AguaClara Cornell

DOM

Dissolved Organic Matter (2023SP)

Investigating the optimal conditions to remove humic acid in drinking water

More at https://github.com/AguaClara/Dissolved-Organic-Matter

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Goal

To determine the effectiveness of implementing coagulant with clay and/or powdered activated carbon to remove humic acid from drinking water and improve the capability of AguaClara water treatment plants.

Background

What is humic acid (HA)?

- Color, taste and odor problems
- Increased heavy metals and organic pollutants

How can we deal with humic acid?

- Flocculation
  - Coagulant (PACl)
    - w/ Clay
    - w/ Powdered Activated Carbon (PAC)
  - Create denser flocs
    - Porous and hydrophobic particles
    - Higher molar masses

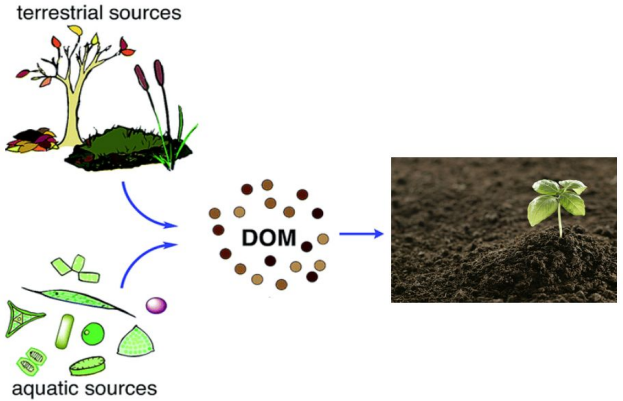


Figure 1. Formation of dissolved organic material from terrestrial and aquatic sources

Relevance to Gracias Plant

Flocculation issues:

- Low turbidity of influent stream
- Pigments particles from sweet gum (liquidambar) tree
  - Too small for coagulant to combine
  - Reduce PaCl's effectiveness in flocculation

Figure 2. Influent (left) and effluent (right) water from the Gracias plant (Honduras) during the rainy season

Schematic Drawing

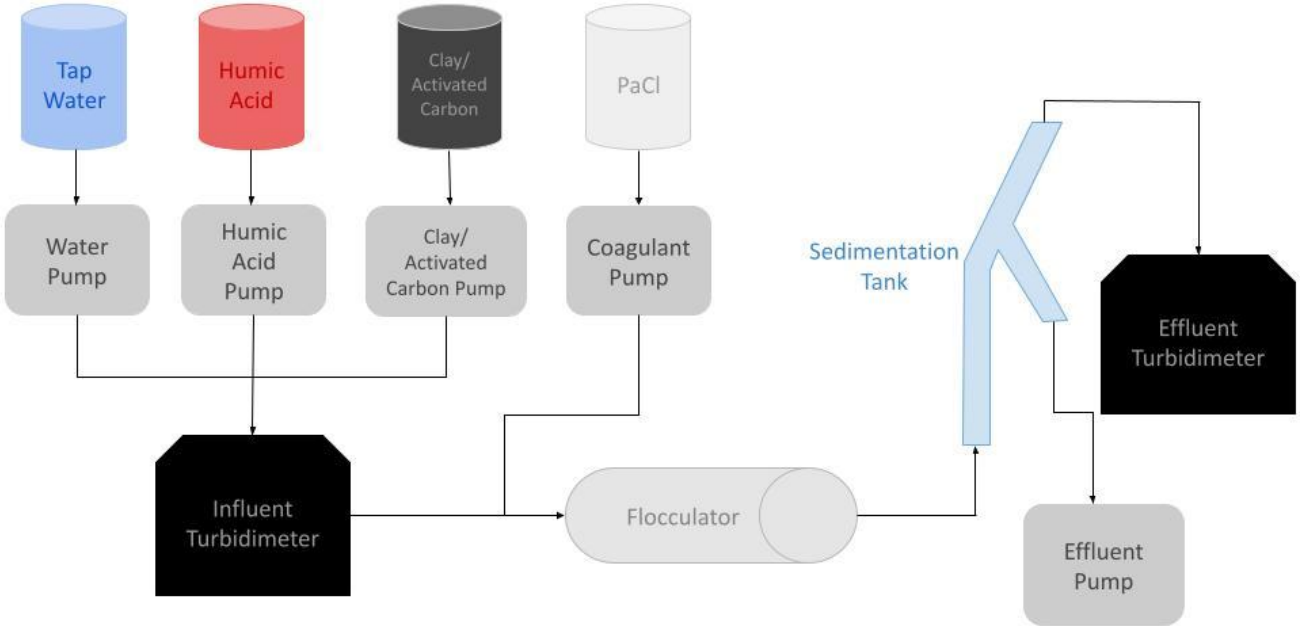


Figure 3. Schematic drawing of the experimental set up for testing varying clay and/or activated carbon concentrations

Experimental Setup

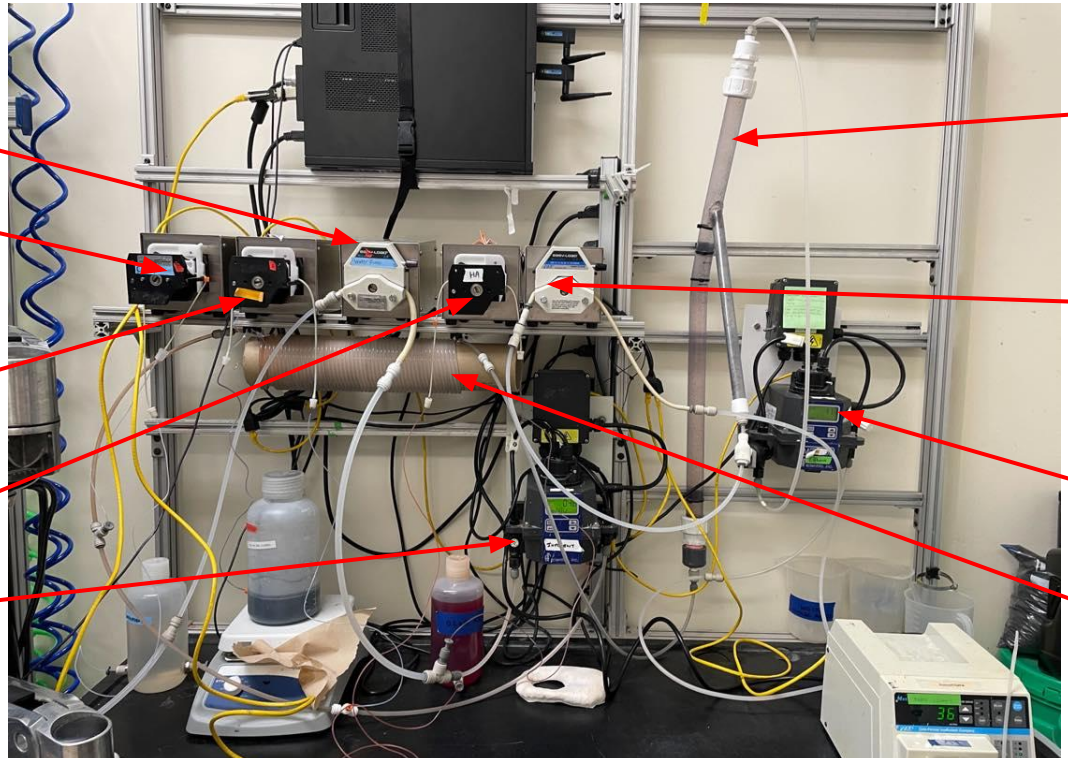


Figure 4. Image of lab set-up and experimental design

Recent Work

1) Conducted flow rate tests for each pump
    a) Calibrated the volume per rev for each pump
2) Automated testing with ProCoDa
    a) Implemented new setpoints and automated the timed release of different clay dosages
    b) Conducted longer trial runs (25 min) at these dosages
3) Analyzing floc sizes for incremental clay dosages
    a) Use ImageJ to take radius at each clay increment

Results and Analysis (1)

- The previously determined volume per rev values were set for each pump:
  - Clay/Activated carbon: 0.113 mL/rev
  - Coagulant: 0.118 mL/rev
  - Humic Acid: 0.109 mL/rev
  - Water: 2.66 mL/rev
  - Waste: 0.850 mL/rev
- All set points were modified to accommodate changes in clay flow rate.
- Clay flow rate increments were based on geometric series:

$$0.5*3^{x} \text{ for } x = 0, 1, 2, 3, 4, 5 \text{ (in rpm)}$$

Clay dosages are: **0.00**, **0.473**, **1.42**, **4.26**, **12.8**, **38.3** mg/s

Results and Analysis (2)

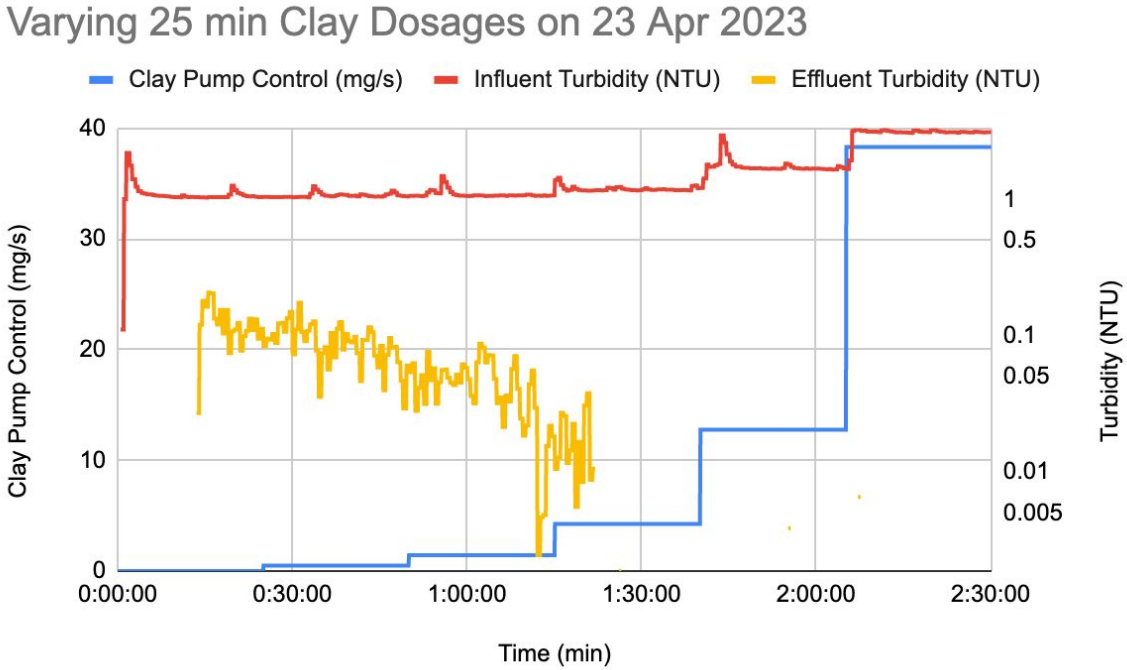


Figure 5. Graph of Turbidity vs Time after Varying Clay Dosages

Clay dosages:

- 0 mg/s
- 0.473 mg/s
- 1.42 mg/s
- 4.26 mg/s
- 12.8 mg/s
- 38.3 mg/s

Coagulant dosage: 23.6 mg/s

Humic acid dosage: 23.6 mg/s

Results and Analysis (3)

Figure 6. 0 mg/s Clay Sed Tank Image

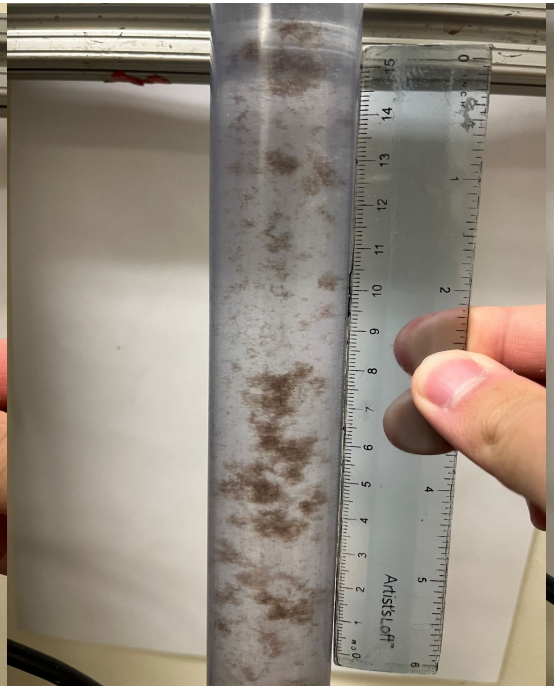


Figure 7. 0.473 mg/s Clay Sed Tank Image

Figure 8. 1.42 mg/s Clay Sed Tank Image

Results and Analysis (4)

Figure 9. 4.26 mg/s Clay Sed Tank Image

Figure 10. 12.8 mg/s Clay Sed Tank Image

Figure 11. 38.3 mg/s Clay Sed Tank Image

Results and Analysis (5)

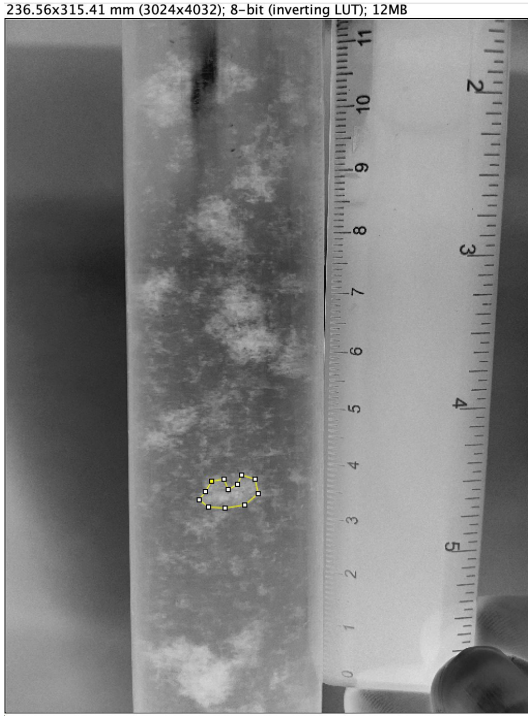


Figure 12. Sedimentation tube after addition of 1.418 mg/s clay (LUT inverted)

Table 1. Floc size analysis for 1.418 mg/s clay dosage trial from ImageJ

	Area (mm^2)	**Perimeter (mm)**	**Radius (mm)**
Mean	73.511	40.205	4.837
SD	27.585	9.194	2.963
Min	21.824	25.043	2.636
Max	114.069	56.389	6.026

Future Work

1) Test trials with no clay (find repeatable upward velocity)
    a) Increase upward velocity to make flocs harder to form
2) Trying to eliminate the floc filter
3) Try to get data with less PACl
    a) Much lower dose → 2 and 5 mL of PACl
4) Quantifying flocs

Appendix Slides

ProCoDA Set Points

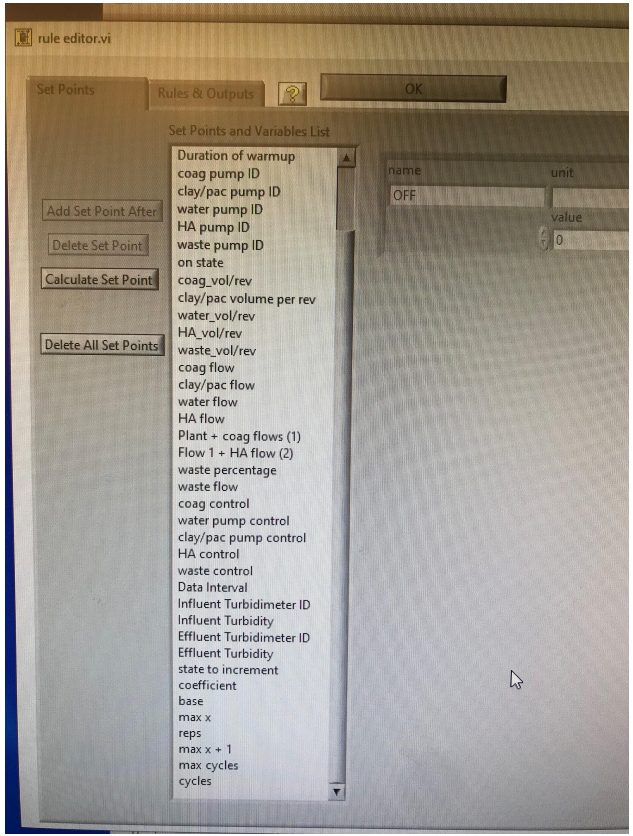
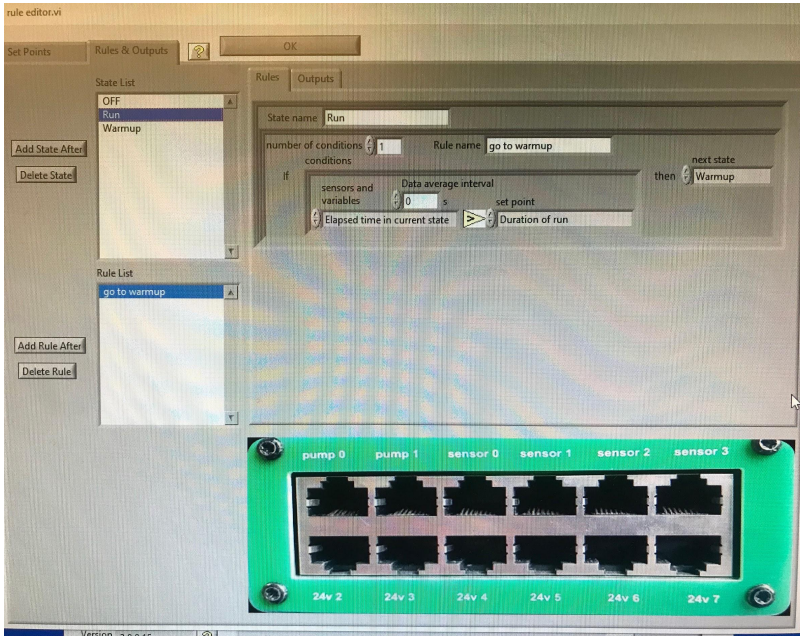


Figure 13. Image of the setpoints of the ProCoDA method file
Link to ProCoDA Method File:
https://github.com/AguaClara/Dissolved-Organic-Matter/blob/main/ProCoDA-Method-Files/DOM%2004232023%20automated%20trials.pcm

ProCoDA Rules & Outputs



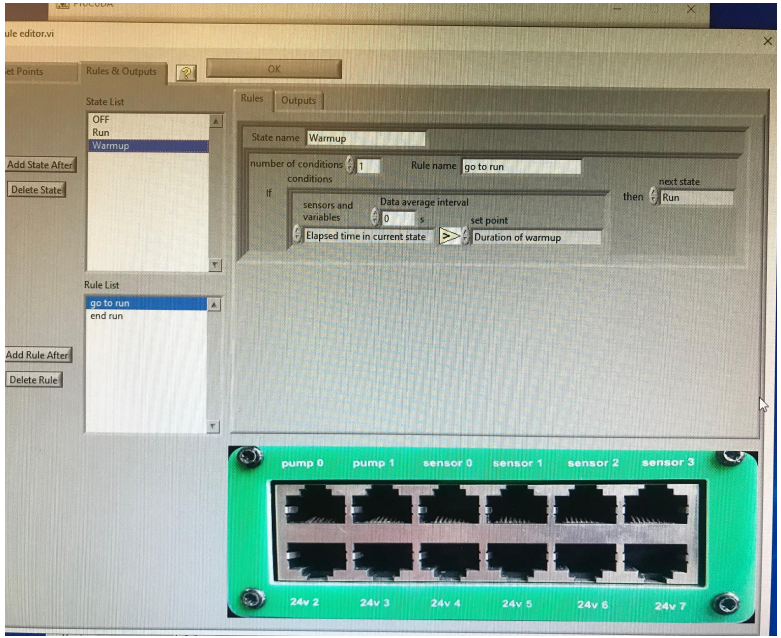


Figure 14. Images of the setpoints of the ProCoDA method file
Link to ProCoDA Method File:
https://github.com/AguaClara/Dissolved-Organic-Matter/blob/main/ProCoDA-Method-Files/DOM%2004232023%20automated%20trials.pcm

Pump Test Calibration (1)

Pump type	Overhead type	Number of revolutions (rev)	Volume pumped (mL)	Volume per rev (mL/rev)	Average volume per rev (mL/rev)
Clay/Activated carbon	Ismatic	32.5	3.66	0.113	0.113
		34.5	3.78	0.110	
		10	1.21	0.121	
		10.5	1.15	0.110	
		10.75	1.2	0.112	
Coagulant	Ismatic	10.25	1.25	0.122	0.118
		13.6	1.64	0.121	
		16.25	1.95	0.120	
		18.5	2.11	0.114	
		22	2.52	0.115	
		22.6	2.59	0.115	

Table 2.1: Pump test data for clay and coagulant pump

Pump Test Calibration (2)

Humic acid	Ismatic	12	1.3	0.108	0.109
		15	1.65	0.110	
		16.5	1.79	0.108	
		19	2.09	0.110	
		21.25	2.33	0.110	
		23	2.52	0.110	
Water	Masterflex	10.5	28.22	2.69	2.66
		12	30.43	2.54	
		5.5	14.85	2.70	
		4.75	12.85	2.71	
		10.5	28.22	2.69	
Waste	Masterflex	6.2	5.26	0.848	0.850
		8.25	7.13	0.864	
		8.5	7.11	0.836	
		10	8.46	0.846	
		9.75	8.3	0.851	
		12	10.23	0.853	

Table 2.2: Pump test data for humic acid, water, and waste pump

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Lin, V. S. (2015). Research highlights: Challenges in the characterization, storage, and isolation of natural organic matter. *Environmental Science: Processes & Impacts*, *17*(12), 2002–2005. https://doi.org/10.1039/c5em90046h

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