Evaluation of Chlorine Disinfection Processes in a Water Treatment and Distribution System in Rural Haiti

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Background

The Cange Municipal Water System was first installed in 1985 by members of the Episcopal Diocese of Upper South Carolina after it was determined that water was one of the biggest needs for the people who had settled in the mountaintop community of Cange, Haiti. The system was later expanded and updated with the assistance of Clemson Engineers for Developing Countries (CEDC). Today, the system consists of three turbines and pumps, filtration, chlorination, four cisterns, and eight fountains.

Figure 1. Cange, Haiti located in the Central Plateau.

"The right to safe and clean drinking water and sanitation [is] a human right that is essential for the full enjoyment of life and all human rights"

The Cange Water System has been recognized as Haiti's first chlorinated municipal water system. Despite chlorine being a known disinfectant that also provides a residual treatment throughout the distribution system, it is not commonly used in treatment systems in the developing world. Despite being recognized as a human right by the United Nations in 2010, 29% of people around the globe still do not have access to a safely-managed drinking water service. Through CEDC's work in the Central Plateau, they have seen several iterations of the chlorination process in the Cange Water System each process with its own set of advantages and drawbacks and is working to develop solutions that will make this treatment method more practical in developing communities.

Figure 2. The Cange Municipal Water System

Objectives

There are several main objectives that have been identified that must be considered for the chlorination process to be successful in resource constrained environments.

Ease of Operations and Maintenance

Need for a system that can be maintained and operated by any skill level

Operates Without Electricity

Electricity is often not available or reliable in developing countries so chlorination cannot be reliant on electricity

Ability to Deliver Consistent Levels of Chlorine

The system needs to have the ability to be easily adjusted to control the level of chlorine at the point of delivery

Cost Effective

Large need to keep costs low because constituents have less expendable income

Robust Design

A design is needed that can be used in varying conditions such as high pressures

Design

In March of 2018 a fiberglass reinforced plastic (FRP) tablet feeder erosion chlorinator designed by CEDC and Fluidtrol Process Technologies, Inc. was installed in the system. The chlorinator lid opens to allow for the addition of 3" calcium hypochlorite tablets that the water erodes as it flows through the system effectively chlorinating the water. This tablet feeder has met many of the benchmarks deemed important as it does not rely on electricity, is simple to operate, has manageable costs, and can withstand the high pressures of the system. However, further refinement is needed to ensure a consistent dosage of chlorine.

Figure 3. The newest chlorinator in the Cange Municipal Water System installed in March of 2018.

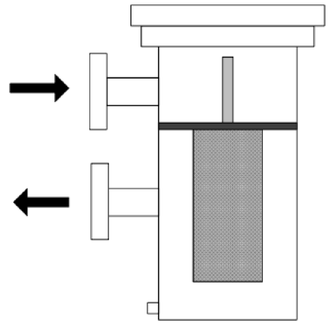

Figure 4. Water flows through a basket containing chlorine tablets that diffuse into the water.

Data Collection

Water data including the levels of free chlorine at the village fountains has been collected and recorded since July 2014 by a local Haitian, Greg Gracia. He was trained on how to correctly collect and test the water and completes the process three to six times a week. He also collects data for the influent and treated water including turbidity, TDS, and pH measurements. The data is then entered into a computer and uploaded to a cloud where it can be viewed and analyzed in Clemson.

Figure 5. Greg Gracia (in orange hat) collects water samples from one of the fountains seen in the background.

Figure 6. Levels of free chlorine are tested in a water testing laboratory using the HACH DR 900 Colorimeter.

Results

The tablet feeder erosion chlorinator designed by CEDC and Fluidtrol Process Technologies is proving to be a viable option for the chlorination of drinking water in this context. Free chlorine levels at the point of delivery have become much closer to the desired value of 0.5 mg/L of residual since the installation of this new process.

Results

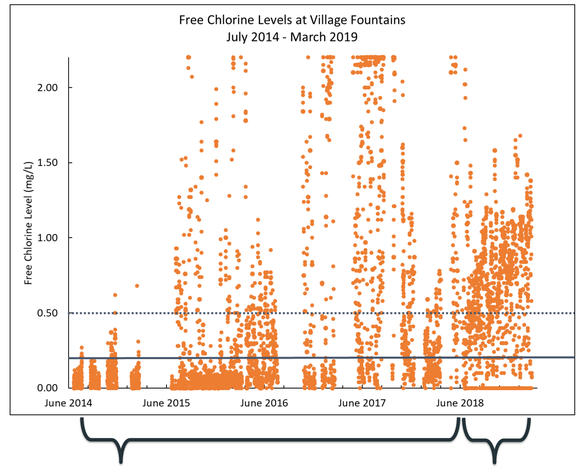

Figure 7. Free chlorine levels tested at the fountains since July of 2014.

Just by switching from previously used chlorination methods to the new tablet feeder erosion chlorinator, the levels of free chlorine present at the fountains has gone from meeting the desired level 26.9% of the time to 68.6% of the time. The data shows that this process has potential, but it needs further refinement to ensure quality drinking water is provided at all times.

Conclusions and Future Work

- The Fluidtrol Tablet Feeder has proven to be the best option when it comes to meeting the criteria discussed in Objectives. Initial evaluations show that this chlorinator has the potential to reach the daily residual chlorine levels needed throughout the distribution system.
- Water testing data will continue to be collected and analyzed and CFD modeling of the system will be completed in order to further optimize the chlorination process.
- Additional training will be done with the Haitian water team responsible for the system to improve knowledge of how the chlorinator works and how it can be operated most efficiently.
- The modeling results and field data will be used to make the system more cost effective when it comes to the use of chlorine tablets.

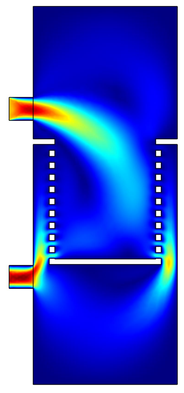

Figure 8. CFD model of flow through the chlorinator.

Acknowledgements

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FLUIDTROL PROCESS TECHNOLOGIES, INC.

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