Developing an Automated Coagulant Dosing System

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INTRODUCTION

IMPORTANCE OF COAGULANT DOSING

Drinking water treatment plants generally require a full-time operator present to manually select the coagulant dose based on influent turbidity. It can take months of training to gain the necessary knowledge and intuition for this job. Between hiring and training plant operators, labor can be the most significant cost for AguaClara plants. By automating the coagulant dosing system, plants will be able to find and maintain optimal coagulant doses without an operator present, reducing the technical and financial barriers to safe drinking water.

SUBTEAM GOALS

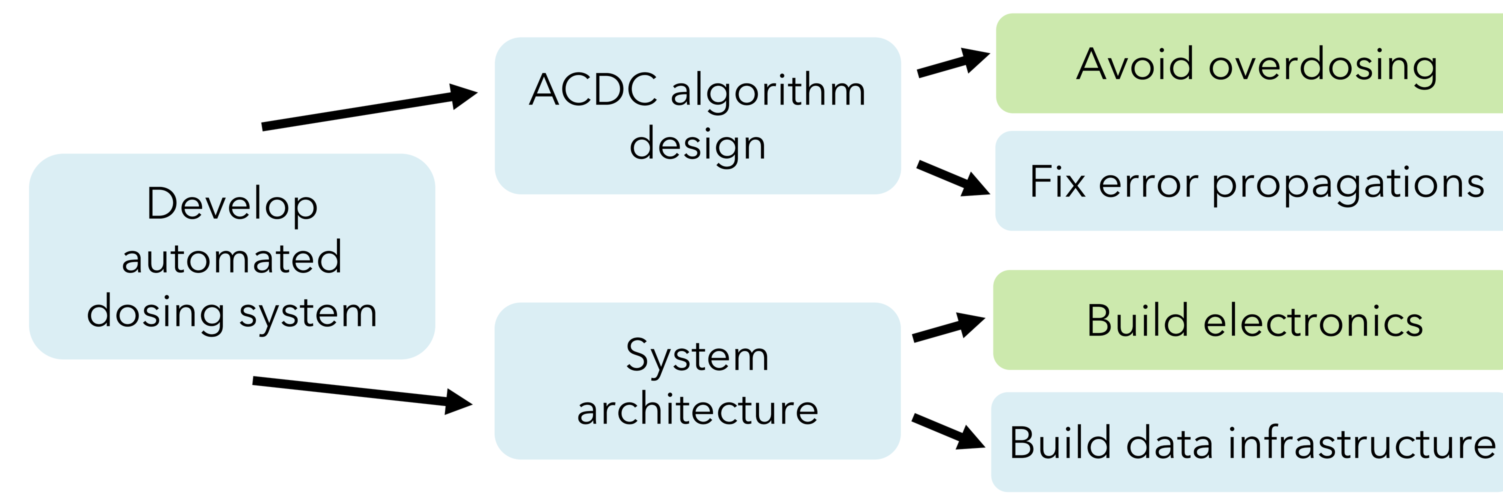

Figure 1. Diagram mapping out goals for the ACDC subteam. Highlighted goals represent our focus for the semester.

ALGORITHM DESIGN

ALGORITHM CHALLENGES

- The current algorithm responds to above-target post-clarified turbidity only by increasing coagulant dose. In the event of an overdose, this leads to an infinite feedback loop.
- Overdosing coagulant leads to flocculation failure, further worsening post-clarified turbidity [1].
- Measurable symptoms of coagulant overdose are currently unknown.

We are determining the measurable symptoms of overdose using jar tests.
The results will inform our adjustments to the algorithm to recognize overdose, prevent infinite propagation of measurement errors, and optimize coagulant use efficiency.

JAR TEST METHODS

To investigate the effects of overdose, we performed a series of jar tests to do controlled simulations of flocculation and clarification. We measured the effects of coagulant underdose, optimal dose, and overdose on floc size and effluent turbidity.

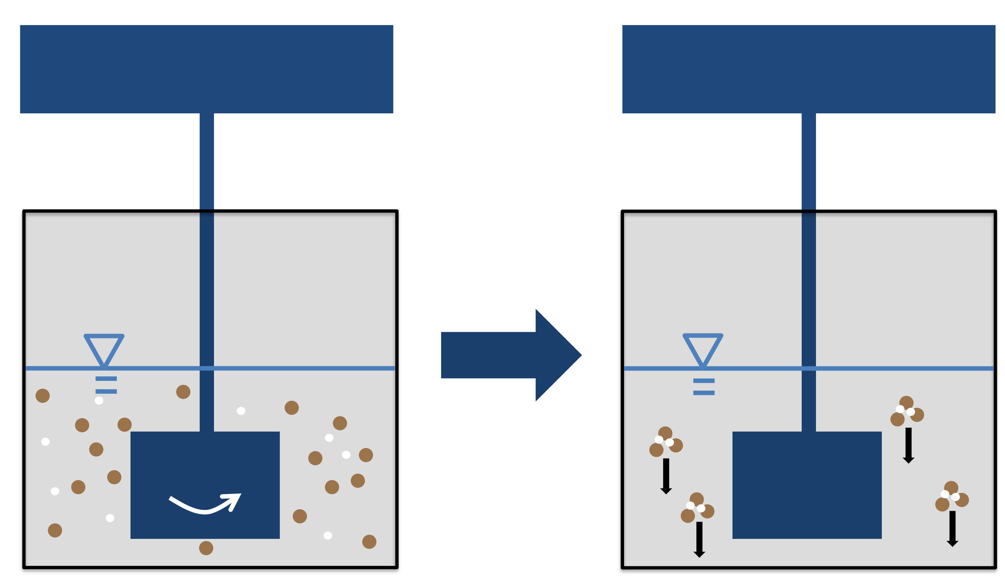

Figure 2. Diagram of the jar test experimental setup. The mixing combines the primary particles (brown) and coagulant (white), shown at the left, into flocs, shown at the right.

INITIAL RESULTS

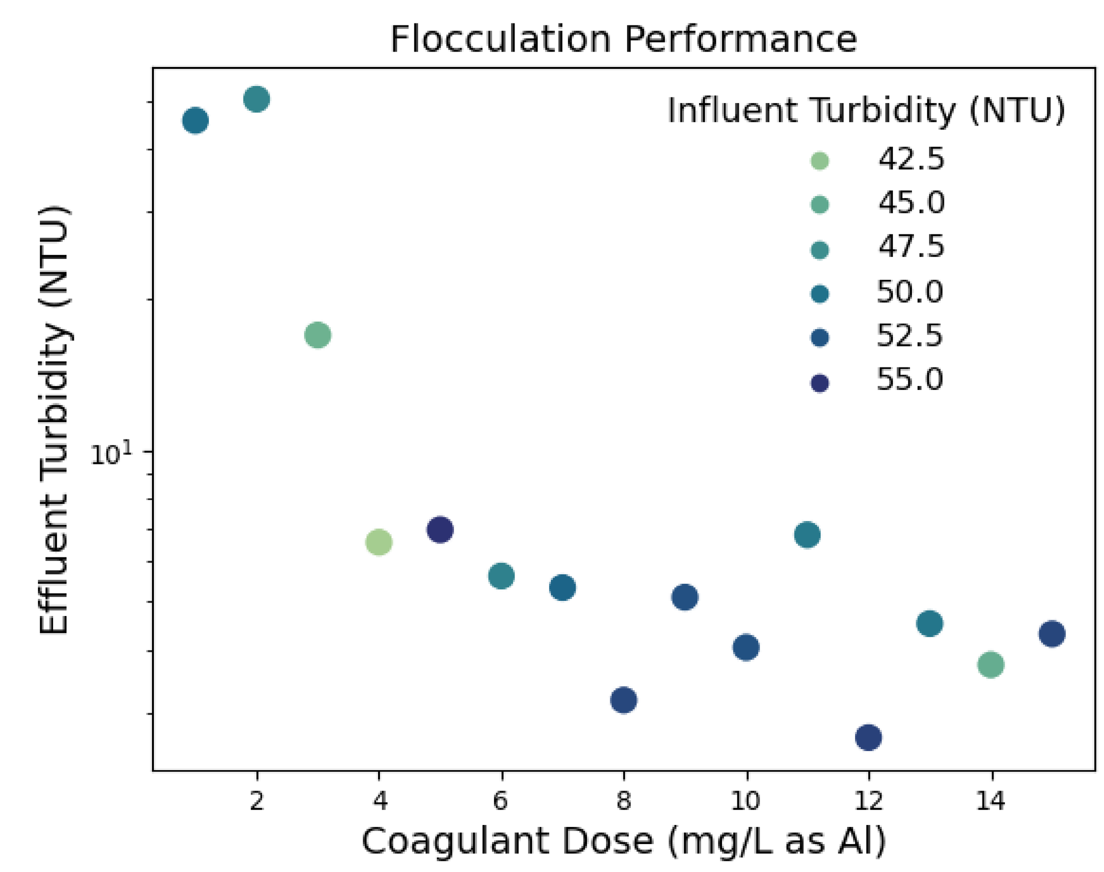

Figure 3. Results show the effect of varying the coagulant dose on effluent turbidity.

For an influent turbidity of 50 NTU, increasing coagulant dose from 1 to 15 mg/L shows an initial sharp drop in effluent turbidity, followed by a broad range of well-performing coagulant doses.

HARDWARE AND DATA INFRASTRUCTURE

CURRENT SEMI-AUTOMATED SYSTEM

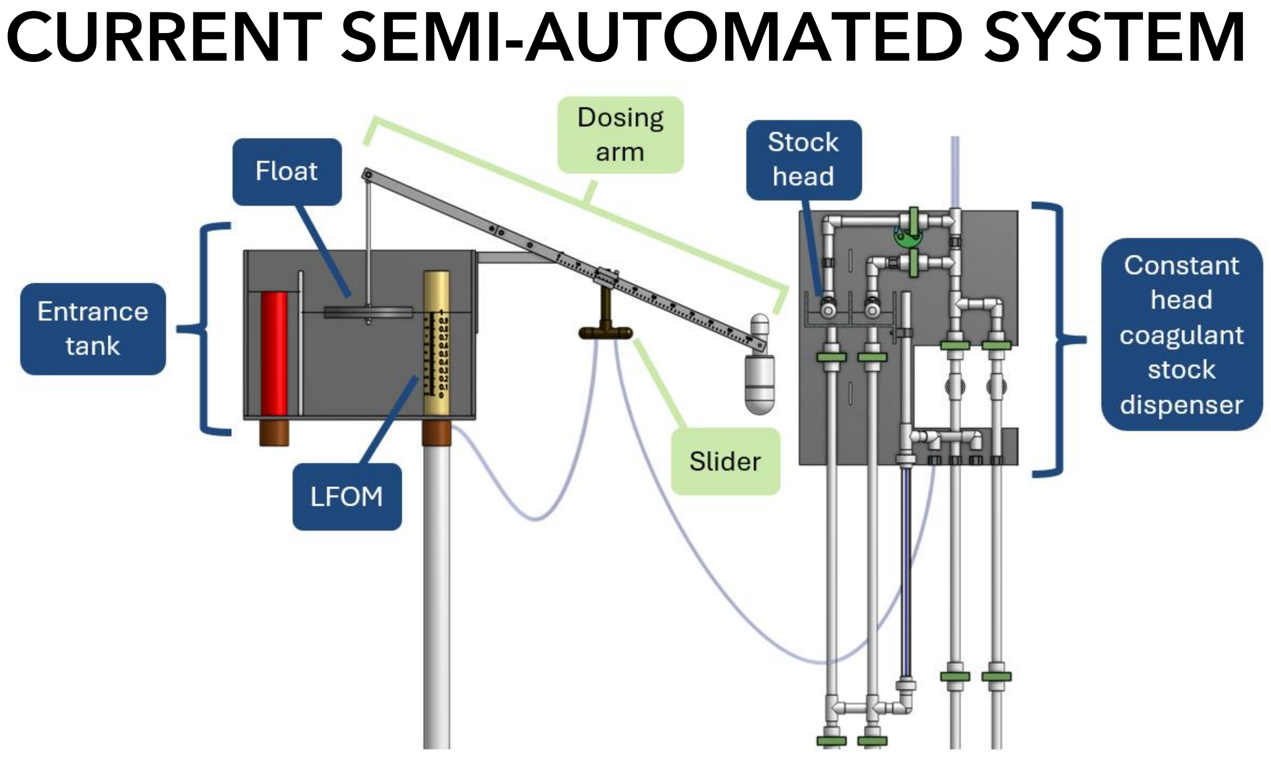

Figure 4. An OnShape model of the current semi-automated coagulant dosing system.

AguaClara plant operators currently use a semi-automated coagulant dosing system. This doser automatically adjusts the coagulant flow rate to the plant, but does not make adjustments based on turbidity. The operator manually makes these adjustments by moving the slider up and down the dosing arm.

Goal: to integrate our algorithm into the current setup by introducing a motor that controls the position of the slider, and several water quality sensors.

SYSTEM REQUIREMENTS

- Automatically respond to changes in turbidity.
- Minimize power consumption by avoiding micro adjustments.
- Grant offsite access but not control.

PROGRESS

- Planned system architecture.
- Tested functionality of each chip.
- Built circuits to operate the motor and begin implementing the wireless link.

SYSTEM ARCHITECTURE

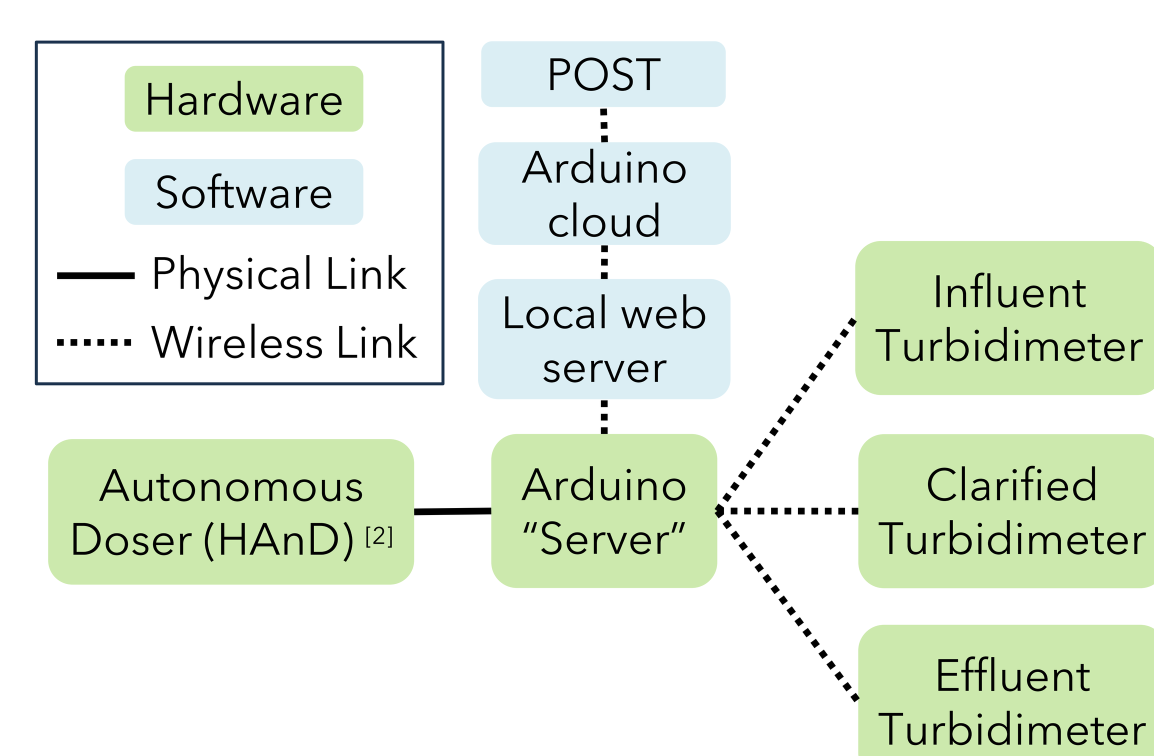

Figure 5. Diagram of the hardware and software links between system components.

NEXT STEPS

- Finish writing the software for the system and extensively test communication.
- Program the server to implement the algorithm and test this functionality.

REFERENCES

[1] Pennock, W. (2019). Theoretical and practical considerations for hydraulic flocculation. [Doctoral Dissertation, Cornell University].
[2] Rosenberg, Y. (2022). Hydraulic Auto-nomous Doser (HAnD): An affordable prototype for autonomous and remote dosing on AguaClara water treatment plants.

ACKNOWLEDGEMENTS

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