ANC Control Reflection Report

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AguaClara Reflection Report

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Abstract

In light of recent successful tests run by the AguaClara Engineers in Honduras with poly-aluminum chloride (PAC), an alternative coagulant to alum which consumes a fraction of the alkalinity, the ANC Control team is preparing to stop research with lime feeders because they will be largely unnecessary when PAC is adopted for all AguaClara designs. In order to bring closure to ANC research the team will write a final paper detailing the insights pertinent to lime feeder technology that AguaClara has gained over five semesters of research. We will also organize the ANC Control wiki page.

Lime Feeders and AguaClara

Flocculation in AguaClara plants performs optimally within a pH range of 6.5 to 7.5. However, the addition of alum solution, the coagulant conventionally used with AguaClara designs, consumes significant alkalinity due to the release of protons in the formation of $Al(OH)_3$ precipitates. In combination with the already-low source water alkalinity typically found in Honduras, the use of alum causes the pH to drop well below the ideal range for flocculation. To maintain a more neutral pH, AguaClara has looked into mixing a basic solution with the raw water to add alkalinity. Calcium hydroxide, or slaked lime, is an inexpensive and readily available chemical in Honduras. Due to its relative insolubility, a plant would need an impractically large volume of saturated calcium hydroxide stock solution to satisfy a day's alkalinity needs. This approach is useful only with more soluble chemicals. Instead, a lime feeder, a reactor which continually delivers saturated calcium hydroxide solution to the plant flow while keeping the effluent free of solid particles, was the proposed technology to solve the alkalinity problem.

However, a recent development for AguaClara plants has called the need for lime feeders into question. Poly–aluminum chloride (PAC) is an alternative to hydrated aluminum sulfate (alum) which is currently used as a coagulant in many conventional water treatment facilities. One of the primary benefits of PAC versus alum is that, while it still consumes some alkalinity, it has a much smaller effect on pH.

PAC has until recently only been widely available in liquid form. However, availability of a crystalline form of the compound has made it much more transportable so that it is economically viable compared with alum in poor countries like Honduras where transportation to rural areas can be a limiting factor. A recent report from the AguaClara Engineers working in Honduras detailed the performance of PAC during jar tests and trial runs at several of the AguaClara plants. The tests were extremely successful; not only did the PAC consume an almost negligible amount of alkalinity compared with alum, but the plants actually performed better with PAC in terms of effluent turbidity. Shortly after the tests were performed, the water board at Cuatro Comunidades decided to adopt PAC as the coagulant for their plant. It seems very likely that PAC will soon become the coagulant used with all AguaClara designs.

Although ANC Control teams have gradually gained insight into the important mechanisms at play within the lime feeder, research with lime feeders over five semesters has seen consistent failure. At present the technology we have is not ready to be implemented because the condition of the effluent is unreliable in terms of total alkalinity, the feeder quickly clogs with calcium carbonate, and the solid lime needs to be replaced far too regularly – less than a 24 hour cycle – in order to maintain saturated calcium carbonate effluent to be practical. The proposed effluent recycle system has potential in theory but will likely take a lot of work before it will be effective, if ever.

Therefore, given the alternative solution to the plants' alkalinity problem provided by PAC, we have decided not to spend further resources on lime feeder research.

Although PAC does not lower the pH to the same degree as alum, plants will not perform optimally with source waters which already have very low pH and little or no alkalinity. Although the addition of alkalinity does not seem crucial for the AguaClara plants currently in operation, it is certainly conceivable that a future treatment plant may need it. The ANC team will leave the project well-documented so that future AguaClara teams can pick up where we left off if needed. Alternatively, a plant built near source waters with low pH may decide to use a chemical dose controller with a stock solution of a more soluble base such as sodium carbonate.

Future Work

The primary goal for the ANC Control team is to write a final report which contains all relevant information the team has learned related to the function of lime feeders. The specifics of the report are detailed in the "Final Report Objectives" section below. In addition to the report, the team will document the ANC project's work by organizing the information on the wiki. The topmost pages will contain compiled information similar to the final report. We will also organize the documentation from past ANC teams so that specific semesters' research can be found easily. A summarized overview of how the lime feeder model has evolved over the semesters will also be included with pictures of all of the past and current designs. Finally, we will create a well-organized MathCAD worksheet with all relevant models, values, and calculations which are useful in the research of lime feeders and/or which are referenced in the final report.

Final Report Objectives

The purpose of the final report is to make available all of the knowledge the ANC Control team has gained about lime feeder technology. The new coagulant, PAC, is very effective in maintaining the pH of the raw water. However, in areas where the alkalinity of the source water is initially too low to reach this pH range even with the aid of PAC, or areas where PAC is unavailable, a lime feeder might still be needed to add alkalinity to the source water prior to being chemically dosed. The calculation done by the team in Honduras that demonstrates the economic advantage of using PAC instead of alum will also be included to justify the switch between coagulants. There might not be a direct need for a lime feeder in AguaClara plants now, but the information gathered by the ANC Control team over the years might still be useful for others in areas where source water alkalinity is too low to maintain an optimal pH after chemical dosing.

The final report will contain all significant experimental results, analyses, calculations, and other insights the team has picked up over the five semesters of ANC research. In addition, we will explore and reference other conventional lime feeder designs. Finally, the report will contain all ideas and calculations related to our proposed solution, the effluent recycle system.

Final Report Preliminary Outline

I. Abstract

II. Introduction

- A. Problem background
- B. Explanation of important concepts
- C. Important equations
- D. Hypotheses for lime feeder failure

III. Conventional Lime Feeder Design and Function

IV. AguaClara Lime Feeder Design and Economics

V. Experiments

VI. Results, Discussion, and Insights

VII. Future Work

- A. Effluent recycle system

VIII. Conclusion

Team Reflections

In the past few weeks, much has happened. Conflicting schedules and miscommunication continue to be a hindrance to our team. As a result, the workload among individual members of the team is often unequal. The team is aware of the problems and is attempting to be more communicative.

The team will try to be more cooperative and communicative in the weeks to come, especially because our project has changed and flexibility would be required among team members. Because most of our work in the next few weeks will be done on computers, time spent together in the AguaClara lab will be less essential than before. However, the team will continue to meet in person on Mondays at 2:30 pm, as well as during and after class time on Tuesdays and Thursdays to work on the final report together.