responded with the Sol-Char Toilet. The Sol-Char Toilet, currently in development, provides a human waste disposal solution that ensures public health, dignity and a cleaner environment while producing an economically valuable product. The Sol-Char Toilet is a self-contained, on site sanitation system that renders fecal waste harmless within a short time span without the need for flush water or electricity. The Sol-Char toilet will utilize concentrated solar energy to reduce the treatment process land footprint and time needed to render the human waste safe and potentially usable as a soil amendment or solid fuel.

A prototype was constructed which uses parabolic solar concentrators that focus sunlight into fiber optic bundles. This high intensity solar energy is transmitted through the bundles which are distributed to a reactor where the various individual cables heat the fecal waste via radiation. The system comprises various containers that are switched between collection, treatment, and removal modes with provisions for gas collection and sensors to track operation. Urine is diverted at the source and treated thermally for potential use as a fertilizer.

Results related to the prototype will be presented. The concentrated solar energy capture and transmission through fiber optics was analyzed and found to be an efficient treatment methodology for a compact land footprint application such as on-site sanitation treatment. Heat transfer modeling of the reactor was conducted and validated through experimentation with the prototype. This verified that the waste is sterilized

in a short time span and significantly reduced in volume. Exhaust gas characterization was undertaken for potential energetic value as well as to ensure safety. Treatment methods for addressing odor issues and other problematic gases were also analyzed to ensure a safe and pleasant user experience. Products from the Sol-Char toilet with promising economic potential were characterized. Biochar derived from urine-diverted human waste was generated in simulated conditions inside a laboratory furnace at temperatures varying from 300°C to 800°C. Results showed a product which is likely to provide some degree of agronomic enhancement with a relatively high cation exchange capacity and pH. While less water and nutrient retention can be expected from these biochars, relative to typical wood-based biochars, the biochar product was found to sequester carbon when generated at the higher temperature conditions. Biochar was also tested as an energy source. Briquettes made from the biochar with lime and molasses binders were found to have a high energy content, comparable to that of typical commercially available charcoals.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	A community directed approach for WASH technology implementation in rural Ghana
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## **Abstract Body \***

**Intro/Motivation:** Since the 1990's there has been increased focus on providing access to improved water and sanitation to those in low- and middle- income countries. Unfortunately, many well-intentioned initiatives to implement water, sanitation, and hygiene (WASH) technologies in rural and peri-urban areas of these countries either fail to meet their intended purpose or to last in the long term. These failures are often due to poor design and/or poor introduction of the technology. A sustainably designed system must address cultural and technological needs, concerns and constraints of the community, and environmental context. A well-introduced system initiates necessary education and behavior change prior to technology implementation.

**Objective:** We assessed the efficacy of a community directed approach for implementation of WASH technology.

**Methods:** We implemented a Biosand filter in a rural Ghanaian village using a community directed approach, and assessed functional sustainability one year after implementation. The Community Directed Development Foundation introduced the Biosand filter in the rural village of Dorgobom, located in Greater Accra, Ghana. Community observations, personal interviews, focus group discussions, household surveys, as well as physical and biological water tests were used to monitor and evaluate the implementation of a sustainable water treatment technology.

**Results:** One year after implementation of the single BioSand filter, the community constructed four additional filters for use in the village primary school. All maintenance procedures were conducted regularly and filters were used continuously. A 78% improvement in water quality was observed. In addition to improving water quality, it is believed the filters helped to improve overall health in Dorgobom as well as promote attendance in primary school.

**Conclusion:** The results of the project suggest that community directed implementation is an effective and sustainable approach for integration of WASH technology. A larger scale study must still be completed to test for scalability. The lack of available funding, personnel, and scientific materials, are also limiting factors in this study.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Estimating water storage in Northern Ghana
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## Abstract Body \*

Efforts to utilize global water resources are increasing for reasons including population growth, economic development, and expansion of agricultural irrigation. Sustainable use of water resources requires an understanding of local water needs, annual water budgets, and water storage. However, estimating water storage within data-sparse areas in developing countries is difficult. Remotely-sensed data offer a means to augment some of the data "gap" needed to estimate water budgets and storage. As an example, the Gravity Recovery and Climate Experiment (GRACE) satellite data are used to estimate terrestrial surface water and groundwater storage within an area of northern Ghana from 2005 to 2010. The GRACE satellites measure monthly gravity changes, which can be used to calculate terrestrial water storage. Changes in storage can be estimated when GRACE measurements are combined with modeled and measured precipitation, surface water flow, groundwater levels, and hydrogeologic parameters. The GRACE measurements exhibit significant seasonal and long-term trends, which are supported by the modeled and measured data. These results are being used to develop a better understanding of annual water budgets and water storage in Northern Ghana. This knowledge of water resources is critical because the area is experiencing desertification, population growth, economic development, and expansion of agricultural irrigation while trying to develop groundwater resources sustainably.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Sustainable Household Groundwater Supply: Building Upon Five Decades of Experience in Eastern Madagascar
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## Abstract Body \*

Manual water well drilling techniques are increasingly being promoted as a cost-effective way of providing water for drinking and irrigation purposes in developing communities throughout the world. The relatively low cost of manually-drilled wells, compared to machine-drilled wells or hand dug wells, as well as the affordability and relative portability of their equipment, make them an attractive household and community water supply option when hydro-geological conditions are favorable. When linked with a low-cost water lifting technology, manual well drilling has potential to drive a sustainable, consumer-driven market for household water supply.

Along the East coast of Madagascar, shallow groundwater is commonly extracted using Pitcher Pump systems. This type of groundwater supply system consists of a manually-driven well fitted with a manual suction pump. The low-cost Pitcher Pump technology was first introduced to eastern Madagascar over fifty years ago, and thousands of these systems are now in use at the household level. Pitcher Pump systems are commonly purchased by individual families at unsubsidized prices of US\$ 40–100. Currently, there are more than fifty small-scale independent workshops that produce Pitcher Pumps in the eastern city of Tamatave, as well as an estimated 1–2 dozen more manufacturers in other coastal areas throughout the country.

The presented research details the potential for improving environmental safety of the Pitcher Pump system through changes to system construction and installation techniques, as a result of field testing/research carried out as part of a partnership between the University of South Florida (Tampa) (USF), RANO HamPivoatra (Water for Progress) – a USAID-funded project in Madagascar implemented by a consortium led by CRS and CARE, and literature review. Specific possibilities are explored to: (1) improve delivered water quality through replacement of lead [Pb] –containing valve weights commonly used in Pitcher Pumps; (2) improve water quality through use of alternative well lining materials and drilling methods that reduce/eliminate the use of Pb-containing components in the well screen. The research also recommends ways to expand the household groundwater supply market to areas with more diverse hydrogeological conditions (i.e. deeper water tables, harder soils) through the use of alternative manual well drilling and water pumping technologies.

The maturity and sustainability of the current Pitcher Pump market in eastern Madagascar, including the expertise of local technicians in pump construction and manual well drilling, is strongly considered in offering recommendations. Recent experiences with the introduction of other low-cost manual drilling techniques and manual water pumps to Madagascar are discussed.



# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	The SaniPath Study: The Consequences of a Broken Sanitation Chain in Four Low-Income Urban Settings in Accra, Ghana
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<b>Primary Author Name *</b>	Christine L. Moe on behalf of the SaniPath Study Team
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**Abstract Body \***

The SaniPath study is the first multidisciplinary investigation to quantify the consequences of a broken sanitation chain in Accra, Ghana, a city of approx. four million people without a functional municipal sanitation system. Urban sanitation problems in developing countries have received inadequate attention over the past decade of the MDGs. Most water, sanitation and hygiene organizations have focused on providing access to sanitation in rural areas because these have typically been where the majority of the population without access to sanitation was located. Rapid urbanization, especially in sub-Saharan Africa, has outpaced the capacity of municipal governments to provide adequate water and sanitation services – especially in slums and informal settlements. One goal of the SaniPath study was to examine sources and movement of fecal contamination in four diverse, low-income urban communities and quantify the risks of exposure to fecal contamination in public (beaches, public latrines, schools, urban agriculture products, drinking water, and open drains) and private (households and childcare centers) domains. Using a mixed methods approach and state-of-the-art environmental microbiology and behavioral science techniques, we collected and tested almost 2000 environmental samples and conducted over 500 hours of structured observation. Environmental samples were analyzed for traditional fecal indicators (E. coli, enterococci, coliphage) as well as pathogens (norovirus, adenovirus, helminths). The results indicate widespread and often high levels of fecal contamination in the environment and the food supply. This contamination has consequences for health and well-being, both for low-income communities within the city and for the whole city population. This presentation will describe this neglected and complex problem, present key findings from the study, and show how this information could be used to strategically plan sanitation interventions for this setting.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Evidence-based behavior change for save water consumption
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### Abstract Body \*

It is not enough to provide people at risk of consuming arsenic or fluoride contaminated water with safe water facilities, because for certain reasons they might not use them or do not use them properly and regularly. Evidence suggests that the effectiveness of technologies is dependent on the degree of compliance. Providing populations at risk with safe water "hardware" must be accompanied by "software" programs that support behavior change. These behavior change programs aim at improving acceptance, adoption, and habitual use of safe water facilities. As behavior is always the result of psychological processing of factors within the individual, behavior change campaigns must take these factors into account. It is important to know which of these behavioral factors keep the target population attached to the old behavior of consuming contaminated water and consequently, in health promotion campaigns one has to take into account how these factors can be tackled using behavior change techniques. This paper presents the RANAS Model (R(isk), A(ttitudes), N(orms), A(bilities), and S(elf-regulation)) of behavioral change, which postulates that for the formation of new habitual behavior, five blocks of factors must be positive with regard to the new behavior: risk factors, attitudinal factors, normative factors, ability factors, and self-regulation factors. Standardized tools for measuring the factors in face-to-face interviews are presented, and behavioral interventions are provided for each factor block. A statistical analysis method is presented, which allows the determination of the improvement potential of each factor. The corresponding behavioral interventions can be selected according to the model. The proposed four-step protocol for conducting behavior change campaigns depicts the important steps to induce behavior change in a systematic way.

The procedure is illustrated by means of the results of two safe water campaigns: a campaign promoting the consumption of arsenic free water from deep tube wells or neighboring shallow wells in Bangladesh, and a campaign promoting the consumption of fluoride free water either from household filters or from community filters in Ethiopia. In the Bangladesh study it could be shown that using a combination of behavior change techniques from the RANAS model increased the behavior change effects of an informational intervention by up to 50%.

In the Ethiopia study it could be demonstrated that a traditional information intervention targeting perceived vulnerability showed no desirable effects but applying a cost persuasion technique from the RANAS model decreased the perceived costs and increased the consumption of fluoride-free water. This showed that altering subjective perceptions can change behavior even without changing objective circumstances (water fees).

This research emphasizes the importance of founding intervention campaigns on sound quantitative evidence.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	The Use of Basic Geophysical Surveys to Map Potential Drinking Water Supplies in Developing Countries
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**Abstract Body \***

Existing published knowledge of the subsurface geologic and hydrogeologic conditions in developing countries has often been historically limited because of a lack of public funding for the collection and sharing of such information. As a result, the effective systematic search and mapping of potential subsurface drinking water supplies is often limited, and a significant impediment remains because of the high cost of drilling equipment and availability of knowledgeable operators to advance supply wells. This causes delays in adequate water supply development and community development planning to address this vital need. The historic use of non-invasive geophysical surveys in providing subsurface earth imaging of potential drinking water resources in developed countries is well known and has increased in recent years because of the advancement of new equipment technology and computerization of data collection techniques and survey positioning that takes place during the field surveys. However, even basic geophysical surveys are still underutilized in developing countries to search for water. Advancement in geophysical technology, while helping to expand the role of geophysics and its use in 1st world countries, has created an even greater chasm to limit its expanded use elsewhere. Current new equipment costs are well beyond the reach of community budgets in developing countries. This presentation will focus on basic geophysical survey techniques and equipment that can be used in developing countries to provide direction for locating drinking water wells. Techniques involving electromagnetics, electrical resistivity and seismic analyses will be discussed. New methods and processes for global collaboration to collect, map and analyze geophysical data generated from these surveys will be discussed in the hopes of providing an open dialogue that leads to an improvement in the search for new water supplies.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Influence of iron and groundwater contamination on residual chlorine of water treated with sodium dichloroisocyanurate (NaDCC) tablets
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## Abstract Body \*

### Background:

Chlorine-based disinfectants provide residual chlorine in treated water, which prevents re-contamination. The effectiveness of chlorine-based disinfectants to treat groundwater at the point of use (POU) varies in Bangladesh due to different levels of chemical compounds in groundwater such as iron and arsenic. For instance, earlier efforts to use liquid sodium hypochlorite to treat shallow ground water failed to provide a consistent adequate residual chlorine. We conducted a study in a rural Bangladeshi setting to assess whether sodium dichloroisocyanurate (NaDCC) tablets, another chlorine-based POU disinfectant, could provide the recommended chlorine residual when used to treat groundwater with varying concentrations of iron.

### Methods:

We conducted the study in six sub-districts of central Bangladesh where iron concentration was previously reported as low. We randomly selected 390 villages from 65 unions of the six sub-districts. We then selected one tubewell from a central point of each selected village, collected groundwater from each selected tubewell and measured the iron concentration using a Hach Pocket Colorimeter for Iron. Subsequently, we treated a 10 L sample of groundwater from each tubewell with one 33 mg NaDCC tablet. After 30 minutes, we measured the free chlorine residual using a Hach Pocket Colorimeter II for Chlorine. If the residual chlorine level was below the CDC recommended dose of 0.2 mg/L, a fresh 5 L sample of groundwater was treated with one 33 mg NaDCC tablet. We assessed the presence/absence of fecal contamination of tube well water by H<sub>2</sub>S testing before treating with NaDCC tablets; 20 ml of water was collected in H<sub>2</sub>S bottles to observe color change 24 hours after collection, indicating presence of fecal contamination.

### Results:

The median iron concentration of the tested wells was 0.7 mg/L (inter-quartile range 0.28–1.78 mg/L) and 16% (61/390) of the wells had iron concentrations above the WHO recommended level of 3 mg/L for drinking water. The median concentration of residual free chlorine after adding one 33 mg NaDCC tablet to 10 L of water was 1.3 mg/L (inter-quartile range 0.62–1.66 mg/L) and 15% (60/390) of samples had residual free chlorine below the CDC recommended 0.2 mg/L. Of these, 55% (33/60) had residual chlorine above 0.2 mg/L after dosing at 66 mg NaDCC tablets in 10 L water. Of the total 390 tubewells, 25% (97/390) had a 24-hour H<sub>2</sub>S positive result, suggesting presence of fecal contamination in the well. In logistic regression analysis, having a residual free chlorine < 0.2 mg/L

was associated with iron concentration  $>3$  mg/L [odds ratio: 99; CI (42–233)] but not with H<sub>2</sub>S positive result.

#### Conclusion:

Iron concentration above the WHO recommended level reduced the effectiveness of NaDCC tablets in treating groundwater. We only tested for iron, but other groundwater compounds could have also influenced residual chlorine. Even in the settings specifically chosen for lower iron concentration, variable groundwater chemistry complicates simple recommendations to treat water with chlorine containing compounds. This presents a barrier to widespread scale up of household groundwater treatment with chlorine.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Promotion of Rainwater Harvesting through the Private Sector in Uganda
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<b>Primary Author Name *</b>	Jonathan Naugle
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**Abstract Body \***

This paper will present the learning from 4 years of research to increase access for poor households to the benefits of rainwater collection. Early on the research confirmed that the biggest impediment to greater participation in domestic rainwater harvesting was the high cost of storage. Low cost rainwater storage would enable households to have the convenience of clean water right at their doorstep. Through two years of field testing and innovation a low cost, flexible, rainwater storage tank with a 375 USG capacity was developed. For the past two years a commercial pilot has been promoting the product, a rainwater bag called bob® through the private sector in Uganda. The rainwater bag solves a problem facing many households around the world, the lack of an affordable large volume water storage vessel. Over 2500 bob®s have been sold in Uganda since March 2011 and more than 96% of the users in a recent survey said that they would recommend a rainwater bag to a friend. The lessons learned cover product development, product promotion and marketing, as well as product performance.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Building Low Cost Local Well Drilling Capacity in Senegal
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## **Abstract Body \***

For the past four years EnterpriseWorks as part of the USAID funded USAID PEPAM Project in Senegal has been building local private sector well drilling capacity through the introduction of appropriate drilling technologies. Local businesses have been trained to drill wells using manual drilling techniques including augering, rotary jetting and manual percussion. These businesses have been equipped with equipment made in local welding and machine shops or purchased on the local market. While drilling wells for the project the well drillers reimburse the cost of the tools, so that they own the tools and can drill for other organizations and individuals.

The key to building sustainable local drilling capacity is to involve the private sector in the drilling as well as the supply and manufacture of tools and the importation necessary supplies, such as drilling polymer. In addition to manual drilling the project has introduced two small portable rigs. These rigs provide a low cost complement to manual drilling in areas where the water table is too deep (>75 feet) or the formations too hard for manual drilling. The small hydraulic rigs can drill through harder formations and to deeper depths.

building needs for stakeholders at different levels, creation of favour political and financial incentive measures to encourage decentralized wastewater concept for consultants, project owners and private service providers. Special focus should be paid for technology selection in early stages of sanitation planning, efforts to spend resources for household connection and collection network construction, whereas all criteria are to be considered in the context of local natural, social and economical conditions. Decentralized wastewater management is a great environment for the creation of new ideas of technical solutions, managerial and financial approaches.



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Implementation of Water Safety Plan for a piped-water supply system in India
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## **Abstract Body \***

The World Health Organization Guidelines for Drinking-Water Quality (Third Edition) term Water Safety Plans (WSPs) as the most effective means of ensuring the safety of a drinking-water supply. Over the last decade, WSPs have gained acceptance as an important framework for achieving water quality and health-based targets. WSPs can be developed for any type of water supply system, piped- or community-based.

This paper describes the process of developing a WSP for a piped-water supply system characterized by interrupted supply hours, ageing infrastructure, low cost recovery and a large number of unregistered connections. The study area, Nagpur, India, was selected based on the willingness of the public operator and availability of government funds.

The study was carried out by the National Environmental Engineering Research Institute (CSIR-NEERI) in collaboration with the World Health Organization (WHO), New Delhi and Nagpur Municipal Corporation (NMC). Activity related to the project was carried out according to the 11 modules of WHO's Water Safety Plan Manual. Risk assessment was carried out at each step of the drinking water supply and based on these findings, an improvement plan was drawn up which includes suggestions regarding corrective actions. Supporting programmes which include training and advocacy material were also prepared.

The findings of this study are being used to prioritize interventions planned as part of the conversion from intermittent to continuous water supply in Nagpur. A number of components of the water supply system are being modified or repaired and management procedures are being upgraded. Longer supply hours, improved water quality and a reduction in the number of unregistered connections have been observed.

Further research is being carried out to better understand the positive impacts of WSP and the kind of challenges being faced during implementation.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Optimising reservoir operation rule curves at Umgeni basin, South Africa
<b>Primary Author Name *</b>	Onyeka Nkwonta
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## Abstract Body \*

Effective water resources development and management is widely recognised as crucial for sustainable economic growth and poverty reduction in many developing countries such as South Africa. The contribution of large hydraulic infrastructure, particularly reservoirs, to development, remains controversial. This controversy stems from the fact that, too often in the past, the construction of reservoirs has brought fewer benefits than envisaged and has resulted in significant social and environmental costs (WCD 2000). Reservoir operation often involves a large number of stakeholders with different objectives, such as domestic and industrial water use, irrigation, flood control and hydropower generation. The conventional methods of operation of reservoirs are based on empirical methods and often the managers of the reservoir system rely on their experience and judgment in taking correct operational decisions. These conventional methods are often not adequate for establishing optimal operation decisions, especially when integrated operation of multipurpose multi-reservoirs is contemplated. In this study, Electrical conductivity (EC) will be used as a surrogate to trace pollution among the monitoring points. The surface raw water pricing structure will be analysed. Evolutionary algorithms in the form of a Rule-Set Function and Bootstrapping will be employed to develop models that will predict treatment chemical dosages. Reservoir rule curves are used for guiding and managing the reservoir operation. These curves typically specify reservoir releases according to the current reservoir level, hydrological conditions, water demands and time of the year. Established rule curves, however, are often not very efficient for balancing the demands from the different water users. Moreover, reservoir operation often includes subjective judgments by the operators. Thus, there is a potential for improving reservoir operating rule curves and small improvements can lead to large benefits. The overall objective of the project is to minimise in real-time water losses from the Umgeni River System and ensure that potable and irrigation demands are met in terms of the water quality and the required quantity at the right time.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	IMPORTANCE OF GREY WATER REUSE IN SOUTH AFRICA
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## Abstract Body \*

It's a waste to irrigate with great quantities of drinking water when plants thrive on used water containing small bits of compost. Unlike a lot of ecological stopgap measures, greywater reuse is a part of the fundamental solution to many ecological problems and will probably remain essentially unchanged in the distant future. Water is abused and wasted by both the wealthy and the poor. Education about water conservation is also needed. This study gives an outline of the sources of grey water in our homes and provides a process of creating awareness on the importance of re-using grey water in our homes, in order to achieve the 7th aim of the millennium development goals by 2015, which is ensuring environmental sustainability.

## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Integrating WASH into development: insights and perspectives
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#### Abstract Body \*

Delivering integrated Water Sanitation and Hygiene (WASH) in emerging regions of the world today remains complicated and increasingly multidimensional. Ensuring sustainable access to Water and Sanitation that responds to local and regional contexts can no longer be as simplistic as the provision of basic infrastructure and services. The WASH domain must move from the traditional and simplistic, to more innovative, inclusive and multi-sectorial interventions, understanding the relations within the other livelihood and development sectors as well as the governance systems within which they function.

WASH directly affects and connects all of the Millennium Development Goals (MDGs) and the expected post-2015 goals. For this reason, it is imperative that WASH always be considered in the true context of wider development issues. Rural communities, and indeed even urban poor populations, are facing dire needs and challenges with their livelihoods now more than ever before. The other livelihood challenges faced by the poor include insecurity and wars, food insecurity, climate change and environmental degradation, land use changes and urbanization.

All these as well as cultural practices, gender norms, ownership and power, decision making structures and inequity continue to hinder the sustainable access to WASH for the rural and urban poor, especially for women and vulnerable groups.

In this epoch, to address the questions of providing life transforming WASH services and infrastructure, WASH must be delivered in the composite context of the wider livelihood and development context of the people. The traditional response of a well and a latrine is no longer tenable if sustainability (defined as continued access) is to be considered as the ultimate outcome. Integrated WASH must go beyond water, sanitation and hygiene being delivered as a stand-alone package to being delivered through the vehicles that address environmental sustainability issues, driven by social and economic factors building businesses and creating prosperity. This is the paradigm shift that is needed, should significant changes be expected in achieving the MDGs and the post-2015 goals.

This shift requires building partnerships, strategic alliances and linkages with other sectors. The health, education and environment sectors are traditional partners to WASH. Going forward, the private sector is increasingly the partner that the sector should court and link with. For every \$1 invested in water and sanitation, an average of \$4 is returned in increased productivity. The market potentials of sanitation particularly need to be better demonstrated and promoted to allow for investments in the urban milieu especially.

Learning from emerging successful models of development that build on existing community social practices and norms ensures sustainable access. Supporting community saving practices in Africa is a viable model that can be adopted in WASH development. It thrives on the power of collective savings and facilitates the

availability of cash within local economies to continue to pay for WASH services and infrastructures yet addressing the other livelihood challenges in these communities.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Evaluation of the Influence of Reactor Design on the Treatment Performance of an Optimized Pilot-Scale Wastewater Treatment System for Developing Nations
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<b>Primary Author Name *</b>	David O. Olukanni
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## **Abstract Body \***

The construction cost for a standard wastewater treatment plant has been a major barrier for the implementation of modern technologies by local authorities in many African nations. These technologies require considerable technical expertise, which is often not available in developing nations to successfully operate these treatment facilities. It is therefore imperative to develop treatment systems that are economical and sustainable. Among the current processes used for wastewater treatment, Waste stabilization pond (WSP) has been identified globally and consistently selected in developing nations as one of the most popular wastewater treatment options due to its high efficiency and low cost. The main focus of this study was to investigate with pilot-scale experiment, the influence of reactor design on the treatment performance of a pilot-scale WSP with specific interest in minimizing the cost of construction material and to maximize the effluent pollutant removal. A typical representative community was selected for establishing WSP design parameters that consider the community's population growth and climatic conditions. A field scale prototype was designed and scaled down to a pilot-scale model using dimensional analysis in the development of the foot print size. Pilot-scale reactors were built with the specifications produced from literature suggested reactor geometric configurations and experimental study was conducted using raw wastewater from a treatment facility to evaluate the performance of optimized pilot-scale WSP configurations. The optimized pilot scale WSPs consisted of an anaerobic, facultative, and a maturation stage with varying baffle orientation, length to width ratio, and depth. 2 mm galvanized metal gauge plates were used for the design of the reactors including the baffle walls. The cost of material per unit surface area was considered a reasonable way to evaluate the cost because the baffle walls were made with the same material as the reactor and matched the reactor depth. The construction cost excludes labor and other costs associated with the construction of the pilot-scale reactors. Comparisons were made on the optimized pilot-scale WSP reactors. The removal performance of the experimental test was based on a number of parameters (Faecal coliform, pH, TDS, and Conductivity). Results showed that the significantly lower cost design displayed slightly better removal performance compared to other WSP design developed from literature data. This paper covers a relevant subject within the field of waste stabilization ponds, namely the representation of the influence of reactor design on the treatment performance of WSP and providing an efficient assessment of alternative pond configurations, thereby, addressing a potential knowledge gap in waste stabilization pond design. The results of this research will directly impact the possible design decisions that wastewater treatment engineers must make related to WSPs design.

# 2013 OU WaTER Conference Abstract Submittal Form

**Abstract Title \*** State of Water, Sanitation and Hygiene (WaSH) Program in Public Secondary Schools in South-Western Nigeria: The Way Forward

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## **Abstract Body \***

The provision of safe water, sanitation and hygiene (WaSH) in educational institutions is globally recognized as a key intervention to promote student's right to health and clean environment. This has been established to improve health, boost educational achievement, and promote gender equity which has a positive impact on the society. However, most public schools in Nigeria are short of the basic water and sanitation facilities, and hygiene education programs are often inadequate. The aim of this study is to ascertain the state of WaSH program in the educational institutions by using public secondary schools as a pilot study. This was assessed by investigating the causes of inadequate potable water supply, poor sanitation and deficient hygiene education in public secondary schools. A total of twelve public schools were selected for the study which span across three Cities (Lagos, Abeokuta and Ota) in two States (Lagos and Ogun), in South-Western Nigeria. The criteria for selecting these schools were based on their prominence in the society and the willingness of the school authorities to grant permit. The standard for WaSH in schools by UNICEF was used as the guiding principles to evaluate the adequacy of the various WaSH components. Sample size, in terms of both numbers of schools and number of students and teachers polled, was influenced by the willingness of the schools to provide information. Data collection methods involved the use of questionnaire, interviews, observation and focus group discussion methods. Out of the 12 public secondary schools visited, only 3 (20%) had drinking water points (boreholes) and 40% of the schools do not have separate latrines for boys and girls. The ratio of toilets to students in the schools ranges between 1:70 to 1:320. Only 1 (10%) of the schools had hand washing points but without soap. It was revealed that Information, Education and Communication (IEC) materials are not provided in any of the public schools and there are no facilities and program in the schools for promoting safety, privacy and security of older girls. This study reveals that the present WaSH facilities and practices in many of the schools are not satisfactory. The possible underlying reasons for poor WASH in the public secondary schools surveyed can be connected to a lack of clear policy, insufficient budget allocations from government and lack of awareness and understanding on the part of the school management system. Therefore, to maximize the potential of students as the most persuasive advocates of good WaSH practices in the society, it is necessary to integrate WaSH program into national education policy and schools should be provided with adequate facilities.

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# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Impact of socioeconomic factors and technology features on household water supply choices in Uganda and the associated environmental consequences
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<b>Primary Author Name *</b>	Christine Prouty
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## **Abstract Body \***

Over the last twenty years or more, Uganda has significantly benefitted from strides in water and sanitation which were initiated by the World Health Organization's Millennium Development Goals. However, as the nation grapples with an increasing population, limited skills for local operation and maintenance of water technologies, and rising costs for improved sources, an independent, compartmentalized look at each issue is not a reasonable path to sustainable solutions. It is important to take a synergistic look at the factors affecting sustainability—social, environmental, and economic.

The goal of this research is to understand the interrelationships between socioeconomic factors, technology features, and household water supply choices. Furthermore, the study will inspect the ways in which people's choices for water supply and treatment have an impact on the environment.

In Uganda, the majority of the population uses a point source water supply (e.g. deep borehole, shallow well, springs, etc). However, these technologies vary with region and between urban and rural populations. For this case study, two villages in Wakiso District on the shores of Lake Victoria were selected—Nalugala and Kitala. The water sources utilized by these villages are boreholes, protected springs, rainwater harvesting tanks, surface and tap water.

This research includes: (1) development and implementation of a country-specific survey of 200 households to gain qualitative and quantitative accounts of socioeconomic factors (e.g., education, gender of head of household, number of household members, etc), technology features (cost, convenience, quality, and quantity of water) and community members' water supply choices; (2) statistical analysis to investigate any relevant correlation between socioeconomic factors, technology features and household choice; and (3) life cycle assessment of each water source and treatment method used in the surveyed communities to highlight their associated environmental impact.

Based on statistical findings from logistic regression analysis, the technology features which are considered most significant to impacting household choice are convenience, visual water quality (turbidity), and cost. Further analysis shows significant correlations between socioeconomic factors (i.e. gender of head of household and construction material of the house's external walls) and household choice of water technology.

Qualitative and quantitative survey data is being analyzed to underscore the gap between community members' perceptions of water quality and actual water quality. This notion (perception vs. reality) is being explored to understand the influence of technology and social aspects on source choice as well as treatment methods.

Future plans for this study are to complete a life cycle assessment of each water source and to quantify the environmental impact of the treatment methods considered—filtering, settling, boiling using various fuels, and chlorination.



# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Developing a Sustainable Non-Governmental Organization Model for Water Projects in Bolivia
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<b>Primary Author Name *</b>	E. O'Neil Robinson, P.E.
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	David Stephenson, Engineers in Action; Dr. Ruben Mamani, Engineers in Action
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## **Abstract Body \***

During the past 5 years, Engineers in Action, an NGO operating exclusively in Bolivia, has launched a unique program aimed at providing sustained support of water and sanitation projects throughout the country. The success of the organization has been based on building a staff of Bolivian engineers whose expertise is dedicated to providing logistical and technical support for volunteer groups and donors with in-country projects. This paper will review several Bolivian projects, outcomes and potential for follow-up research related to obtaining measurable criteria to assess the impact and sustainability of the EIA model.

## 2013 OU WaTER Conference Abstract Submittal Form

**Abstract Title \*** Arsenate Adsorption onto Iron Amended Rubber Tree, *Havea Brasiliensis*, Sawdust Char and Activated Carbon

Primary Author Name \* Hayley Ryckman

**Primary Author Affiliation \*** University of Oklahoma WaTER Center

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**Secondary (Co-) Author(s) and Affiliation(s)** Dr. David Sabatini

## Abstract Body \*

In addition to regions of the United States, many developing countries have arsenic in their groundwater which exceeds the provisional guideline limit of 0.01 mg/L established by the Environmental Protection Agency and World Health Organization. While microbial contamination can cause one to become sick immediately, with long-term intake, chemical contaminants, such as arsenic, can be detrimental to one's health. Arsenic has been classified as a group one carcinogenic by the International Agency for Research and Cancer and can result in arsenicosis, skin lesions, cancer, and is possibly linked to cardiovascular diseases, infertility, and retarded development in children. Common arsenic treatment methods include oxidation, membrane and nano-filtration, enhanced coagulation with iron or aluminum salts, polymeric anion ion exchange, and adsorption using granular ferric hydroxide. Given that UNDP estimates that over half of the world's population lives on less than \$2 a day, the need for sustainable and affordable treatment technologies in emerging regions is essential.

The focus of this research was to develop a sustainable technology to remove arsenic from drinking water, with a focus on Cambodia. From the literature and previous arsenic removal techniques studied at the University of Oklahoma WaTER Center, involving iron amended sand and rice husk char, it has been observed that the starting material and activation method impact pore size distribution while the iron amending technique has an effect on the iron loading. The combination of high surface area, large pores, and high iron distribution results in optimal arsenic adsorption. For this research rubber tree sawdust was selected for study since the tree is widely available in Cambodia, the sawdust is considered a waste product from the milling process, and since the material is highly lignocellulos and can provide high surface areas and pore volumes.

For this research, the rubber tree sawdust received physical or chemical activation treatment to increase its pore size and surface area. Following activation, the media was amended with ferric nitrate or ferrous chloride to provide the necessary surface chemistry to enhance arsenic adsorption. The physical and chemical properties of the unamended and amended materials were analyzed and compared. The adsorption capacity of each media was determined to see which of the selected physical and chemical activation methods resulted in the optimal physical characteristics for iron loading and arsenic removal.

The hypothesis predicted that chemically activated iron amended medium would provide better adsorption compared to the physically activated material because of a combination of higher specific surface areas, greater percentage of meso- and macropores, and increased iron content. We also hypothesized that the media amended with the ferrous chloride amending method (Gu, et al., 2005) would provide greater iron loading and adsorption when compared to the  $\text{Fe}(\text{NO}_3)_3$  amended media (Chen, et al., 2007) since the iron would be able to penetrate into the pores during the amending stages prior to oxidizing. Lastly, we hypothesized that the precursor material would impact the iron loading and arsenate adsorption capacity. Results elucidating and confirming these hypotheses will be presented.

## 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Capacity Building: Collaborative Graduate Program with Chulalongkorn University, Bangkok, Thailand
<b>Primary Author Name *</b>	David Sabatini
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	M. Nanny, R. Kolar, R. Knox, Sutha Khaodhiar, Manaskorn Rachakornkij and Chantira Tongcumpou; National Center for Environmental and Hazardous Waste Management (EHWM)

### **Abstract Body \***

Since 2002 we have participated in an international graduate program with the National Research Center of Excellence for Environmental and Hazardous Waste Management (EHWM) at Chulalongkorn University in Bangkok, Thailand. Chulalongkorn University is the oldest and is widely considered the most distinguished university in Thailand, founded in honor of King Chulalongkorn in 1917. Other universities participating in this collaborative graduate program include NJIT, Iowa State, and South Dakota State. As part of the collaboration OU faculty teach graduate courses at Chulalongkorn in a four week format that has the same number of contact hours as when taught at OU, with courses range from environmental chemistry to ground water quality protection. Over time Chulalongkorn faculty have integrated into teaching the courses and are currently teaching one-half of each course. In addition to teaching, OU faculty co-advise graduate students, training both the students and Chulalongkorn co-advisers in research. Many Ph.D. students spend four to five months each year working on their research at OU. Examples of research conducted by Chulalongkorn students are: water treatment processes, sorption and transport of pharmaceutical compounds in the subsurface, surfactant-modified surfaces as environmental adsorbents, and surfactant microemulsions for replacing hexane in oil seed extraction.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Defluoridation using Bone char in the Ethiopian Rift Valley
<b>Primary Author Name *</b>	Mengesha Esayas Samuel
<b>Primary Author Affiliation *</b>	NGO (Oromo Self Help Organization)
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Ariane Schertenleib: research institute (Eawag); Sisay Feyera, , Feyisa Lema and Gutema Kissi: NGO (OSHO)

## Abstract Body \*

Around a billion people most living in the developing world do not have access to safe and adequate water (UNICEF/WHO, 2012). The WHO estimated that around 94% of the global diarrheal burden and 10% of the total disease burden are due to unsafe drinking water, inadequate sanitation, and poor hygienic practices. In Ethiopia unsafe water due to biological contamination and excess fluoride in ground water that causes endemic fluorosis are the major concerns related to water. According to Tekle-Haimanot (1990) over 80% of the children in selected areas have developed varying degrees of dental fluorosis, while an increasing number of crippling skeletal fluorosis cases are being seen among people who have consumed high fluoride over a long period of time. It was predicted that over 80% of the total population in the Ethiopian Rift Valley are exposed and are likely to develop endemic fluorosis unless preventive measures are taken (Tekle-Haimanot, 2006). Since the first report of fluorosis in 1960's in Wonji Showa Sugar estate only finger counted defluoridation technologies were attempted in Ethiopia. These technologies didn't prove to be sustainable and failed to be scaled up to the required level due to inadequate capacity; lack of understanding of the limitation associated with the technologies; affordability; lack of awareness by the users and absence of proper material supply chain. Cognizant of the fact that there is no defluoridation technique sustainably implemented in Ethiopia so far, Oromo Self Help Organization (OSHO) initiated defluoridation project which has been looking at field testing and implementation of low cost fluoride removal techniques such as bone char and contact precipitation. Bone char had been considered unaccepted technology to treat water with high fluoride due to cultural and religious reasons in Ethiopia (Tekle-Haimanot et al, 2006). However studies and field implementation experience showed that the acceptance is directly related with the quality of bone char but not with the technology (Samuel E. et al 2009). There was no objection to the household and community bone char filters implemented by OSHO over the last 4 years in 3 districts and more than 8 villages with the distribution of 320 household and construction of 3 community filters (Samuel E. et al 2013). In 2013 OSHO will construct a total of 6 additional community filters, out of which 2 are already operational; increasing the bone char community fluoride filters to 9. OSHO in collaboration with Nakuru Defluoridation Co. (NDC) and Swiss Federal Institute of Aquatic Science and Technology (Eawag) established the first bone char production facility in Ethiopia in 2011 with the financial support of Swiss Inter-Church Aid (HEKS). The annual production capacity is around 10tons of grey bone char with various particle sizes. This paper presents the bone char production process, regeneration and its fluoride removal capacity both at laboratory and field level.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Components & Cost Benefit Analysis of Properly Constructed Wells
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<b>Primary Author Name *</b>	Steve Schneider
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**Abstract Body \***

Wells are the primary source of drinking water in developing countries, especially in rural areas. Without clean water, it is doubtful that adequate sanitation is achievable. This presentation will discuss the importance of proper well construction and maintenance for the long term health and safety of its users, in addition to providing groundwater resource protection for future use. The presentation will also discuss the results of a cost-benefit analysis of properly constructed wells. Attendees, especially those who specify, regulate or construct wells in developing countries, will be provided the latest English edition of WATER SUPPLY WELL GUIDELINES for use in DEVELOPING COUNTRIES along with a customizable tool for analyzing the Cost-Benefit of proper well construction for their own application.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Willingness to Pay for Sanitary Latrines and the Impact of Financing on Latrine Sales – Evidence from a Cluster Randomized Trial in rural Cambodia
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<b>Primary Author Name *</b>	Neil Buddy Shah, MD, MPA/ID
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<b>Secondary (Co-) Author(s) and Affiliation(s)</b>	Stu Taylor, iDE; Stuart Shirrell, IDinsight; Tamara Baker, iDE
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## Abstract Body \*

This study answers two related questions central to understanding how to increase access to sanitary latrines in rural Cambodia – 1) what is the true willingness to pay for latrines and 2) what is the impact of consumer financing on latrine uptake? The true willingness to pay for latrines was measured using the Becker–deGroot–Marschak (BDM) mechanism, which is an incentive compatible auction procedure used in experimental economics to accurately measure willingness to pay. We find that average willingness to pay for a low-cost sanitary latrine is 28 US dollars (USD), as compared to the average market price of 50 USD. In a cluster randomized trial, we test the impact of offering a latrine financing package (in the form of a declining balance 12 month loan with 2.8% monthly interest) on latrine uptake. We find that willingness to pay for latrines increases from 28 USD without financing to 50 USD in principal (excluding interest on the loan) with financing. This means that 12% of all non-latrine owners would buy a latrine at market price without financing, whereas 50% would buy a latrine at market price with financing. Furthermore, the operational cost per latrine sold is decreased by 70% in the financing study arm, because many more latrines are sold at each village sales meeting. This four-fold increase in sales at market price and 70% decrease in operational cost per latrine sold due to financing provides strong evidence that expanding access to consumer financing for latrines has the potential to dramatically improve sanitation in rural Cambodia. This study was the result of an action research collaboration between iDE–International Development Enterprises and IDinsight (the lead research partner). VisionFund was the microfinance partner.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	The Challenges of Water Well Drilling in Niger West Africa
<b>Primary Author Name *</b>	John C. Stam
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## Abstract Body \*

**Introduction:** Starting out with significant and demonstrated need, a shared vision, and a great amount of enthusiasm, we have learned much after 9 years of searching for water in sub-Saharan Africa.

As a result of a 2004 trip to Niger we became convinced clean water was one of the greatest needs of this impoverished, land-locked, overlooked country. After training by Living Water of Houston, TX, we shipped our first drilling rig in the fall of 2004. In January 2005 we completed our first two wells. We are now on target to send six teams this coming year. In the fall of 2009 we shipped a much larger trailer-mounted rig, which allows us to do in one day what used to take five.

**Results and Discussion:** To date, through rotary drilling, we have completed 35 producing wells. Our wells vary from 26' to 160'. We have found the drilling conditions to be difficult and varied. We often run into un-consolidated, non-producing gravel zones, which frequently cause us to lose circulation of our drilling fluids. To date we've been unable to successfully seal off these "loss-of-circulation" zones. We've attempted very thick slurries of drilling muds, and have discussed using locally available millet husks. However, this past year we shipped in foaming agents and an injection pump, and these have proved relatively successful. However, it also introduces significant additional expense, as these products are not available in country.

At the very beginning of our drilling efforts we made the training of a Nigerian team a high priority. We now have six team members who assist us in our drilling efforts. At the conclusion of our drilling trips, our African team members complete the development of our wells and install the pumps. They also handle the necessary maintenance of the installed pumps.

At the beginning of our experience we saw the need to keep our pumping mechanisms as simple and inexpensive as possible. Niger is littered with broken western technology for which there is neither the will nor the money for repair. We initially used a hand pump called a "bush pump" for which parts are easily obtained. After researching various pumps, we switched to the AfriDev as the bush pump did not hold up well, especially in some of the environments where our pumps served a village of 1,000–2,000 people. We shipped a container of 100 AfriDev pumps into Niger from India in the summer of 2009.

**The Future:** We are committed to seeing our water well program benefit the people of Niger for years to come. Some of the challenges we face are:

1. Increase village level ownership of each well through village well committees and nominal use fees
2. On-going training and expertise of our Niger Team
3. Addition of a sustainable drilling method that can be carried on by our Nigerian team possibly by moving in the direction of a Water4 cable rig
4. Soliciting additional donations at \$2,500 per well
5. Developing a replacement program for drilling equipment and vehicles

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Market-Based Water, Sanitation, & Hygiene (WASH) Approach
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## Abstract Body \*

Market-Based Water, Sanitation, & Hygiene (WASH) Approach

Stimulating the Private-Sector to Provide Appropriate & Sustainable WASH Services in Uganda

Problem Statement

The current supply-driven approach to WASH in rural Uganda has not adequately addressed the large gap in access to key WASH services: safe water-68% & sanitation-34% (UNICEF/WHO, 2012).

Few countries have achieved universal safe water coverage without a market-based, self-supply approach to water provision (Kiwauka, 2011).

Objectives

To advocate for sustainable, market-based WASH services.

To strengthen the WASH capacity of the private-sector.

Results

World Vision Uganda (WVU) has trained private enterprises in manual drilling (3), rope pump fabricating (2), sanitation slab production (10) and managing tree nurseries (7)

There has been an increased demand for manually-drilled water sources due to cost reduction and availability of services: \$720 USD compared to the conventional machine-drilled well of \$7,500 USD.

Low-cost rope pumps are available in Uganda as an alternative to India Mark II hand pumps for shallow wells.

Implementation Process

WVU helped to shape the Gov't of Uganda's National Self-Supply Strategy for water provision and trained local Gov't staff in the target districts on low-cost WASH approaches to contribute to self-supply initiatives. WVU gained the support and buy-in of local government to promote this technology by working under the above self-supply framework.

Trained and mentored private-sector enterprises in: low-cost water supply; sanitation slabs; tree nurseries; equipment for People with Disabilities (PWDs), etc.

WVU established linkages with international NGOs that have documented best practices in area of market-based, low-cost WASH (e.g. SHIPO, MSABI, Connect Int'l).

Trained other NGOs on low-cost WASH approaches (e.g. Mercy Corps) and WASH for PWDs.

Lessons Learned

Enabling Environment - World Vision is benefitting from the support of the central government, since the project is implementing a 'strategic issue' on the government's agenda (e.g. piloting market-based WASH approaches).

False Economy vs. "Base of Pyramid" - The private WASH sector have been "cocooned" in a false economy created by NGOs and foreign funds, which has resulted in inflated prices for low-cost interventions. World Vision is working with them to understand the potential business opportunities of targeting the "base of the



pyramid" market.

Supply Chain – For new private-sector WASH services to last, there is need to strengthen the supply chain in order to overcome general problems of inadequate access to quality materials in the rural areas.

Access to Micro-finance – Many private-sector players and potential consumers require start-up capital to invest in the low-cost WASH interventions.

#### Way Forward

As more data is generated from WVU's initial market-based WASH interventions, WVU will modify approaches and scale-up promising approaches to other ADPs throughout Uganda. Promotion of low-cost, market-based WASH approaches is an attractive option for both Gov't/Corporate/Foundation donors, as well as for long-term ADP programming.

WVU will continue to promote adequate supply chains, in order to support low-cost WASH services in target areas.

WVU needs to strengthen its existing financing models (e.g. "rent to own" equipment, etc.) in order to expand WASH services to more markets (e.g. the vulnerable).

#### Conclusion

A solid self-supply strategy framework exists in Uganda, which provides an enabling environment for market-based WASH interventions.

There is significant interest in promoting market-based WASH interventions among the following key stakeholders: 1) government, 2) NGOs, 3) Private sector, and 4) communities.

Functional private-sector WASH service delivery enterprises exist in communities to provide low-cost WASH services.

Demand for low-cost WASH services is on the rise in target communities. Low-cost, appropriate technology is expanding the WASH private sector in Uganda, while providing consumers alternative technology options within their financial reach.

#### References

UNICEF/WHO (2012). Progress on Drinking Water and Sanitation – 2012 Update.

Kiwanuka, J (2011). Accelerating Access to Safe and Reliable Water Through Self Supply In Uganda. 6th Rural Water Supply Network (RWSN) Forum 2011. Kampala, Uganda.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Dental Fluorosis and the extended health effects in children: Guidelines for rectification and improving the well-being of children
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Ground water contamination with fluoride is a problem causing scarcity of safe water (with  $F^- < 1.0$  mg/l) for human consumption in India and other developing countries. The objective of this communication is to highlight the health issues emanating in children as a result of fluoride poisoning. Dental Fluorosis is a warning to suspect a variety of other health issues which have disastrous consequences on the growth and development of the children. Children with Dental Fluorosis have been investigated for:

i. Thyroid hormone levels. Fluorosis and iodine deficiency disorders (IDD) co-exist. The primary cause of IDD may not be always due iodine deficiency; but it can be induced by  $F^-$  poisoning. Prevention and control of Fluorosis and IDD therefore require an integrated approach for diagnosis and patient management contrary to the existing practises. Children with Dental Fluorosis living in endemic area of Fluorosis may have thyroid hormone derangement that requires special care and attention.

ii. Rickets but would not respond to treatment i.e. drug resistant category. Fluoride is withdrawn from consumption and gastric mucosa and microvilli regenerate so that orally administered calcium and vitamin D are absorbed and Rickets rectified in children.

iii. Anemia in children with hemoglobin  $< 12.0$  g/dl. Diet editing and Diet counseling called for, for improving the health of such children. The results of 2500 school children aged 10-17 investigated upon fluoride poisoning and anemia rectified.

iv. Low IQ may be due to sub-normal brain development. The presentation is focusing on the above, the extended health effects of children following ingestion of fluoride more than 1.0 mg/l for a long period which may commence from intra-uterine life, fluoride entry through maternal blood. The guidelines for addressing of the above health issues are highlighted in the presentation.

In all the 4 categories of ailments in children due to fluoride poisoning besides detecting Dental Fluorosis, estimation of fluoride in drinking water, urine are indeed necessary to assess the situation correctly for introducing interventions besides therapeutic modalities.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Climate Change Impacts on Rain-fed Agriculture and Crop Yields in the Niger Basin
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## Abstract Body \*

Around 65% of the labor force in the Niger Basin depends on rain-fed agriculture for their livelihood. Globally, rain-fed agriculture accounts for approximately 62% of the world's staple foods. Economically, rain-fed agriculture also accounts for about 45% of the GDP of sub Saharan African (SSA) countries. Despite such contributions, much emphasis on food security in SSA tends to focus on irrigation agriculture. However, irrigation development faces a number of constraints related to affordability of water, access and tenure to irrigation lands, as well as inertia on the parts of farmers to convert from rain-fed agricultural systems to irrigation even where opportunities for doing so exist. Thus, even if all of the irrigation agriculture potential in the Niger basin was fully developed, food security would not be achieved. Therefore, addressing climate risks related to both irrigation and rain-fed agriculture is critical to achieving food security in the Niger basin. Climate change adaptation and management measures must include both agricultural systems.

This study used the CROPWAT and AQUACROP software to investigate changes in reference evapotranspiration (ET<sub>o</sub>), crop water consumption (ET<sub>c</sub>) and crop yields for various temperature and precipitation change scenarios. The scenarios include combinations of average annual temperature changes of 1°C, 2°C, and 3°C as well as average annual precipitation changes of -10%, +5%, and +10%. The crops investigated include millet, sorghum, cowpeas, and maize for select sites in the Niger basin. The data used come from the CLIMWAT 2.0 data base of FAO, as well as inbuilt data bases in AQUACROP. For each climate change scenario, we compare ET<sub>o</sub>, ET<sub>c</sub>, and crop yield for the present (climatic normal) and future climate.

The results show that ET<sub>o</sub> and ET<sub>c</sub> are likely to change by 2% for each 1°C increase in average annual temperature. Thus, by 2050, both ET<sub>o</sub> and ET<sub>c</sub> would have increased by 4%, slightly conservative but consistent with the estimates derived in other sources (4.5% to 5%). Further, crop yields increase nearly linearly as a function of precipitation increase, on average about 2.00% for each percentage increase in precipitation. In contrast, yield decrease as a function of temperature increase by approximately 5-9% for each 1°C increase, depending on location and the crop. The combination of increasing temperature and decreasing precipitation provides the worst-case scenario for crop yields. For both millet and cowpea, a 2°C temperature increase and 10% precipitation decline results in greater than 25% reduction in yields. For sorghum, losses approach 50% in semi arid west Africa.

Moderate temperature rise (1°C to 20C) combined with precipitation rise may still produce higher yields in several crops. This scenario needs to be considered as an important adaptation measure that allows farmers to take part of the time advantage of increased rainfall. In other words, climate change may hold some opportunities for increasing crop yields. For all levels of temperature change considered, precipitation increase moderates the effects of temperature increase.

## 2013 OU WaTER Conference Abstract Submittal Form

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**Abstract Title \*** Adaptation to changing water demand and climates in Sub-Saharan Africa: the role of groundwater

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**Abstract Body \***

Freshwater demand in Sub-Saharan Africa (SSA) is expected to increase substantially in coming decades with projected rises in land under irrigation and water volumes required for domestic and industrial purposes. Anthropogenic warming is projected to further amplify variability in rainfall and river discharge that is already the most extreme in the world. Current metrics of freshwater availability (e.g. water stress index, relative water demand) misrepresent the "water crisis" in SSA as they greatly exaggerate freshwater demand, define renewable freshwater resources in terms of mean river discharge and, critically, exclude groundwater storage. Total groundwater storage in Africa (~0.66 million km<sup>3</sup>) is more than 100 times annual renewable freshwater resources, and more than 20 times the volume of freshwater stored in African lakes. Although substantial quantities of fossil groundwater in Africa have long been known to exist and are heavily exploited in arid landscapes remote from people (e.g. Great Man-Made River Project), less well understood is the comparatively small (equivalent to water depth of 0.5m) but vital groundwater storage that underlies much of SSA where people live. The extent to which this estimated groundwater storage is both accessible and renewable remains unclear. Recent research based on ground-based observations in semi-arid and humid areas of Tanzania and Uganda reveals the strong dependence of groundwater recharge on heavy rainfall events in excess of 10 mm per day and extreme rain events associated with the El Niño Southern Oscillation (ENSO). Consequently, the shift to fewer but heavier rainfall events projected under climate change may enhance groundwater recharge while reducing rain-fed soil moisture and exacerbating flooding. Under such circumstances, increased use of groundwater resources not only to supplement soil moisture through irrigation but also to meet increased freshwater demand may prove a hydro-logical adaptation in SSA. Increased reliance upon groundwater resources has led to groundwater depletion of regional aquifer systems in the USA, China and India through competitive abstraction and aquifer mismanagement. In contrast, aquifer systems underlying much of SSA are localized and characterized by low transmissivities and low storage. 'Small is beautiful' since these systems greatly restrict the impact of competitive, unregulated abstraction witnessed in other groundwater-dependent countries and enable low-intensity abstraction for which the impacts of overuse are largely localized. Thus, the prevailing geology naturally resolves the 'Tragedy of the (aquifer) Commons' that complicates management of productive, regional aquifer systems. Indeed, the potential for distributed, low-intensity groundwater use strongly complements land tenure systems in SSA that are characterized by a large number of distributed, smallholder (< 1 hectare) plots. Groundwater in SSA represents a low-cost, distributed and potentially renewable store of freshwater that can enable many communities to adapt to changing water demand and climates. Two key physical challenges that currently constrain the realization of this potential are: (1) reducing the prohibitively high cost of drilling that currently impedes the development of groundwater by small landholders; and (2) resolving the aggregated impact of multiple low-intensity groundwater users to ensure the continuity of groundwater supplies and groundwater-dependent ecosystems.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Bringing safe and reliable drinking water to abiginal communities in Canada's Far North
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## Abstract Body \*

Federal and Territorial governments in Canada struggle to provide adequate utility infrastructure to remote communities in Canada, particularly in the sparsely populated Northwest Territories and Nunavut. Most of these small, remote communities are predominately populated by Aboriginal Canadians and the Federal government of Canada has a constitutional obligation to provide essential services including safe and reliable drinking water.

In 2008 the Government of the Northwest Territories, with substantial funding from the Government of Canada, issued a Request for Proposals to qualified entities to provide "turn-key" design, engineering, fabrication, assembly, delivery, installation and commissioning of five (5) modular water treatment plants for the remote communities of Edzo, Deline, Tuktoyuktuk, Aklavik, and Ulayaoutuk. The population of these communities varied from as few as 250 people in Ulayaoutuk to 1,500 in Tuktoyuktuk and the raw water quality varied from pristine lake water to extremely high turbidity water from the McKenzie River.

Corix Water Systems was the successful bidder and, following the negotiation of a fixed price contract with an absolute deadline of March 31st, 2010, set out in late 2009 to complete the project. Corix had to address considerable challenges presented by the project including;

- A lack of skilled trades people in the communities
- Minimal, if any, support services in the communities (e.g. fabrication shops, lifting equipment, construction equipment)
- Limited skills and training of the water plant operators in the communities
- The requirement to provide water service during installation of the new plants
- Limited transportation options (e.g. river barges, winter (ice) roads)
- Severe winter weather conditions for many months of the year thereby limiting transportation and installation timing
- Guaranteed operation of the plants for the initial 24 months following installation and long term warranties for materials and workmanship

To address these formidable challenges Corix employed a number of innovative approaches to the project including;

- The design and fabrication of fully self-contained modular water treatment plants with length, width and height dimensions that allowed for transport by truck over normal highways and roads in Canada. As well, the modular units were built with weight restrictions in mind but were also built on robust frames that could withstand the forces applying by excavating and earth moving equipment used to lift and place the units at their final locations.
- The fully self contained units included interior heating, back-up power supply, water testing facilities, remote communication capabilities and other requirements all enclosed within structurally designed, insulated wall panels that could meet the harsh winter weather conditions often reaching -40 degrees C or

lower for extended periods of time.

- The modular units were made fully operational at a subcontractor site in Edmonton, Alberta and fully tested for operational capabilities prior to acceptance by government officials and shipping to the north.
- With all relevant dimensions and specifications known prior to arrival of the modular plants at site, most of the site preparation work was completed in advance including preparing foundations for the new plant, new power supply arrangements, etc.

One of the most significant challenges was to address the training needs of the water plant operators. Many of the communities have small populations (less than 300 people) with few formally trained individuals and minimal access to accredited training facilities. Often, the village staff tasked with operating and maintaining the water treatment plants have other duties in the community which limits the time they can spend on duties related to the water treatment plant.

To address the training challenge, Corix provided the following;

- Intensive training for plant operations and maintenance to local and regional staff at the time of commissioning the plants. As every component of the plant has to be proven operational before being officially accepted by the Government, Corix must demonstrate the operation of each segment of the treatment process as well as the ancillary equipment such as the standby generator and the oil fired heating system.
- Corix installed remote monitoring equipment for each plant and can scan and evaluate operation of the plants from thousands of kilometres away. If a local operator is having any difficulty with operation or maintenance of the plant they can contact a Corix technician for assistance and that technician can access the plant systems remotely to obtain real time information.
- In addition to providing all required manuals for the plants, Corix provided the operators with an interactive, computer based training module that includes photos of the actual equipment at each site and specific details regarding operation and maintenance. By scrolling over the graphic of each phase of the treatment process the operator has more detail about that particular piece of equipment pop up on screen and the ability to immediately reference greater detail.

Notwithstanding the formidable challenges with the project, Corix met the contractual requirements and had all five modular water plants delivered, installed, and operational by the March 31st, 2010 deadline and within the government's budget constraints. The success of the first project to deliver five modular water plants resulted in Corix being successful in winning the competition to supply an additional five plants to another five remote communities. Corix has already completed the design fabrication, transportation and installation of four of the five plants.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Intercultural Bridges for Sustainable Projects: Experiences of Rural Development Projects in Bolivia
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## **Abstract Body \***

One of the greatest practical and intellectual challenges facing humankind is improving the anti-poverty performance of investments (Chambers, 1988). This was written almost two decades ago. Poverty has grown, but so has experience.

In the mid 90's the EU did a study that showed that only the 20 % of these projects were acceptable. It is considered risky to invest in rural development projects. This perception comes from the failure of thousands of projects that invested large amounts of money and people in technical support, infrastructure, training, etc. If the decision to start a rural development project in an emerging country is based on the results of previous projects, the communities would be condemned to eternal poverty, they will be considered unviable, incapable to maintain sustainable a project.

While working in Bolivia with engineering projects the scenario doesn't change much; almost every community has had an NGO working with them or at least they have heard about the NGO's work. Many communities have a bad perception of NGO's; some do not allow them in their communities at all.

We are used to open-ended projects with high investments and very modest results. So much so that many believe that it is not even possible to generate rapid and significant change in poor communities (Imerzeel, 2006). Engineers In Action (EIA) has been working in Bolivia since 2005. There are aspects that make EIA a special NGO that have helped attain sustainability in rural development projects. The variety of projects EIA has implemented (erosion control, well drilling, eco-latrines, etc.) comes from EIA's belief that the communities are the solution, not the problem; they will be the ones who determine their needs and a Participatory Development of Technology (PDT) will be applied.

One of the characteristics of EIA is the creation of "intercultural bridges", which are strong motivators for action and strengthen the cultural identity and self-esteem of the people. This is a first and essential step to strengthen people's organizations. These bridges are built between the indigenous communities, local authorities/organizations, North American universities (students, teachers, etc.) and indigenous engineers.

Intercultural bridges are the engine of EIA projects. Engineers from U.S. universities share their technical knowledge to improve the quality of life of Bolivian indigenous communities. These communities share their knowledge too, a knowledge that would have never been gained in a university; this helps young engineers find a meaning for their careers, making these engineers eager to work in similar projects during their professional life. Indigenous engineers are the link between indigenous communities, U.S. engineers and local authorities; they provide the necessary resources each of these actors need to build trust and motivation for the development of the projects.

Over 24 projects, reaching over 30,000 people and saving an estimated 30-50 children from dying from waterborne diseases each year is the result of the joint will of U.S. engineers, indigenous engineers and indigenous communities to improve the quality of life in rural communities, by helping each other in a horizontal level, building bridges.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Socio-economic factors affecting the adoption of Ecological Sanitation approach in Benin
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## Abstract Body \*

Since 2002, WSA-BENIN has introduced ecological sanitation (EcoSan) approach in Beninese communities. The purpose of this paper is to identify the factors which influence the adoption of EcoSan approach. Socio-economic investigations were carried out using a questionnaire addressed to a random sample of 268 heads of households who benefit from EcoSan facilities or not, who use EcoSan fertilizers or not. The heads of household are chosen from a random sample of 15 villages selected among those which are implied in the project as well as those surrounding the firsts but not implied in the project. Data are collected mainly on the socio-economic characteristics of households, the institutional and physical factors, and on the perceptions of heads of households about EcoSan approach. These data were analyzed with descriptive statistics. The adoption decision is modeled following Saha et al. (1994) and Dimara and Skuras (2003) who stated that people can only adopt a technology if they are aware of it. Once an information threshold is crossed the adoption decision becomes relevant. Probit model is used to estimate Ecosan approach's adoption equation according to the procedure suggested by Heckman (1979) to avoid selection bias. According to Heckman (1979), we obtain the Probit estimate from the Probit selection equation in order to estimate the so-called inverse mills ratio (IMR). As a second step, we add the IMR in the Ecosan approach's adoption equation and we obtain the estimates. The results show that the sample is characterized by a majority of men (83%). Only 33% has received a formal education. The main activity of the heads of households is still agriculture (48%). Some of them do business (10%) and craft industry (18%). About perceptions, more than 50% of the sample thinks that consumers won't have a reticence relate crop fertilized with Ecosan fertilizers. But they all accept that the necessity to mix urine with water is a constraint. They all think also that excreta are as rich in nutrient as mineral fertilizers. Six variables appeared determinant in the probability of adoption of the EcoSan approach. These variables are: access to credit, perception about initial investment cost of the EcoSan technology, perception about easiness of the use of the EcoSan facilities, perception about the competitiveness of the EcoSan fertilizers in comparison with the mineral fertilizers, age and level of education. The analysis with Likelihood-Ratio test showed also that the information source influences the adoption of the EcoSan approach. The results revealed a difference in term of behavior of adoption of the EcoSan approach between people who are informed by the agents of dissemination and those who are informed by the endogenous hygiene committees. The households are more convinced by the dissemination agents of WSA than hygiene committees composed of endogenous agents. The recommendations suggested by the findings are: to set up a policy of adapted credit and to continue the experimentation of sensitization by village hygiene committees whose capacities should be reinforced for more effective influence on communities' perception of the EcoSan approach



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	A Non-Linear Systems Approach to Sustainable Rural Water Services in Developing Communities
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## **Abstract Body \***

The objective of this study was to investigate the appropriateness and application of system dynamic modeling with iSee's STELLA to aid in the strategic planning and program operation for international water interventions in developing countries. As a high percentage of international WASH interventions have failed, there is a need for a thoughtful systems based approach to navigate within the complex and non-linear constraints of economical, political, technical and social influences that often confound the sustainability of water services. Initial system dynamic model parameters were prioritized and calibrated using the analytic hierarchy process (AHP). A case study plan was created with survey questions to validate the SD model parameters based on these prioritized system parameters. Using case studies from water aid organizations in Central America, qualitative and quantitative data related to project sustainability was used to validate the reinforcing and balancing feedback loops that describe water services during their lifetime. The concept of viability loops was used as a way to predict the effect of intervention strategies to balance out destructive influences that can lead to system failure. While the general concept of applying system dynamics approaches with STELLA to aid in the formation of better informed WASH intervention strategies shows incredible promise, further program modeling and collaborative learning is needed to create a more robust and useful model.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Cloud-based Crowd-sourcing Global Flood Disaster Community Cyber-infrastructure
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## Abstract Body \*

Flood disasters have significant impact on the development of communities globally and often connected with life and property losses. It is increasingly important to create a unified cyber-infrastructure to collect, organize and manage flood disaster information and provide these useful information back to both authorities and the public. Global Flood Inventory (GFI) was used as our primary data source to create this cyber-infrastructure (<http://eos.ou.edu/flood/>). GFI was organized by our group, which contains detailed information of global flood events from 1998 to 2008. In order to expand our data inventory to the present, we provide web entry for the public to report their witness of flood events. Cloud computing is integrated in this cyber-infrastructure by utilizing services provided by Google, which accelerates the speed during data processing and visualization over the internet. As a cloud-base cyber-infrastructure, people can access it from any places around the world with access to the internet. Data download is also provided to the public and flood events are linked to our group's existing real-time surface runoff and precipitation products which verify the flood events reports from crowd sourcing and provide more details about a particular event. The goal of this cyber-infrastructure is to better serve the global water community, provide essential information about water-related disasters (floods, droughts, and landslides in the future) and help people to prevent unnecessary damages caused by these disasters.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Integrating the Edutainment social approach in hygiene and fluorosis mitigation Behavioral change: A case study of Mirera-Karagita in Naivasha, Kenya
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## Abstract Body \*

According to the experiences of CDN (P. Jacobsen 2006), the fight against fluorosis has not really been in the limelight and this was, and partly still is attributed poor information flow. Nakuru Defluoridation Company Ltd (NDC) took the challenge of finding a way to reduce the fluoride concentration to acceptable levels. After having an applicable Defluoridation technology, it has become necessary to introduce fluorosis effects and hygiene promotion to the target groups. Awareness creation and training facilitated increase in uptake of the technology alongside proper hygiene. NDC has considerable experience of community awareness creation and long-term reinforcement of hygiene and fluoride messages. This has been through, building theatres for community projects through its relationships with Partners. Whilst NDC's expertise originally grew out of scientific research and expertise, it has since learnt the importance of taking a holistic approach to disseminating the technology it developed, recognizing that the social dimension cannot be divorced from the technology. Mirera-Karagita is an urban poor estate in Naivasha town. Naivasha Municipality in Kenya's Rift Valley is home to Lake Naivasha, Kenya's second largest freshwater lake – yet most low income people in the surrounding areas are unable to access safe, potable and affordable water. Residents mainly depend on underground drinking water sources, with high fluoride levels. Consumption of water with high fluoride levels causes fluorosis, dental fluorosis and skeletal fluorosis. A hygiene and fluorosis behavioral campaign was carried out using an edutainment approach and mandated to carryout sessions for analyzing community risk behavior and development of appropriate messages covering hygiene and fluorosis. Propose and develop an appropriate education and entertainment methodology and tools for communicating hygiene and sanitation behavior messages. Carry out the hygiene promotion campaigns in Mirera-Karagita Area of Naivasha Municipality and Conduct campaign efficacy monitoring. The baseline study that focused on Naivasha showed that the major challenges with fluorosis were Supply versus Quality, Poverty, attitude, social beliefs & religious norms, lack of knowledge, Technological challenges and availability of filters. The driving factors were prevalent in fluorosis and social discrimination. While in Hygiene the challenges were lack of water, poverty, lack of knowledge and ignorance. The driving factors here were high rise in diseases related to poor hygiene and death of children <5 years. This edutainment approach involved creative youths who use their creativity and existing scenario in plays, skits, poems and songs to influence the target population. The target groups were in schools, flower farms and Market places. The findings showed a high impact in using the edutainment approach that kept the audience alert and the concept of imitating their own behaviors' to express their failures and how to overcome them changed them. The impact of positive behavior rose up to 95% in fluorosis and 98% in hygiene behavior practices. The aim of this paper is to share experiences in using the edutainment approach to impact on behavioral change in water sanitation and hygiene campaigns. These findings will go a long way in ensuring sustainable projects and technologies implementation hence a healthy community.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Optimization of bone char technology for Fluoride removal in drinking water: Fluoride removal by Co-precipitation with Calcium and Phosphate using bone char as a media/catalyst for the precipitation. "A case study of Nakuru technology (Pellets)"
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## Abstract Body \*

This paper describes the development of contact precipitation as a method of defluoridation of water. In this method, water with fluoride is brought into contact with calcium phosphate pellets in presence of bone char which acts as a catalyst. The main processes involved in contact precipitation are mainly dissolution and precipitation. The process is studied in columns on a laboratory scale. An appropriate set up from the laboratory experiments is then designed and then implemented in the field using low cost and locally available material. For the minimization of the prevalent of the dental fluorosis as well as skeletal fluorosis, the demand for efficient method of defluoridation of drinking water has increased in the recent past. Because fluorosis especially dental fluorosis is endemic in many developing countries, simple and inexpensive methods such as bone char method which is an adsorption/ ion exchange has attracted many people. Though bone char method is simple and inexpensive, it suffered a number of disadvantages such as: regeneration is not easy and the lifespan of the filter is shorter. To overcome these drawbacks, contact precipitation as a method of fluoride removal is more effective. In this method ion exchange and surface adsorption on bone char are regarded as supplementary reactions rather than principal mechanism. In contact precipitation, fluoride is precipitated with calcium and phosphate which is added to the water. The chemical processes involved are assumed to be basically dissolution and precipitation of a combination of Calcium Fluoride ( $\text{CaF}_2$ ) and fluorapatite ( $\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$ ) Using this concept, Nakuru Defluoridation Company Limited (NDC), is currently producing Pellets (Nakuru Technique) which releases these two elements essential for precipitation fluorapatite and calcium fluoride. Since early 2004 NDC in collaboration with Swiss Federal Institute of Aquatic Science and Technology (Eawag) has been carrying out laboratory experiments to further develop the idea of contact precipitation, using pellets that release Calcium and Phosphate instead of continuously adding the chemicals. The production of these pellets was a great achievement in that the research which was conducted showed that the filter life was prolonged three times or more better than bone char technology and after having carried out promising column experiments full-scale implementation started in 2006. There are still unsolved research questions not only from a scientific point of view but also from a practical one. The main aim and strengths of the collaboration is the combination of practical implementation skills with research expertise to find and optimize this method of defluoridation

The aim of this paper is to share experiences in production of Bone char and Calcium Phosphate based pellets (Nakuru Technique), laboratory findings together with field experiences in the implementation.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Women, Water and Sanitation: Vulnerabilities in the Field
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**Abstract Body \***

Women in their role of household water managers in rural communities of the developing world are vulnerable to a range of dangerous and often harmful situations. Conflict arising from a breakdown of societal norms, a lack of public safety or increasing poverty can put women at great risk of physical and emotional harm. This presentation will highlight some of the ways in which water-related responsibilities of women in poor communities make them vulnerable to discrimination, loss of opportunities and, in some cases, physical violence. Women (and young girls) have the primary responsibility for water collection, management and use in most households in the developing world. The burdens of collecting water forces women to walk many hours every day to distant and insecure water points where they are vulnerable to attacks by strangers, bandits, even military or rebel forces. In addition, girls who often assist in this burden may not be able to attend school because of the time spent carrying water. Although men and boys may also be water collectors, women and girls bear the brunt of this responsibility. The most serious effects of these vulnerabilities include rape, abduction, fear and the consequent choice of alternative water sources of poorer quality and quantity. The impacts on the women have a cascading effect on the entire community. Initially the women are effected, then the household and eventually the entire community is caught up in a cycle of fear, reduced water consumption and behavioral changes leading to poor health and reduced economic activity. The overall effect is the creation of a cycle of poverty: violence against women reduces household and community stability, which in turn reduces economic productivity, leading to social and economic decline and an increase in poverty. Development programs need to give direct consideration to reducing these vulnerabilities – though technical design of water and sanitation systems, establishment of working groups on gender and child protection, development of a “gender lens”, and the empowerment of women in program planning. Moreover, operational tools should be developed to identify and assess conflicts around water points, to prepare guidelines on women and conflict for WASH program managers, and to institutionalize frameworks for action that do not exacerbate the vulnerabilities of women and girls in their roles as household water managers.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Implementation of Biosand Filters in Northwest Honduras: Experiences of the Oklahoma State University Student Chapter of Engineers Without Borders
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**Abstract Body \***

Over the past five years, the student chapter of Engineers Without Borders at Oklahoma State University has been working in the village of Seis de Mayo in northwest Honduras. Partnered with an NGO, Gathering Hearts for Honduras, the chapter's primary objective has been the introduction of biosand filtration units to homes in the village, which has approximately 1000 residents. Activities have included adapting the biosand filter design and construction methods developed by the Center of Affordable Water and Sanitation technology (CAWST) to fit local conditions, testing these adaptations in the village, training residents in the construction, use and repair of the filters, monitoring the effectiveness of the filters implemented, and helping residents of Seis de Mayo and neighboring villages to begin local businesses to manufacture and sell the filters. Currently, nearly 30 filters have been constructed and are currently in use. Educating the local population about the importance of clean water and techniques for maintaining the filters have also been an important part of the project. Many lessons have been learned regarding the construction and use of these filters and on the implementation of a program like this.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Water and sanitation in integrated Population–Health–Environment interventions: A case study from Ethiopia
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## **Abstract Body \***

Climate change and environmental degradation pose a fundamental threat to survival in rural populations of low-income countries reliant on subsistence agriculture. New global donor organizations such as the Green Climate Fund are charged with directing resources to low-income countries to foster effective adaptation for these affected populations. Integrated Population, Health and Environment (PHE) programs have been proposed as a way to address the interlocking challenges of health and development in an era of rapid environmental change. We examined how the concept of integration was operationalized in Ethiopia by a national coordinating body of organizations implementing PHE programs, and by two local organizations operating in distinct ecological settings.

We found that both organizations struggled to implement all three types of interventions in an effective way. Both emphasized improving livelihoods for communities through activities such as microcredit loans, livestock fattening programs, beekeeping, improved seedlings, and plant nurseries. Household income and its relation to issues like food security, health care, and education are chief concerns of beneficiaries. As such, economic concerns are linked closely to understandings of the reciprocal effects of population and environment.

In the domain of water and sanitation, the main activities are latrine construction, and elimination of open defecation through the community-led total sanitation (CLTS) methodology. Water and sanitation is viewed as a key health sector activity. At the same time, it is somewhat peripheral to the overall PHE programs, because it does not link directly to the central concerns of livelihoods and income generation, prevention of land degradation, and population. The health and productivity of livestock relate directly to livelihoods. For water and sanitation interventions to play an important role in this new generation of integrated programs, they will need to be positioned differently from how they are typically positioned in health sector programs.

First, the scope of CLTS and other sanitation interventions needs to be broadened to include livestock grazing management, separation of livestock from water bodies through fencing and provision of animal drinking troughs, and prevention of soil erosion. This may have two benefits for the implementation of sanitation interventions: 1) It may make them more effective by limiting contamination of surface waters by livestock; and 2) It may make sanitation of greater interest to communities, as it will link sanitation interventions to economic concerns and livelihoods linked to livestock production.

Second, water and sanitation interventions need to be linked more directly to livelihoods, for example through local production and sale of water and sanitation technologies. Livelihoods are the lens through which various interventions in the PHE package are presented to communities. If water and sanitation interventions cannot be seen through this lens, there is the risk they will be excluded in this new generation of integrated programs.

# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	Treatment of Ground Water with High Humic Acids for Low Cost Drinking Water Supply
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## **Abstract Body \***

Ground water from wells can often be used as drinking water with little or no treatment. However, when the ground water contains high concentrations of humic acids (HA) and other natural organic matter, its treatment can be problematic. High concentrations of HA are common in geographic areas with large amounts of peat and give the water an unpleasant taste and color. The region of Pontianak, West Kalimantan (island of Borneo), Indonesia is one such region. Many locals in this area gather water from shallow wells and the taste and color caused by HA cannot be removed by filtration. These can be removed with alum addition, which coagulates and precipitates the organic matter that causes the problem. However, alum addition leaves a messy precipitate and the storage tanks must be frequently emptied and cleaned. The purpose of this research was to develop a treatment method using alum to remove the taste and odor from the Pontianak ground water with simple operation and low cost. The first step in this process was to determine the optimal alum dosage for treatment based on the characteristics of the Pontianak water. The second step for this project was to investigate modifications to a holding tank currently manufactured in Pontianak to determine how the design might be adjusted to remove alum precipitate from the bottom of the tank with ease. These simple modifications to current available treatment technology would allow for groundwater to provide a low cost drinking water supply to those around the city of Pontianak.



# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Life Cycle Assessments of Materials for Fluoride Removal from Drinking Water in Developing Regions
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## Abstract Body \*

While it is estimated that 780 million people lack access to an improved drinking water source, an additional 200 million people may be consuming groundwater that contains elevated concentrations of fluoride. Consumption of elevated fluoride concentrations through food or water can cause dental and skeletal fluorosis. These conditions can be physically debilitating, painful and cause a social stigma. Therefore, where elevated fluoride concentrations are naturally occurring in groundwater it is important to either find an alternative water source or treat the water.

Researchers have investigated many treatment methods including coagulation, adsorption, membrane processes and electrolytic defluoridation. When considering rural areas of developing countries, adsorption can be one of the best options because locally available materials can often be used to produce adsorbents. The United Nations World Commission on Environment and Development in 1987 suggested that sustainable development should consider both current and future needs when thinking about technology development and the use of resources. This suggests that while working to meet safe drinking water challenges, it is essential to consider methods of water treatment taking into account the use of natural resources and minimizing harmful environmental impacts. Several treatment technologies utilize media that are effective at fluoride mitigation but whose production and/or usage is known for emitting harmful air contaminants, producing high amounts of waste sludge, requiring large amounts of energy to function, or are imported and thus can require long distance transportation – all of which can produce negative environmental (ecological and human health) impacts. As resources continue to be consumed and environmental emissions become more concerning, it is increasingly important to consider environmental impacts and select the treatment methods that have the lowest possible long-term effects.

One systematic way to assess environmental impacts is through life cycle assessment (LCA). Although various adsorbents have been studied to remove excess fluoride from drinking water supplies, to our knowledge no specific investigation has been conducted with regard to the environmental impacts of these adsorbents. In this study, an LCA of several fluoride adsorption materials, including activated alumina, bone char, aluminum coated wood char, and treated waste alum, was conducted. The scope of the study included raw material acquisition, production of adsorbents, transportation, and waste management stages, and the functional unit was defined as the quantity of adsorbent necessary to remove fluoride from 100,000 L of water with a starting concentration of 10 mg/L to meet the World Health Organization safe drinking-water level of 1.5 mg/L. Data was obtained from the Eco-invent 2.2 and US-Life Cycle Inventory databases and mass balances, while SimaPro v. 7.3.3 was used to build life cycle models of products and the Tool for Reduction and Assessment of Chemicals and other Environmental Impacts (TRACI) was used to calculate and compare environmental impacts for different impact categories.

Preliminary results of this work suggest that bone char, produced from locally available waste bones in some areas, produced a much smaller environmental impact than activated alumina due to the environmental impacts from the bauxite mining and refining processes.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	What is the potential for smallholder agricultural water management in Sub-Saharan Africa? An integrated hydrologic-economic assessment
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## Abstract Body \*

Sub-Saharan Africa is faced with great challenges for reducing poverty and increasing food security. Smallholder agricultural water management may help boost agricultural productivity, increase incomes and help diversify nutrition and diets in the region. Although there have been many successful examples of irrigation development in various locations in Sub-Saharan Africa, it is still an open question as to what extent agriculture in the region can benefit from the application of various smallholder irrigation technologies. This paper presents a study to assess the application potentials in Sub-Saharan Africa for four smallholder agricultural water management technologies: (1) diesel pumps, (2) treadle pumps, (3) communal river diversion, and (4) small reservoirs. An integrated modeling system that combines GIS data analysis, biophysical and economic predictive modeling (SWAT & DREAM), and crop mix optimization tools was developed for this assessment.

The study shows that Sub-Saharan Africa possesses a large potential for smallholder agricultural water management` with profitable area of up to 21 million ha for motor pumps, 17 million ha for treadle pumps, 1.1 million ha for communal river diversion, and 0.4 million ha for small reservoirs. Up to 160 million people could benefit from these technologies reaping profits of up to \$7.5 billion per year. Area expansion is limited, in some countries, by the availability of surface runoff in the dry season. Rapid expansion of smallholder irrigation will impose stress on aquatic environments which calls for regulation of smallholder agricultural water management activities.

# 2013 OU WaTER Conference Abstract Submittal Form

<b>Abstract Title *</b>	Fluoride mitigation options: challenges and opportunities
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### Abstract Body \*

There are three billion people living in rural areas of developing countries, of which 28% lack access to improved water sources due, in part, to a lack of appropriate technological and policy solutions [1, 2]. Although scientists, NGOs, governments, and corporations have made much progress in evidence-based treatment solutions for some of these problems, development of solutions to many others lag far behind. Fluoride in drinking water is one such straggling problem that needs demonstrably successful mitigation options backed up by an effective implementation strategy and comprehensive information concerning its health impacts and distribution.

According to the World health Organization (WHO), an excessive amount of fluoride in drinking water is exposing millions around the world to health risks. The world population living in fluoride-risk areas is estimated at 200 million, with 70 million in India and 45 million in China alone [3–5]. Other parts of the world where groundwater is contaminated with fluoride include the region that stretches from Syria, through Jordan, Egypt, Libya, Algeria, Sudan, Ethiopia, Kenya and Tanzania as one of the main fluoride belts.

Most of the people affected by high fluoride concentration in groundwater live in the tropical countries where the per capita consumption of water is more because of the prevailing climate. This is a typical situation in Sub-Saharan Countries like Ethiopia, Kenya, and Tanzania where ground water is heavily loaded with fluoride (up to 33 mg/L. A conservative estimate shows that estimated more than 11 million is living in the Ethiopian Rift Valley Region alone. An elevated concentration of fluoride is known to cause catastrophic health impacts on communities living fluoride endemic areas. With the explosive rise in population and with increasing efforts to meet the MDG targets, there is evidence that more groundwater supply sources have been in operation and under construction. To ensure safety of drinking water, the water sector and NGOs are confronted with an important question relating to reduce the level of fluoride in drinking water. Moreover, considering the WHO recommendation of 1.5 mg/l as the maximum permissible concentration of fluoride in drinking water, most of the water wells in the high fluoride areas of the developing regions would be closed down.

Health impacts of fluoride intake, such as dental, skeletal and systemic fluorosis which include damage to the kidney, liver, brain, and cancer [6–9], depend on the intensity and duration of exposure, as well as on the age of the individual. Fluorosis often precludes the ability to work, leading the low-income communities deeper into poverty. As a typical example, people's average daily intake of fluoride from drinking groundwater alone in several communities was found to be significantly higher than the recommended WHO value of 6 mg/day, with intakes ranging between 4 and 54 mg/day. Doubtless, exposure to excess fluoride will drastically increase as more people turn to groundwater for drinking water in fluoride endemic areas of Africa. The widespread effects of fluoride in drinking water, though preventable, remain largely unrecognized and neglected in many Developing Countries.

To mitigate fluorosis in an integrated manner, it is important to understand the level of fluoride exposure from water and other sources, exposure level of specific age groups, health and economic impacts, dietary patterns, and nutritional status of the endemic communities. Fluoride in food ingredients also plays a role on the daily fluoride intake. When fluoride rich water is used for food preparation, all of the fluoride is retained in the food. Reducing the fluoride concentration of the water to the lowest possible level is essential to minimize the total daily fluoride intake. In areas where providing alternative safe drinking water is not feasible, the use of technologies such as reverse osmosis, activated alumina, and synthetic resins have been tried. However, high cost, operation and maintenance and ensuring a supply chain for the treatment chemicals and materials are the major challenges in developing countries. Relatively simple and low cost technologies for the removal of fluoride from groundwater such as

Nalgonda Technique and bone char have been tried. Most past efforts to implement sorption and precipitation techniques to treat water for fluoride in rural Ethiopia and other developing countries have proven not to be sustainable [10]. For example, the sorption capacity of fluoride on activated alumina is 2.41 mg/g (in distilled water at neutral pH)[11], which is quite low. Finding a new high-capacity material is particularly important in developing countries because the groundwater fluoride levels can be unusually high which makes the commercially available technologies not efficient or cost effective.

The first goal of this paper is to show the alarming nature of fluoride distribution in the Ethiopian Rift Valley [12], discuss the importance of total dietary intake of fluoride and assess the health risk factor in terms of disability adjusted life years (DALYs) based measured data fluoride intake in selected endemic communities, using a Quantitative Chemical Risk Assessment (QCRA) tool [13]. Surveys were carried out in eight villages with different fluoride levels (1–11 mg/L) and dietary pattern. Dental fluorosis was assessed using Dean's Index [14], and skeletal fluorosis was evaluated on the basis of a physical exercise method developed in India [15]. Daily fluoride intake was assessed by a questionnaire survey, including sampling and analysis [16] of foods. Dental and skeletal fluorosis prevalence was converted into DALYs for each village. The result indicated that there is suggestive evidence of skeletal fluorosis at total fluoride intakes above about 6 mg/day, and clear excess risk when total intake exceeds 14 mg/day [17]. Dental fluorosis was observed at concentration as low as 1 mg/L in water.

The second goal of this paper is to demonstrate that synthetic aluminium hydroxide-based adsorbent (AO) has very high fluoride adsorption capacity (23.7 mg/g) and can remove fluoride effectively in poor, rural settings using locally available materials for synthesis. We demonstrated both in the laboratory [19,20] and in the field that the AO can be used in packed bed column (the AO process) and also can be used to significantly improve the efficiency and applicability of the old Nalgonda Technique (the NT-AO process). We have initiated a partnership approach with GOs, NGOs, and Multi-lateral Organizations (MOs) to disseminate the newly proposed technologies.

In conclusion, groundwater and lakes are unusually enriched with fluoride in the Ethiopian part of the Great East African Rift System. Drinking water is the principal contributor of fluorosis in the rural communities, and DALYs are a useful tool for the continuous monitoring of success of options. Skeletal fluorosis could be significantly reduced by providing low fluoride water alone, but preventing dental fluorosis requires further studies. AO and NT-AO processes can be applied both at household and community scales in high-risk areas where the fluoride level exceeds 10 mg/L. Further studies are underway to optimize the technology and to develop mechanisms to ensure sustainability.

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# 2013 OU WaTER Conference Abstract Submittal Form

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<b>Abstract Title *</b>	An Assessment of Reservoir Filling Policies and Downstream Impacts under a Changing Climate: Ethiopia's Grand Renaissance Dam
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**Abstract Body \***

The Grand Ethiopian Renaissance Dam (GERD) in Ethiopia is poised to facilitate regional development, however thus far, no reservoir filling rate policy has been established. This policy will have clear implications on the GERD's ability to generate hydropower in the near-term and coincidentally impact people and livelihoods in Sudan and Egypt through reduced streamflow availability. Implications of climate variability and emerging climate change within Ethiopia cast further uncertainty on potential filling policies and system operations. To address this challenge, numerous filling policies are evaluated through a climate-sensitivity approach to estimate impacts on GERD hydropower production and downstream flows, specifically at Egypt's Lake Nasser. This provides viable and timely points of comparison for regional water managers and politicians negotiating system operations in the midst of ongoing project construction.