Cornell University
College of
Engineering

AguaClara

Municipal Water Treatment | Open Source Engineering

Over the past 5 years the AguaClara program at Cornell University has developed a new approach to municipal drinking water treatment and has demonstrated the approach through collaboration with Agua Para el Pueblo, a Honduran NGO specializing in water supply systems. Municipal drinking water treatment has had limited success in resource poor communities due to high capital and operating costs and the use of non-resilient technologies. Extending safe drinking water coverage to this sector required multiple engineering innovations and a new approach to implementation. The AguaClara team has created resilient technologies that do not require electricity or external power sources for the treatment of high-turbidity surface waters.

The engineering designs are shared online to facilitate technology dissemination. National engineering firms (non-profit, private, or governmental) are trained to build the water treatment facilities using locally available materials and community labor. Community-based enterprises are empowered to maintain and operate their water supply systems. The AguaClara technology and implementation methodology has been tested and documented in 5 small Honduran towns with populations between 1,500 and 10,000. The results confirm that the AguaClara technology produces safe drinking water with turnkey design/build/operation/training/transfer costs of $15 to $30 per person served ($4000 to $10,000 per L/s of capacity) and incremental operating costs of $2-$4 per person per year.

The AguaClara goal is to disseminate this technology globally and we estimate that well over 100 million people living in Latin America and the Caribbean, Africa, and Asia could benefit. We are actively seeking partners who share the objective of globally increasing access to safe drinking water.

Introduction to AguaClara

AguaClara is a program in Civil and Environmental Engineering at Cornell University that is improving drinking water quality through innovative research, knowledge transfer, open source engineering and design of sustainable, replicable water treatment systems. The AguaClara team formed in the fall of 2005 in response to the need of hundreds of Honduran communities that rely on contaminated surface water sources for their drinking water supply. The team is directed by Monroe Weber-Shirk and has worked in partnership with Agua Para el Pueblo to implement the technology in rural Honduran towns. Cornell designed AguaClara municipal water treatment plants in Honduras are providing over 15,000 people with drinking water.

The AguaClara technology is uniquely capable of producing high quality drinking water from turbid surface waters without using electricity. It is simple to manage, and is sustainable even by resource-poor communities. Our mission is to

create an open source technological solution coupled with a strategy for dissemination that can be adopted by implementation partners (IPs). As a Cornell University program we have the mandate to develop new knowledge and to share that knowledge. We are actively engaged in capacity building with current and potential IPs and intend to encourage the formation of a network that will share best practices for implementation and long-term operation of community based water treatment facilities.

The Challenge and the AguaClara Niche

Many municipal water treatment plants in the Global South have been imported from industrialized nations. These conventional water treatment plants are dependent on pumps, mechanical mixers, air compressors, and computerized control systems. When operated away from their normal supply chains and trained technicians, these "high tech," non-resilient systems are not sustainable and completely vulnerable to disruptions in energy and to failure of mechanical and electrical components. The net result is that these highly vulnerable technologies spend a very high fraction of their time either completely out of service or producing unsafe water because of component failures. The AguaClara program is a response to the need for a resilient and sustainable water treatment technology that empowers rather than creating dependency.

The AguaClara technology is designed for towns and cities with populations between 1000 and 100,000 (3 to 200 L/s of water). The processes that we use are able to remove sediment and pathogens from the water and thus are able to make most surface waters safe to drink. Towns and cities that already have piped water but that don't have adequate water treatment are ideal candidates for the AguaClara technology. If the water source elevation is adequate to bring water from a higher elevation to the water treatment plant, to a storage tank, and then to the households in the community, then no additional pumps or energy sources will be required.

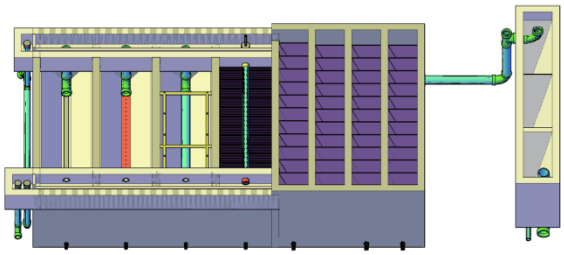
AguaClara technology is an innovative way to bring economy of scale to water treatment, while maintaining simplicity of design that can be sustained even in resource-poor communities. The AguaClara plants require no electricity and all repairs can be completed with local materials and labor. Plant designs are robust and scaled to meet the need of each community. The program also provides sustainable designs for communities with populations that were previously assumed to be too small to support a water treatment plant. The smallest community served to date is an association of 4 rural communities with a total population of 1500. The community water board is saving funds for future repairs and system expansions and there is a high demand for new service connections now that they are providing safe water. The success of that small facility suggests that even smaller communities could benefit from the AguaClara technology.

Technological Innovations

The AguaClara program addresses multiple technological limitations and implementation challenges. The existing technologies were not sufficiently robust or economical to be a sustainable solution for resource poor communities. Innovations include a gravity powered chemical dose controller, linear flow meter, orifice rapid mix, small scale vertical flow hydraulic flocculators, shallow sedimentation

tanks, and stacked rapid sand filters. However, a robust and economical design that relied on locally-available materials would still have been too expensive to implement due to the high engineering costs. To reduce the engineering costs and address the need for hundreds of thousands of water treatment plant designs over a wide range of flow rates the AguaClara team created and is now refining an automated, on-line, design tool.

The design tool incorporates all of the equations that are required to size the many components of the water treatment plant (tanks, channels, pipes, valves, etc.). The design of all of the plant components are integrated to create a compact and efficient plant layout. The design tool first calculates the dimensions of all components and then in a second step it creates drawing scripts for the entire plant. The drawing scripts are sent to AutoCAD to create a highly detailed 3-D drawing. The entire design process takes about 5 minutes of computer server time. An engineer with access to the internet can request a custom design for a specific flow rate and with customized dimensions based on materials available in the national market. The design request is processed automatically and the engineer receives an email with design documents a few minutes later. It is important to note that the design must be reviewed by a professional engineer and that the structural design must be performed by a local engineer based on the building materials and national codes.



The AguaClara technology included in each design consists of gravity powered dosing of coagulant, hydraulic rapid mix (to blend the coagulant with the contaminated water), hydraulic flocculation (to form large aggregates of the contaminants), high rate sedimentation using custom fabricated plate settlers (to remove the large aggregates of the contaminants), and disinfection using a calcium hypochlorite solution (to kill any residual pathogens that escaped the previous treatment steps). The designs were elaborated over five years of research and full-scale implementation. The designs rely on materials that are sourced in the community and national supply chains. The exceptions to this policy are a portable turbidimeter and a small $5 float valve that is used in the chemical dosing system.

Implementation Strategy

The vision of the AguaClara program at Cornell University is to empower implementation partners (IPs) to build the AguaClara water treatment plants. The IPs work with the communities to procure financing. In Honduras, the IP is a local non-governmental organization. We expect other IP models to be tested in the coming years. For example, countries with well- run central governments may use engineers from the national authority responsible for water and sewer. Private, for profit, engineering firms could also build AguaClara facilities. However, for successful implementation it is imperative that the community be supportive of the project and that the project include a significant capacity-building component so that community members can operate and maintain the facilities.

Successful dissemination of the AguaClara approach to other countries and global regions requires that the IP approach be systematized and shared with new IPs. Implementation methodologies must empower the local community and there must be institutional support for facility performance monitoring, technical support and ongoing training. In countries with weak central government institutions these requirements suggest the need for networks of AguaClara communities who together fund a technical support program. Countries with an effective central government can provide the technical support and

performance evaluation through the national water authority.

Where do we hope to be in 5 years?

We are currently working to extend the project reach to at least 2 additional countries in Central America. Our goal is to facilitate the spread of the knowledge between our current implementation partner in Honduras and new IPs in neighboring countries. This approach will minimize the demands on the team at Cornell and will be a demonstration of our proposed method to scale the project globally. It will likely take about 2 years to develop and train new partners that then go on to select cities, develop funding sources, and finally design/build/train/operate/transfer new AguaClara facilities. The Cornell team's involvement with the global scaling of the technology will be to provide a well-documented design tool. Dr. Weber-Shirk will continue to provide short courses at national universities in the host countries in order to explain water treatment process theory to engineers and technicians. After the initial training phase it is expected that implementation partners will continue to build water treatment plants without requiring much technical support from the Cornell team. In Honduras we provide Cornell graduates to assist with the technology transfer and that model may be useful for some of the new IPs as well.

By 2012 we hope to begin launching the technology in at least two new global regions. There is a need for robust drinking water treatment plants in Africa, Asia, and the Americas south of the Rio Grande.

With 5 years of additional research we expect to have characterized the optimal energy dissipation rate in flocculators, developed recommendations for the use of floc blankets in vertical flow sedimentation tanks, and conducted parametric studies of water treatment plant performance while varying the design of the flocculator and sedimentation tank to obtain the optimal design. We anticipate incremental changes to the online design tool that will further optimize facility performance and reduce construction costs. New designs will be tested with a single IP and then integrated into the online design tool after the design is validated.

Beyond 5 Years

We estimate that more than 100,000,000 people are currently living in communities that have a water distribution system that provides untreated surface water to their taps. Approximately three AguaClara-type water treatment plants would need to be constructed every day for 10 years to meet this backlog. This estimate only represents a tiny fraction of the total need for water supply infrastructure that will require upgrades, replacement, and expansion in the coming decades.

We also anticipate many decades of useful and productive research. Over the past 5 years we have developed unprecedented capabilities for laboratory and full-scale research of surface water treatment, but there is much more to be learned to optimize the designs.

The AguaClara goal is to develop and share the knowledge base so that NGOs, engineering firms, and municipal and national governments, can build resilient water treatment infrastructure. The focus of the team at Cornell will likely continue to be on making the technology as resilient and high-performing as possible in context of resource-poor communities. We will continue to provide an online design service so that implementation partners can access detailed, customized designs on demand.

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