Passive Chlorination: Providing Clean Drinking Water to Rural Ecuadorian Communities

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Introduction

In 2002, the World Health Organization (WHO) reported that nearly 1.7 million deaths worldwide were caused by unclean water. The risk of death is elevated for young children, for which the second cause of death worldwide is diarrheal disease, which is largely caused by microbes; these microbes, when unaddressed, can proliferate in drinking water. Health risks are further elevated in rural communities, which often lack access to the technology necessary to treat water for microbial contamination. This can be seen in Ecuador, in which only 52.8% of rural households have access to safe drinking water.

The problem of infected drinking water in rural communities begs the question: how does one effectively eliminate the risk of microbial contamination without the use of electricity and complex, expensive components? A solution: passive chlorination. Passive chlorination systems use the flow of the water itself to release chlorine. The chlorine then disinfects the water, leaving it safe to drink.

A passive chlorinator design, called the CTI-8, was developed and tested in South America by Compatible Technology International, a nonprofit organization dedicated to helping developing nations. Based on prior literary review, the CTI-8 was determined to be a promising chlorinator for disinfecting water in rural Ecuadorian communities because of its affordability and simplicity to construct using commercially available PVC components. However, the provided building instructions didn't include enough numerical data for determining the expected concentration of chlorine released into the water. As a result, extensive testing was conducted to determine the behavior of the CTI-8, with the intent to install one in rural Ecuadorian communities should the design prove a success.

Overview of Research

Chlorinator Design

"The CTI-8 is built entirely from schedule 40 PVC pipe, fittings, and ¼-inch sheet PVC. The parts are constructed with simple tools and assembled with standard PVC cement and stainless-steel screws or PVC pegs. The body of the unit is a 4-inch PVC tee. A 4-inch riser, 12 inches long, is fitted into the branch of the tee, and is closed on top by a cap" (CTI p.8).

The method of chlorine delivery using the CTI-8 is relatively straightforward: directed by an inlet baffle, water rushes over a cylindrical chlorine tablet and exits through an outlet weir plate (Figure 1). The tablet erodes and releases chlorine molecules that disinfect the water. As the first tablet erodes, the next tablet above it replaces the first tablet; this continues if the stack of chlorine tablets is regularly replenished.

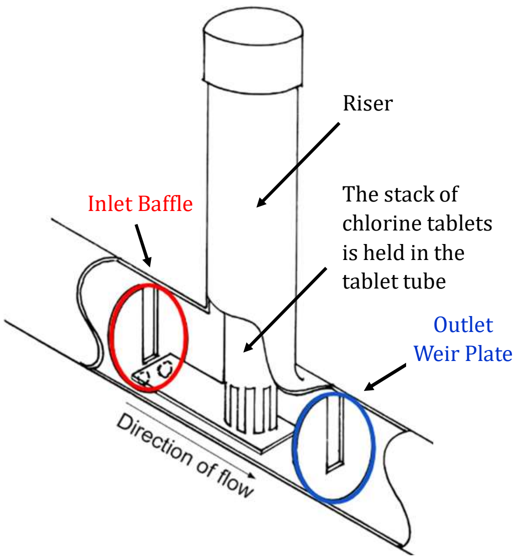

Figure 1. Cutaway schematic of the CTI-8 from The CTI-8 Chlorinator *manual.*

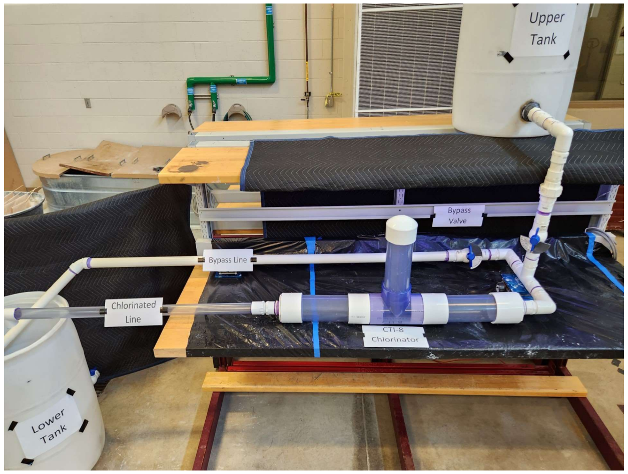

Figure 2. The double line passive chlorination system, with a chlorinated line and a bypass line. The bypass valve changes the final mixed concentration of the two lines.

Testing the Chlorinator

The CTI-8 was installed and tested in a model water delivery system, which was fed by two garden hoses with flowmeter attachments. These hoses fed into a fifty-gallon upper tank, which drained into a double line PVC pipe system comprised of a chlorinated line and an unchlorinated bypass line (Figure 2). The percentage of system inlet flow that bypassed the chlorinator was controlled with a ball valve. Depending on the position of the ball valve, the outlet concentration in the fifty-gallon lower tank, into which both lines drained and mixed, could be controlled.

Conclusion

The main takeaway from testing was that the CTI-8 releases chlorine based on the surface area of chlorine tablets exposed to water, which in turn is dependent on the water height inside the chlorinator. The water height is determined by the system inlet flow rate and the percent of system inlet flow that is diverted through the bypass line. What this means is when the bypass line is closed, the water level inside the chlorinator is solely dependent on the system inlet flow rate; if the flow rate increases, the water level rises, more tablet surface area is exposed, and the amount of chlorine released increases. However, because more water is flowing through the chlorinator (increase in flow rate), the chlorine concentration from the chlorinator will be approximately the same as that for lower flow rates.

This independence of system inlet flow rate makes the CTI-8 extremely versatile: if there is a temporary increase (surge) or decrease (recession) in flow rate, the CTI-8 will still dose to approximately the same concentration as would be expected at typical steady flow conditions. This consistency in dosing also holds true for sustained variations in system inlet flow.

Because of its dosing consistency and simplicity of construction, the CTI-8 will be implemented in an Ecuadorian community by July 2023 for a trial run. The results will inform the next phase of chlorinator installment, set to take place near the end of 2023.

Acknowledgements

Special thanks to Professors Chad Tatko and Julie Wildschut for their insights and recommendations, and to Lachlan Beebe for his aid in building and testing the CTI-8 and the model system. Additional thanks to Calvin University for supporting the research, and to Pfizer, the Newhof Engineering fund, and the Clean Water Institute for funding my efforts.