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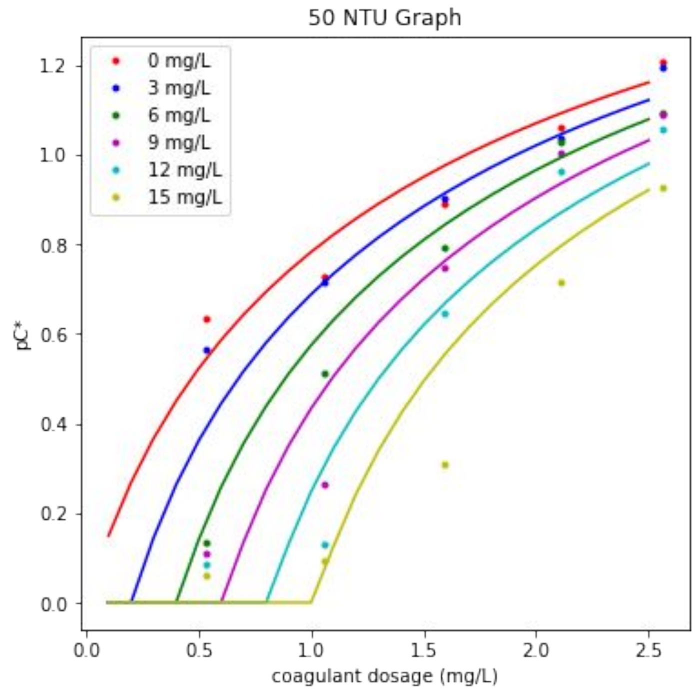
2 Stage Coagulant Addition

Design, Fabrication, Adjustment of the system
Preliminary Study of
1 stage coagulant addition VS 2 stages coagulant addition

Introduction

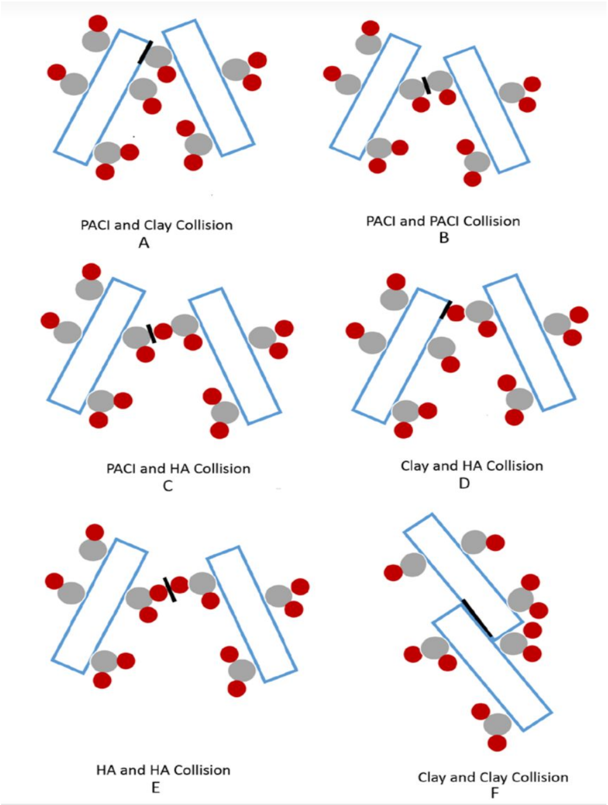


Yingda's thesis

Semester Goals

- Design and fabricate the apparatus
- Code the experiment: ProCoDA and Python
- Preliminary tests 1 stage vs 2 stage

Background



Swetland

Technical terms

- PACl: Polyaluminum Chloride (coag)
- NOM: Natural Organic Matter
- HA: Humic Acid
- DOM: Dissolved Organic Matter

Figure: Humic Acid

Experiment Apparatus

- Clay and Humic Acid mixed in one tank

- Electronic scale used to trace the mass difference of coagulan

- Pump Control

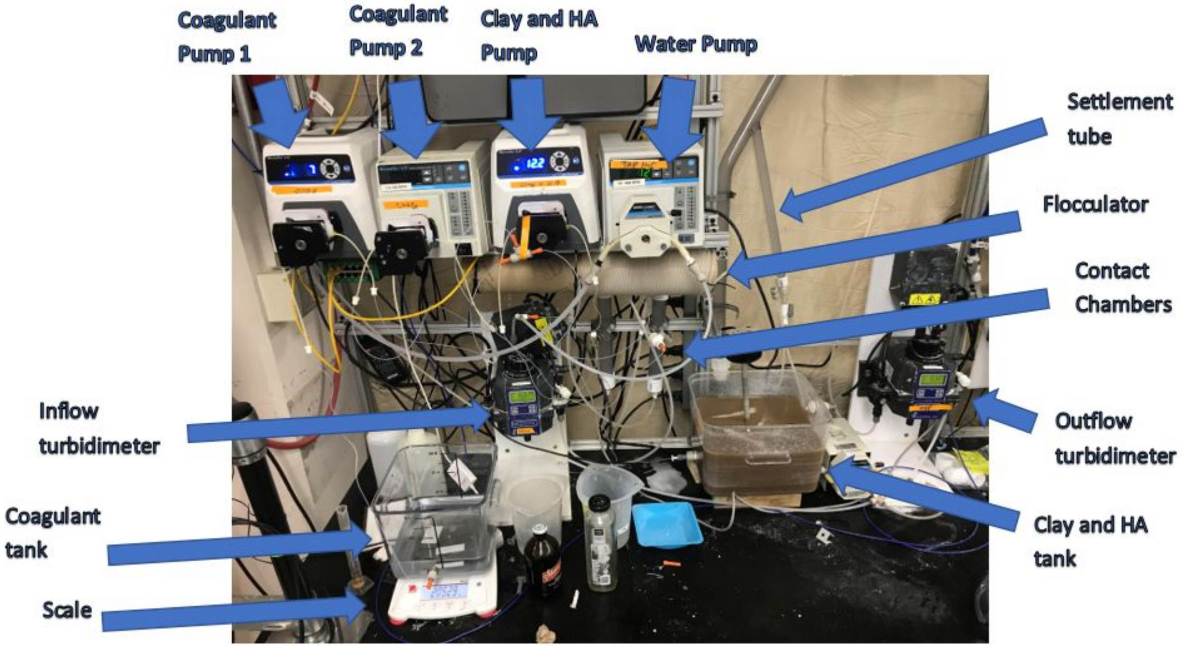


Figure: overall experiment apparatus

Pump Control in 2 stage

- ProCoDA can only control two pumps

- How do we maintain control of 3 pumps?
    - T Connection
    - Manual RPM input
    - One pump drain from other

Figure: Design for Pump Control

Experiment Method

- T connection between the two coagulant pumps

- Fixed HA concentration, while dosing of coagulant between 0.5 - 2.5 mg/L

- ProCoDA increment function to switch different coagulant dosage

- Chemical(PACl, HA) dosage calculated by Python

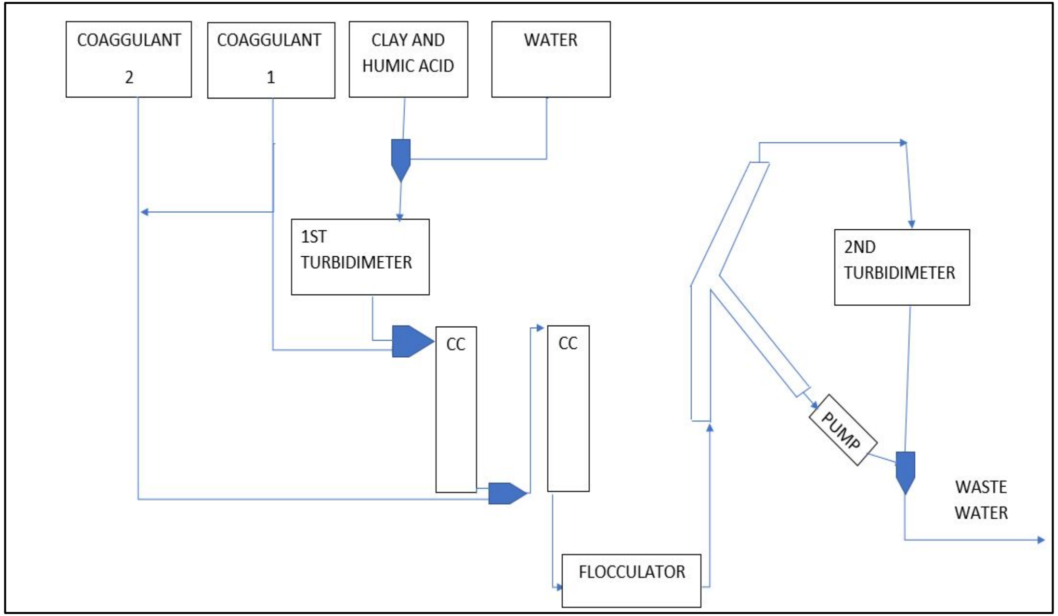
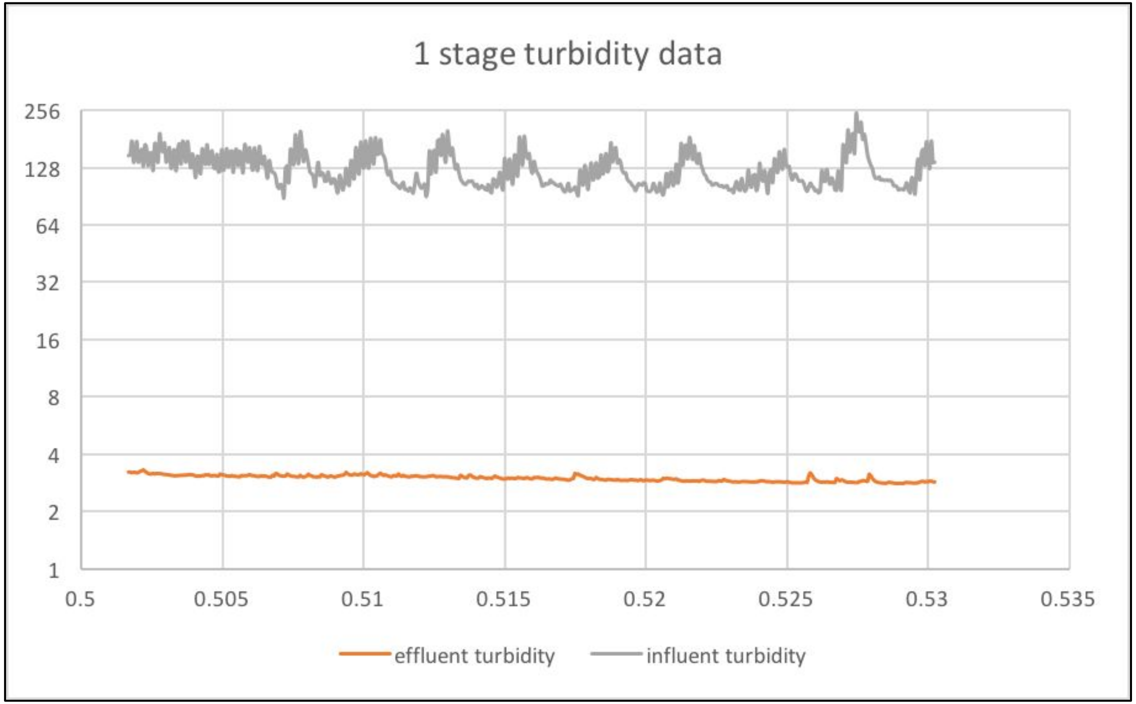


Figure: Flow Diagram

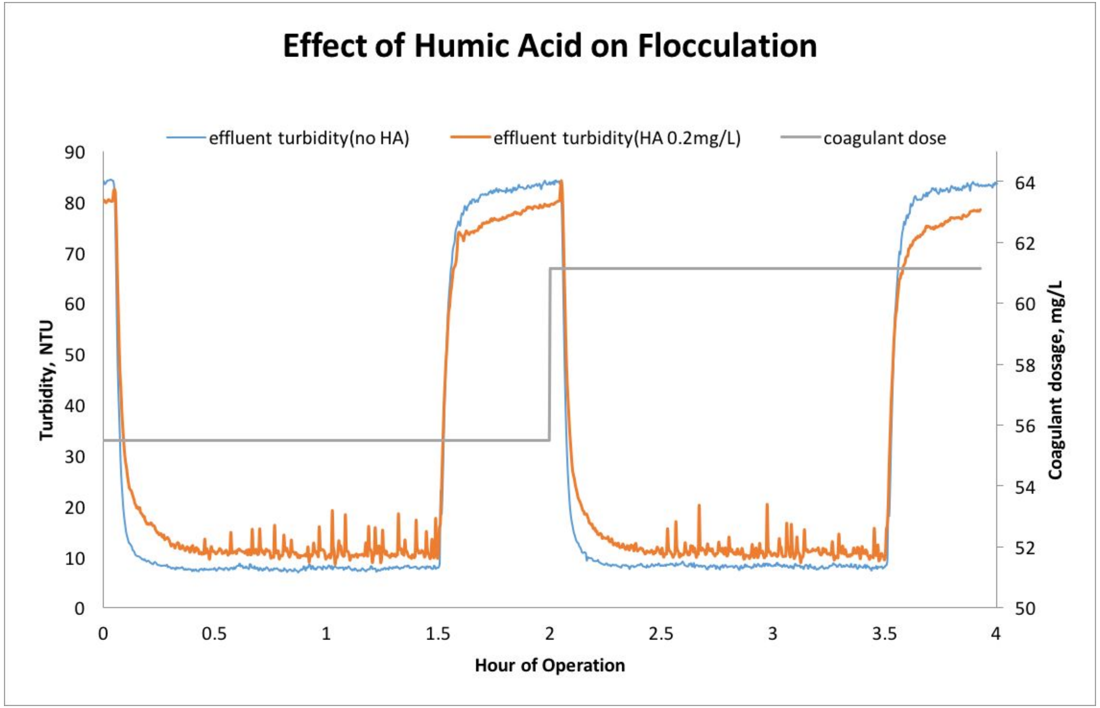
1 stage result

- Target Influent Turbidity:
  100 NTU
- HumicAcid concentration:
  10 mg/L
- Lowest Effluent Turbidity:
  2.98 NTU
  (meet the requirement of filtration)



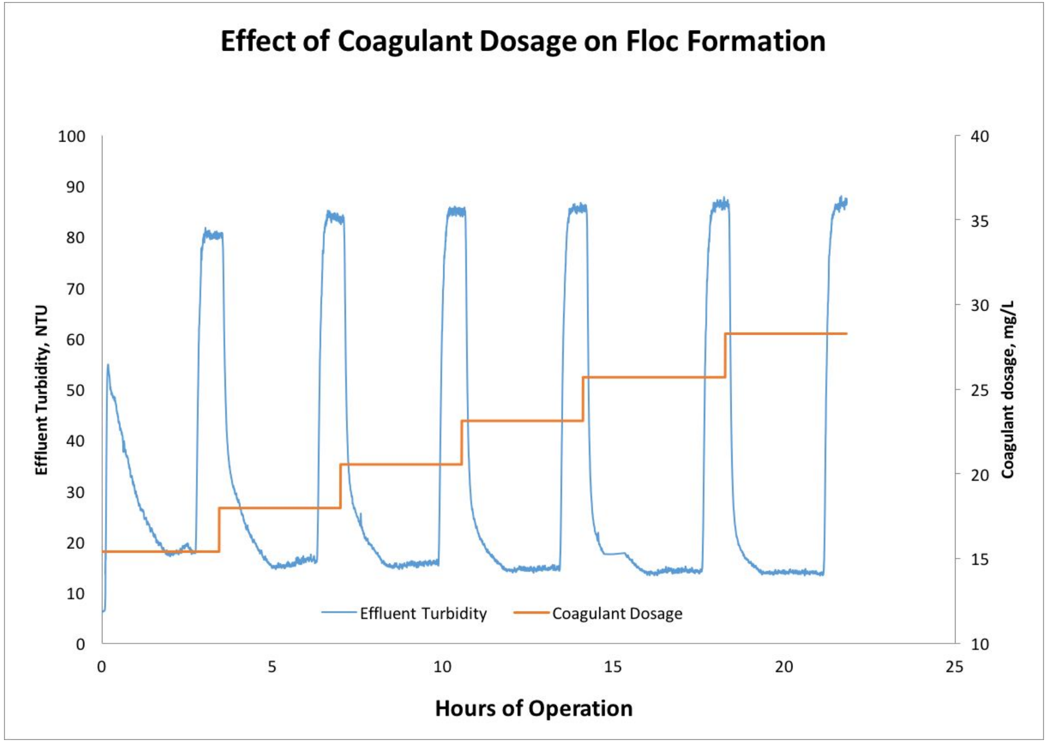
Impact of Particle Surface Charge

- Target Influent Turbidity:
  100 NTU
- HumicAcid concentration:
  10 mg/L
- Lowest Effluent Turbidity:
  5 NTU



Impact of Coagulant Dosage

- Target Influent Turbidity:
  100 NTU
- HumicAcid concentration:
  10 mg/L
- Lowest Effluent Turbidity:
  5 NTU



1-Stage VS 2-Stage

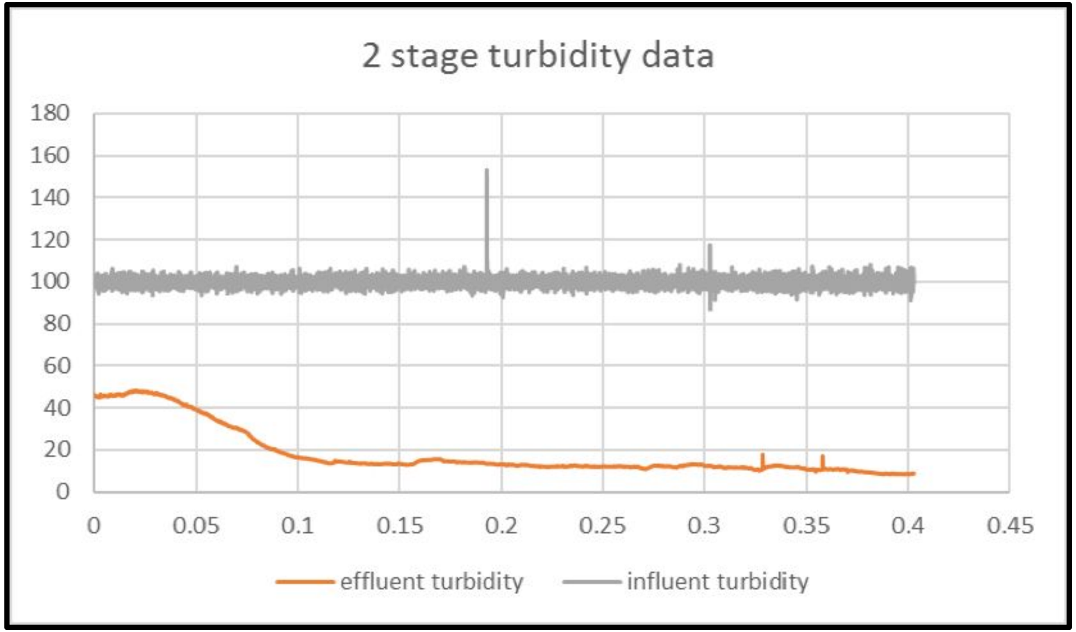
- Target Influent Turbidity:
  100 NTU
- HumicAcid concentration:
  10 mg/L
- Lowest Effluent Turbidity:
  6 NTU

2 stage result

- Target Influent Turbidity:
  100 NTU

- HumicAcid concentration:
  10 mg/L

- Lowest Effluent Turbidity:
  6 NTU



Conclusion

- Apparatus
- Software & Coding
- Experiment Results

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- Software & Coding
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Future Tasks

- Experimentation:
  - Vary coagulant dosage (vary from 1 to 3 mg/L)
  - Vary HA concentration (3, 6, 9 , 12, 15 mg/L)
- Second coagulant pump
- Compare Results
- Find optimal dosage levels of coagulant for 1st and 2nd stage addition
- Further research on effects of HA on Flocculation

Floc blanket

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Floc blanket

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Questions and Recommendations

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Appendix Slides

Python Code

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- Converted MathCad doc into a python code
- Used to calculate
  - flow rate of system
  - mass flow rate of coag
  - Pump RPM control
  - Clay and Ha dosage

Clay & HA dosage

In [67]:
```
# concentration of the clay
turbidity_target = (100*u.NTU)
print(ut.sig(turbidity.to(u.g/u.L),3))

# concentration of the humic acid
conc_HA = 10*(u.mg/u.L)
print(conc_HA.to(u.g/u.L))

# clay&HA in tank
# the concentration of the solution in stock tank is K times concentrated than system requirement
V_mixture = 5*u.L
K_condense = 20
clay_add = turbidity_target*K_condense*V_mixture
HA_add = conc_HA*K_condense*V_mixture

print("so we add",clay_add.to(u.g),"clay and ",HA_add.to(u.g),"humic acid into the system.")
```

```
0.170 g/l
0.01 gram / liter
so we add 17 gram clay and  1 gram humic acid into the system.
```

In [40]:
```
# coag pump running w/ 16RPM(coag_conc=1.5mg/L), we can have a effluent turbidity from 3 to 4, and the floc blanket ca
n form within\
# a short period of time.
```

In [58]:
```
V_reservoir = 5*u.L
V_lab_solution = V_reservoir*conc_reservoir/conc_labsolution
print('The volume of lab concentration solution we need to add into the reservoir is',ut.sig(V_lab_solution,3))
```

```
The volume of lab concentration solution we need to add into the reservoir is 15.0 ml
```

In [60]:
```
# The flow pumped out of the pump per round(measured by experiment)
# Q_perRPM_coag1 = 0.00042*(u.ml/u.s)
Q_perRPM_coag2 = 0.0025*(u.ml/u.s)
numRPM = Q_reservoir/Q_perRPM_coag2
print('The pump should run with a speed of',numRPM.to(u.dimensionless))
```

```
The pump should run with a speed of 2.859 dimensionless
```

In order to use Yingda's model, we would start from 10 mg/L humic acid and ??? mg/L clay.(which parameter guide the dosage of clay?) after we can run the system w/ 10 mg/L HA, I plan to do both increase and decrease on the dosage of HA, from 0 mg/L to 15 mg/L, the interval could be 3 mg/L per experiment.

Pump Property

In [61]:
```
# water pump:
QperRPM = ((52*u.ml/20)*60)/(30*u.s)
print(QperRPM.to(u.ml/u.s))
# taget RPM
waterpump_speed = 60*Q_system/QperRPM
print(waterpump_speed.to(u.dimensionless))
# clay pump control by ProCoDA
# coag pump 1
QperRPM_p1 = ((1*u.ml/(10)))/(240*u.s)
print(QperRPM_p1.to(u.ml/u.s))
# coag pump 2 # exp2: 10RPM 3ml 127s
QperRPM_p2 = ((3*u.ml/10))/(110*u.s)
print(QperRPM_p2.to(u.ml/u.s))
```

```
5.2 milliliter / second
11.69 dimensionless
0.0004167 milliliter / second
0.002727 milliliter / second
```

Equations

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$$Q_{system} = V_{sed} * A_{pipe}$$

Flow rate of System

$$MassFlow_{PACl} = C_{PACl} * Q_{system}$$

Mass Flow of Coagulant

$$Q_{reservoir} = \frac{MassFlow_{PACl}}{C_{reservoir}}$$

Flow of Reservoir

$$RPM = \frac{Q_{reservoir}}{Q_{perRPMcoag2}}$$

RPM of Coagulant Pump

$$clay_{add} = Turbidity_{target} * K_{condense} * V_{mixture}$$

$$HA_{add} = C_{HA} * K_{condense} * V_{mixture}$$

Mass of Clay and HA in reservoir