Coagulant Dosing: Investigating Floc Filter Dynamics

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Abstract

Coagulant dosing in the AguaClara drinking water treatment process involves adding a specific amount of coagulant to influent water to remove pollutants, enhance floc formation, and neutralize water. For communities that cannot afford full-time operators, it is beneficial to create a fully automated coagulant dosing system. A critical first step is creating a model that predicts floc filter dynamics in the clarifier.

Introduction

The current clarification model underperforms clarification:

$$C_{clarified} = C_{flocculated} e^{-k_c \frac{C_{coagulant}}{C_{influent}} (1 - P_{floc\ saturated})^{2/3} h_{floc\ blanket}} \quad where\ k_c = k' \beta \frac{\pi r^2_{floc} C_{floc\ blanket}}{m_{floc}}$$

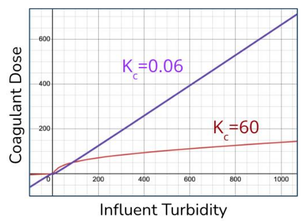
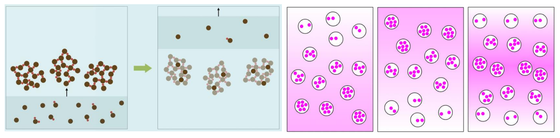


Figure 1. Significant difference between fitted (purple) and theoretical (red) predictions

The current model does not account for temporal and spatial variation in floc saturation and floc filter concentration (Figure 3). Further investigation is required to predict these dynamics.



Figures 2, 3. Floc saturation in floc filter (left) and varying spatial distributions of floc saturation (right). As flocs capture particles, their pores are filled, increasing the saturation of the flocs.

Methods

A novel experimental approach is developed to investigate how influent conditions (turbidity, coagulant dosage, DOM) affect (1) floc filter concentration, (2) floc saturation, and (3) clarification performance.

Experimental Setup
We are designing a benchtop-scale clarifier that is modular, has a short residence time, and enables us to visualize concentration and floc saturation in the floc filter.

Measurements
- Clarification performance: influent and clarified turbidity
- Floc filter concentration: reflected light, imaging floc filter with horizontal camera, similar to Hurst et al., 2013
- Floc saturation: floc filter coloration (Figure 4)

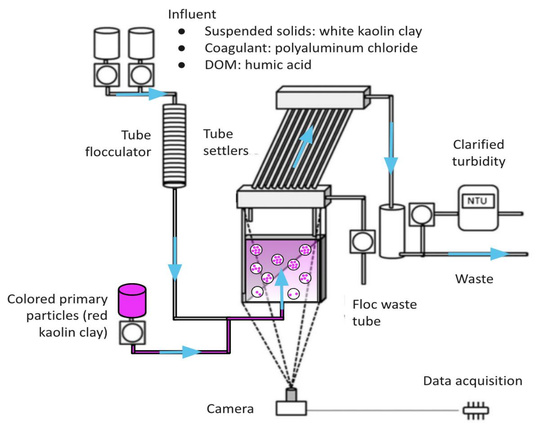


Figure 4. White flocs and colored primary particles enter the clarifier. As floc sweeping occurs, colored particles attach to flocs in the floc filter, increasing floc saturation. Relative coloration of the floc filter may therefore indicate saturation. (Hurst et al., 2013)

Results

Jar Test
Initial jar test with red kaolin as dye showed promise in creating colored flocs. Visibility of a coloration gradient in the floc filter requires further testing with an actual clarifier design.

Miniature Clarifier Prototype
A fully modular design led to issues with water-tightness. The current iteration utilizes two resin-printed housings and a piece of fitted glass, requiring few water-tight interfaces. Interfaces are sealed with rubber gaskets and Teflon tape (Figure 5).

Other features include:
- Diffuser and plate settler angles accurate to AguaClara plants
- Glass viewport for visualization of floc filter
- Easy to disassemble (no adhesives or cement)

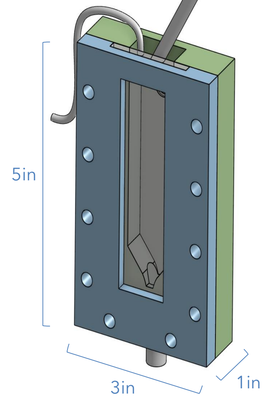


Figure 5. Mini clarifier CAD

Conclusions & Broader Applications

- Apply model to automate coagulant dosing and inform floc waste tube placement.
- Modeling spatial and temporal variation in floc saturation and floc filter concentration to work towards optimizing the particle removal process in the clarifier.

Future Work

- Design a modular and water-resistant clarifier.
- Examine how floc filter concentration and floc saturation is affected by fluctuating coagulant dose, influent turbidity, and DOM concentration.
- Develop and validate a mathematical model to describe the clarification process.
- Test novel approach to visualizing floc saturation.

References

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