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Granular Sequencing Batch Reactor

Improving aerobic granulation wastewater treatment processes with PACl dosing

Motivation

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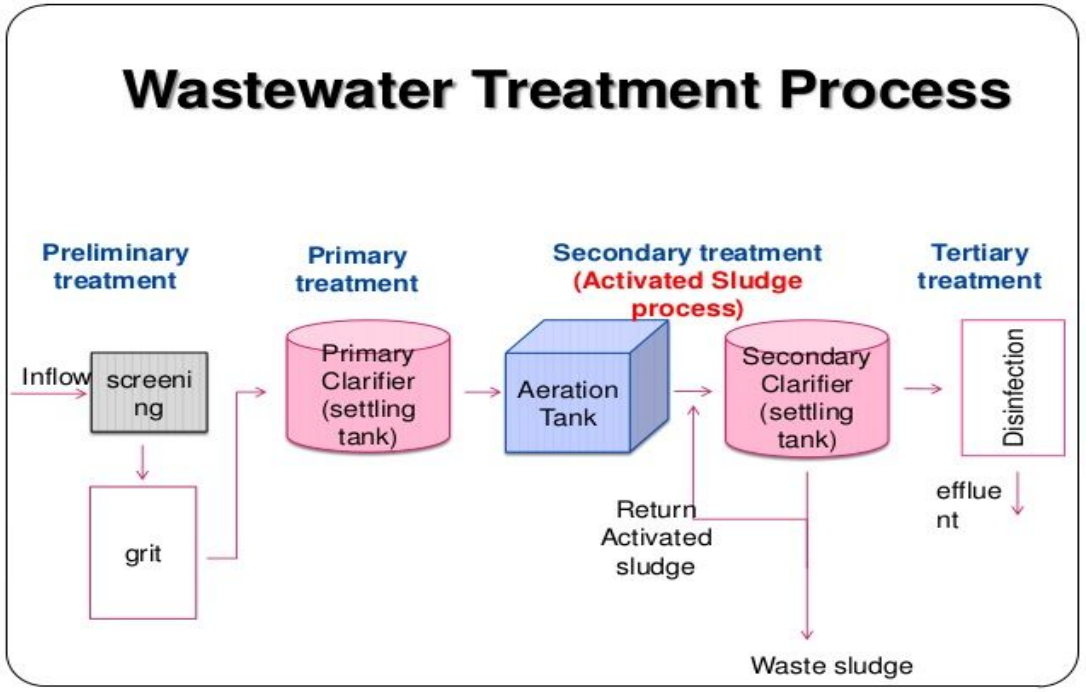
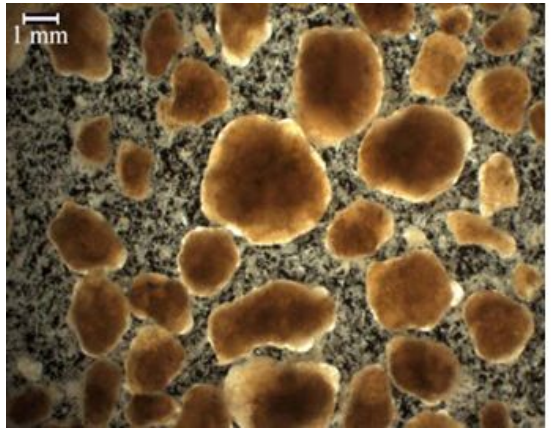
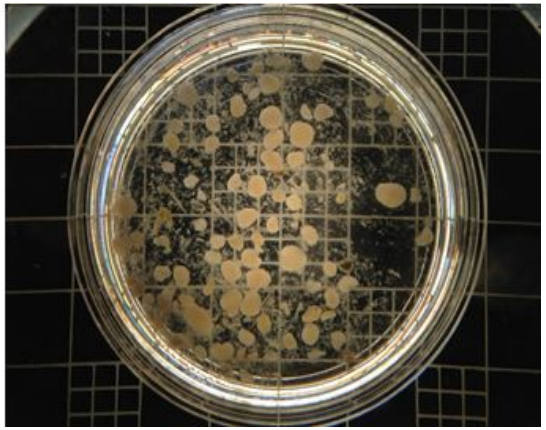
- Conventional wastewater treatment:
  - Energy intensive
  - Complex
- GSBR more sustainable alternative
  - Smaller footprint
  - Less energy

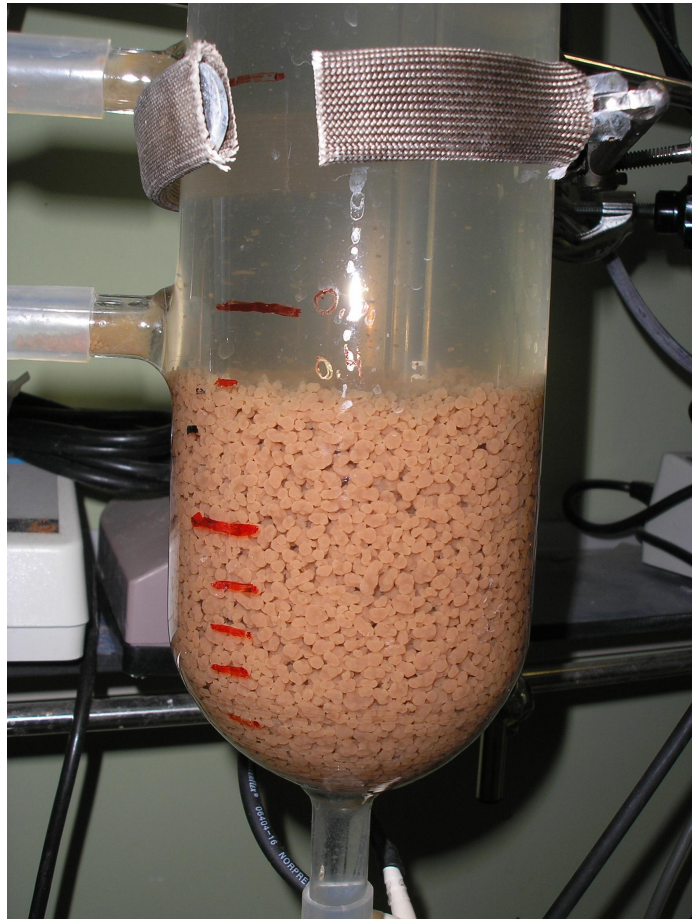






Introduction to GSBRs

- Granular Sequencing Batch Reactors
  - Same functioning as Sequencing Batch Reactors
  - Only difference is that sludge is granular
  - Sludge settles faster since it is granulated
  - Granulation believed to be caused by variety of reasons.



How it works

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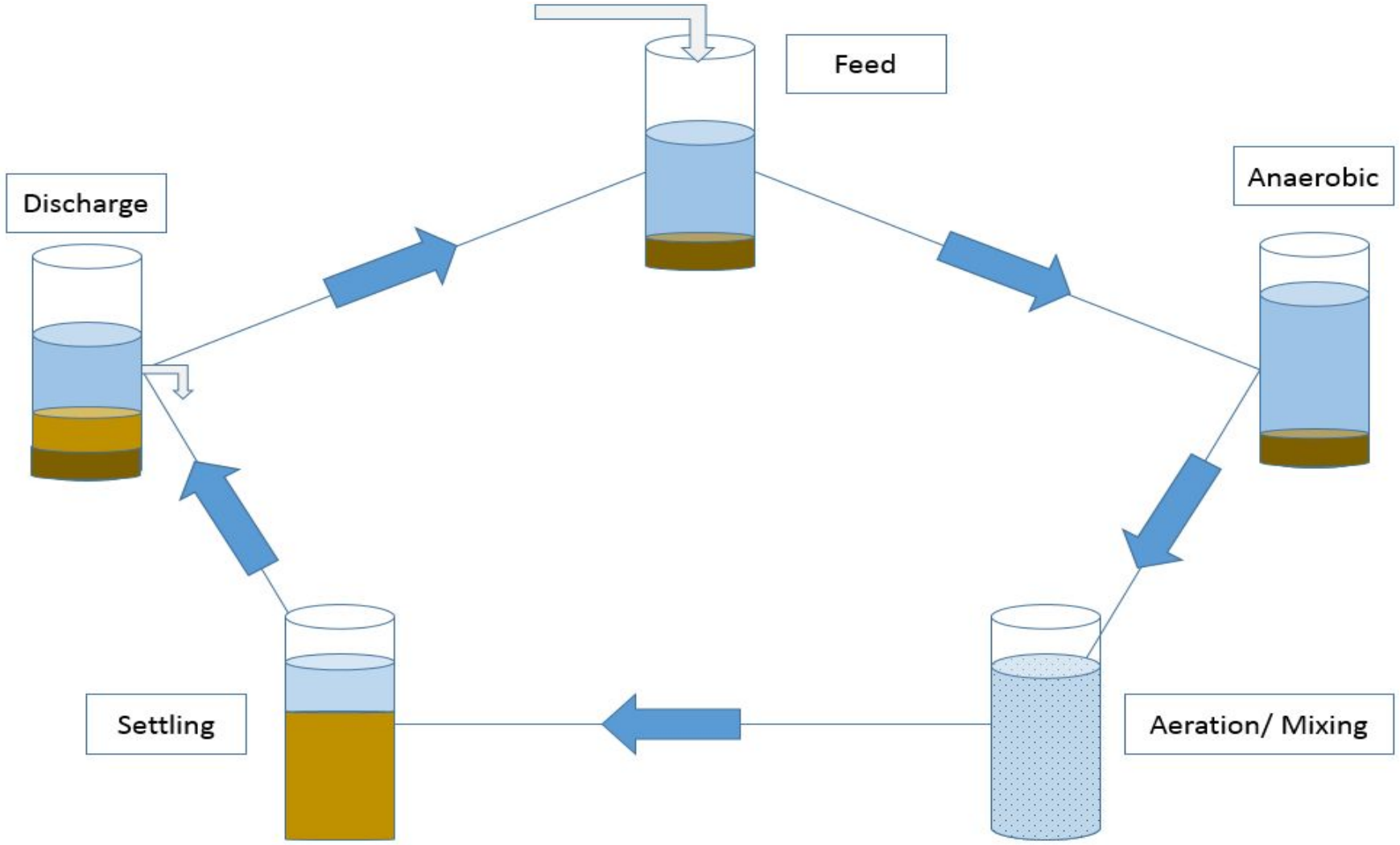
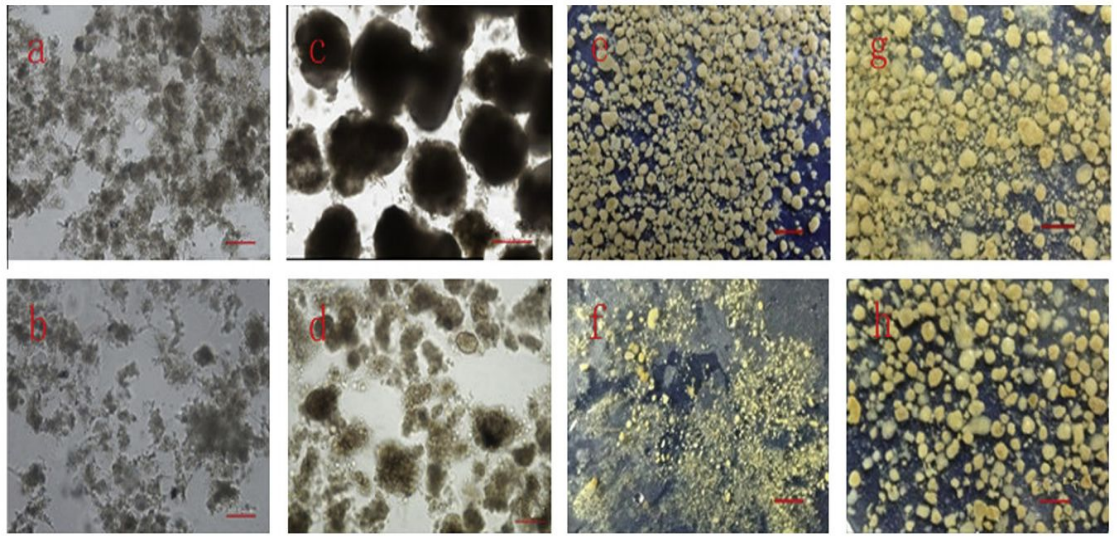
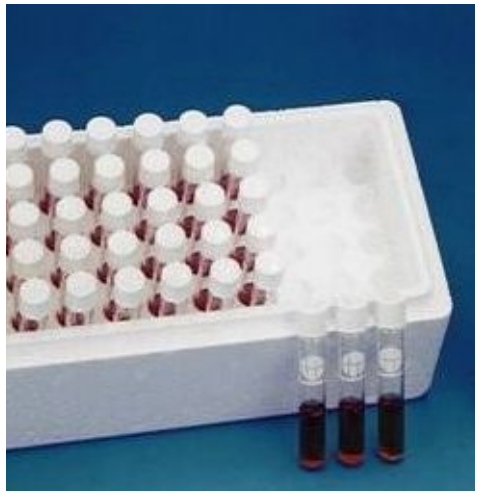
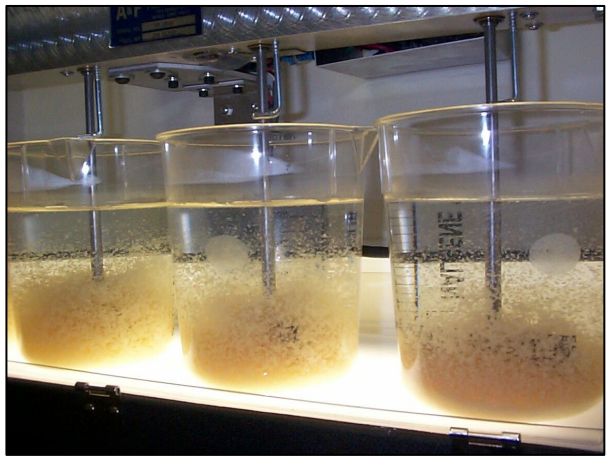
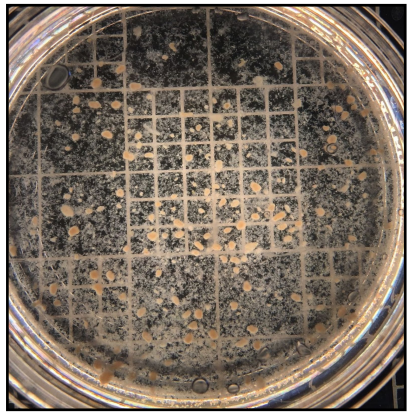


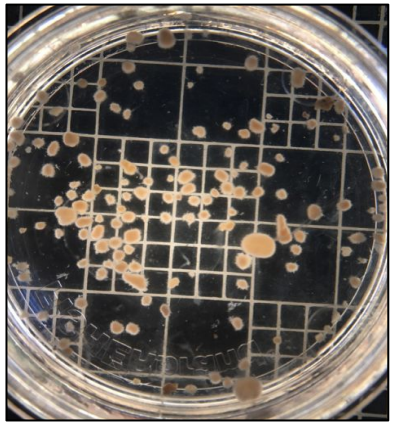
Improving Granulation











Goal: Reduce granulation time, increase granule size, increase solids retention by several methods.

GSBR

- Average granulation time - **several months** for full-size plants
- Granulation time cut in half due to divalent ions (calcium and magnesium)
- Granulation in 7 days adding PACI (80 mg/L of Al) vs. 17 days.

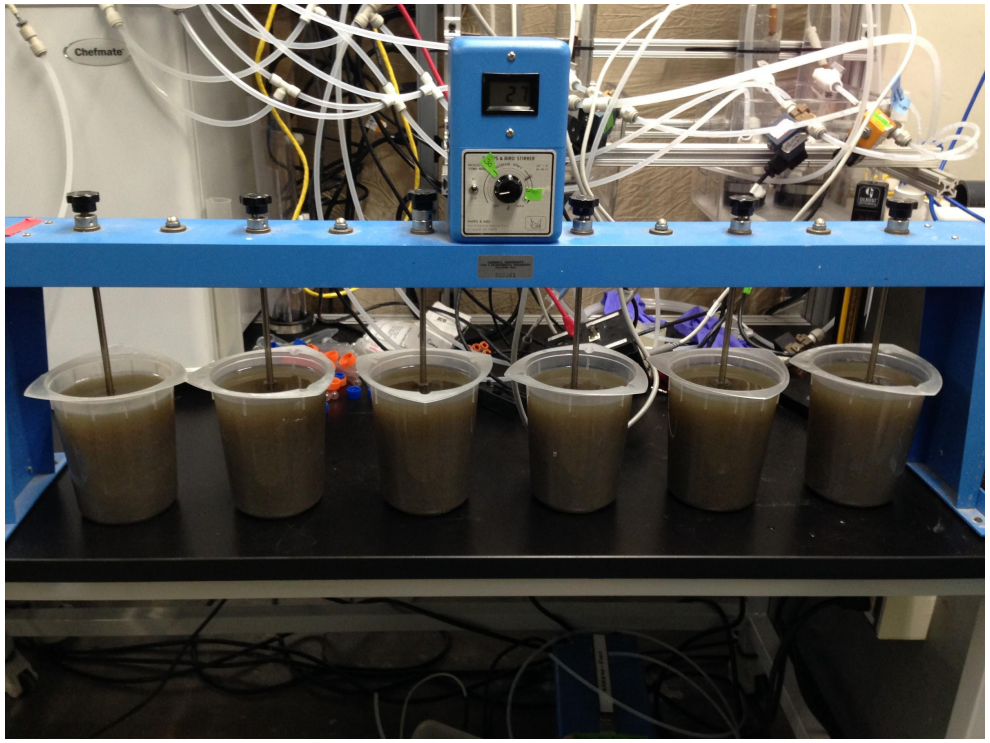
Experimental Plan - PACI

- Reactors with different dosage of PACI
- Reactor inoculation (IAWWTP)
- ProCoDa methods
- Turbidity measurements
- DO and COD measurements
- Biomass images

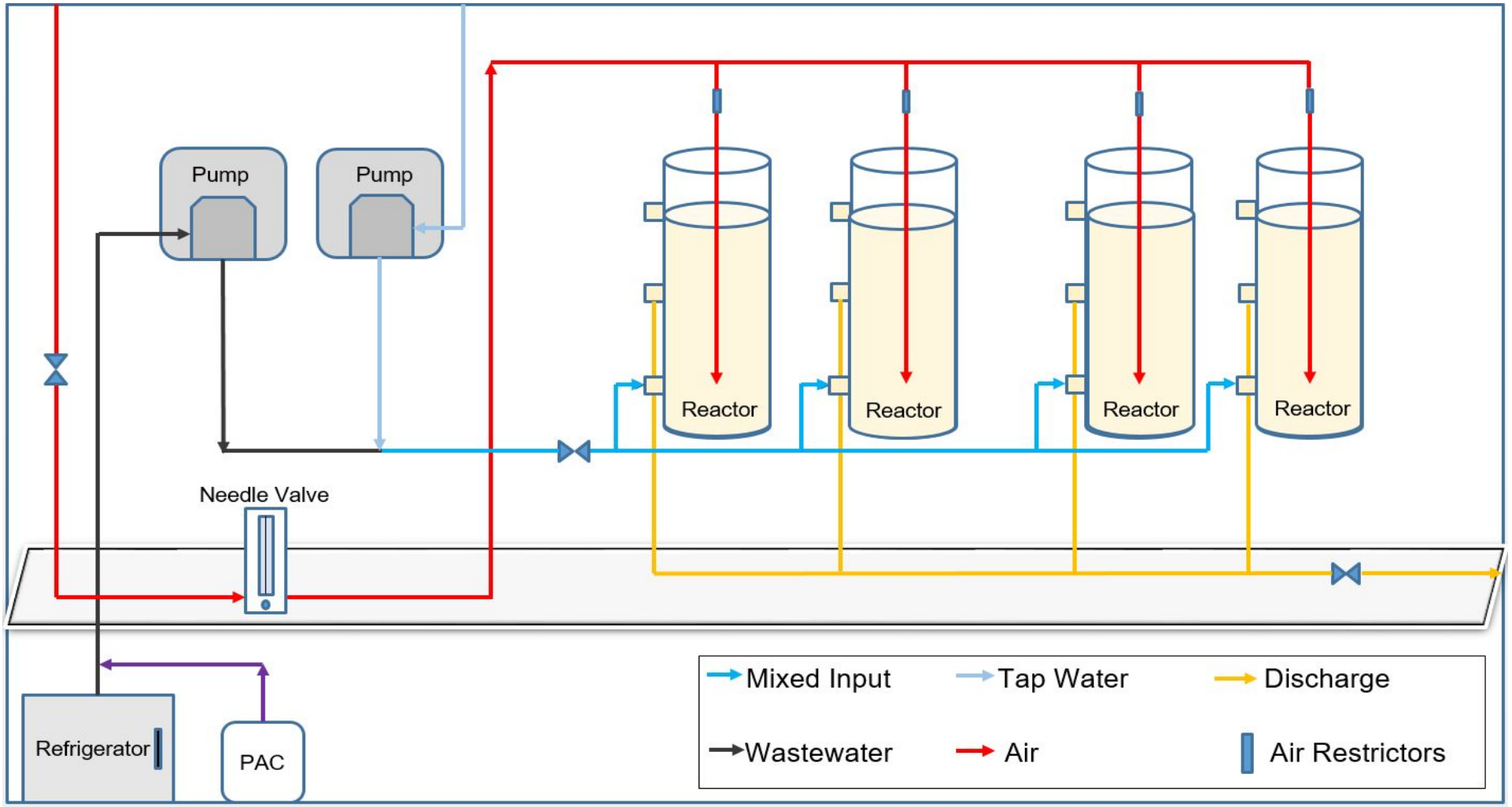
Cycle Schedule

Order	Name of State	Time (min)
1	Feed	3.5
2	Aerate + Mix	2
3	Anaerobic	31.16
4	Aerate 1	2
5	Measure DO 1	0.75
6	Aerate 2	40.25
7	Measure DO 2	0.75
8	Aerate 3	40.25
9	Measure DO 3	0.75
10	Aerate 4	40.25
11	Settle	16.67
12	Discharge	1.67
	Total	180

Jar Test Results



Experimental Setup



Why DO Probe Method

- COD (Chemical Oxygen Demand) test is toxic
- Time intensive test (3 hours)
- Lots of samples

Alternative

- Use Dissolved Oxygen Probes to measure COD Removal

Dissolved Oxygen through Cycle

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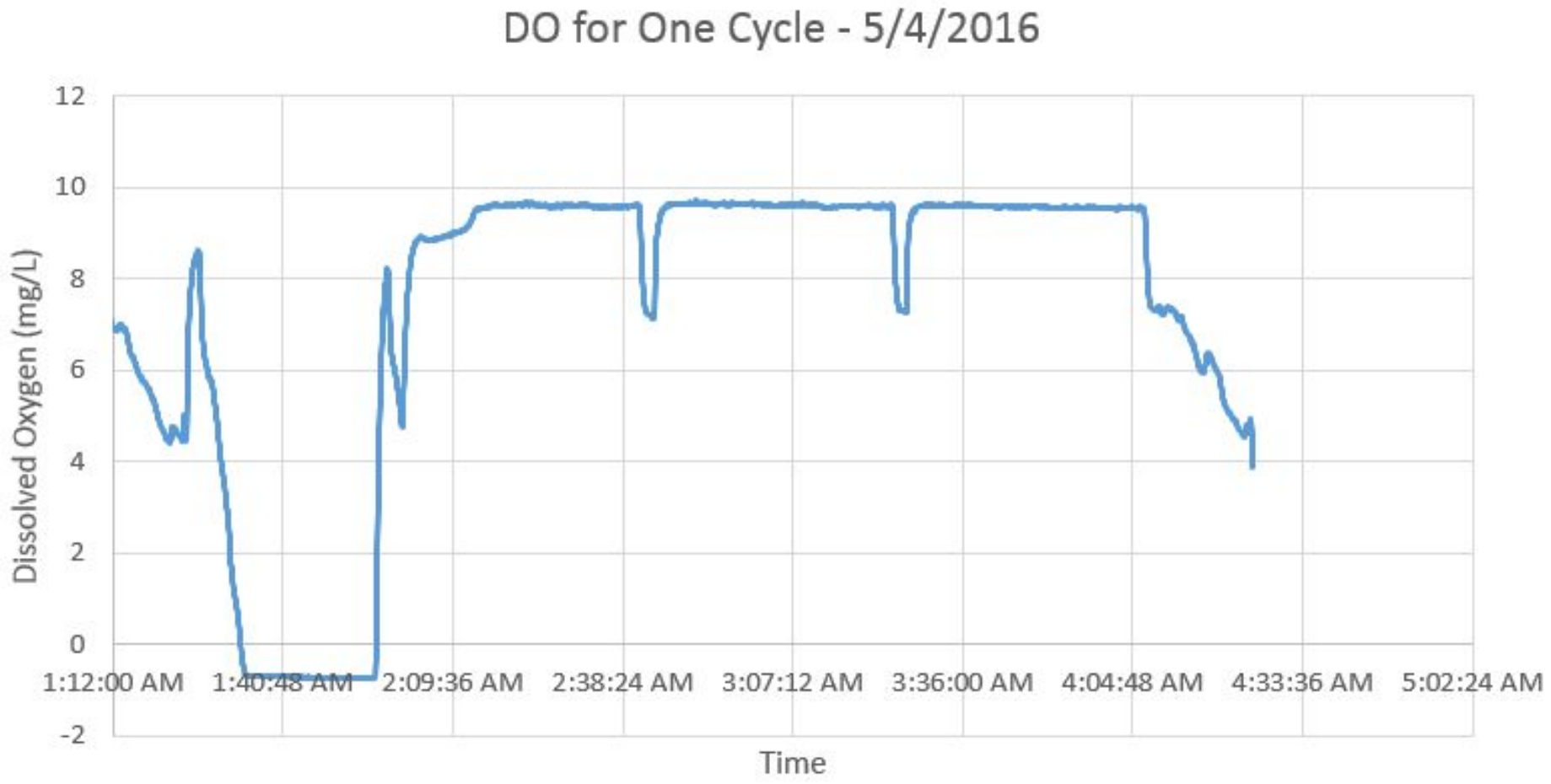

DO Measurement Method

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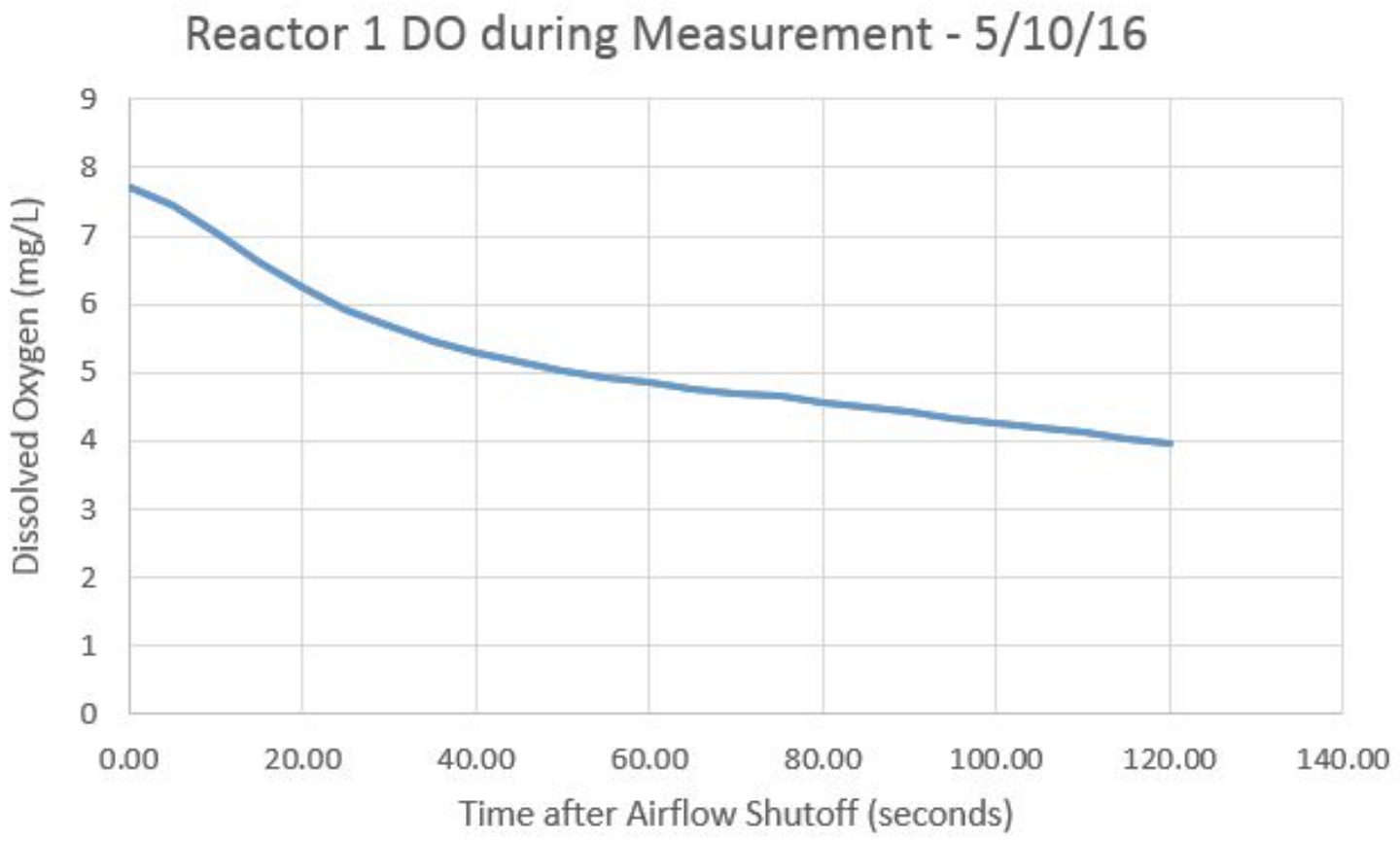

DO Measurement Method

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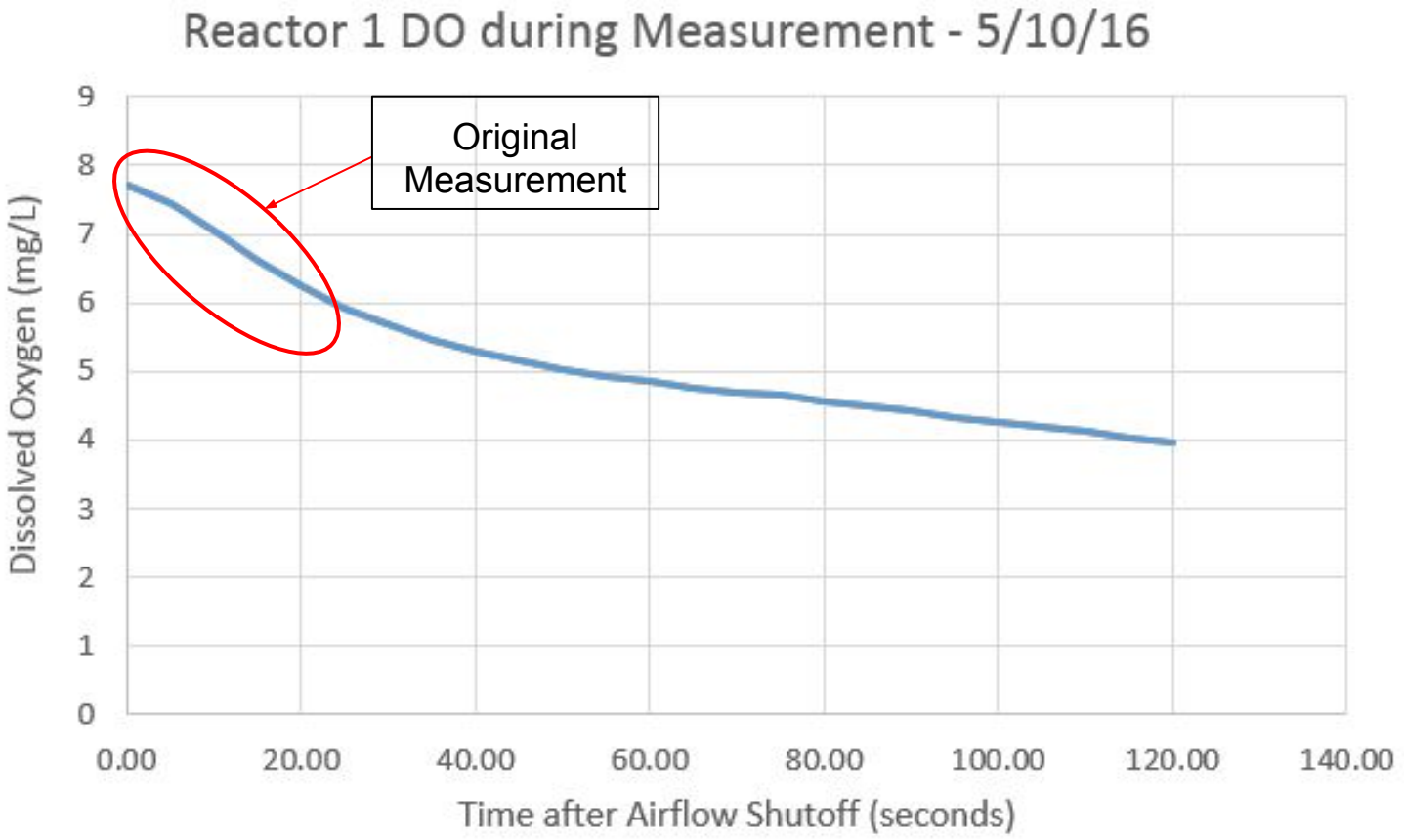
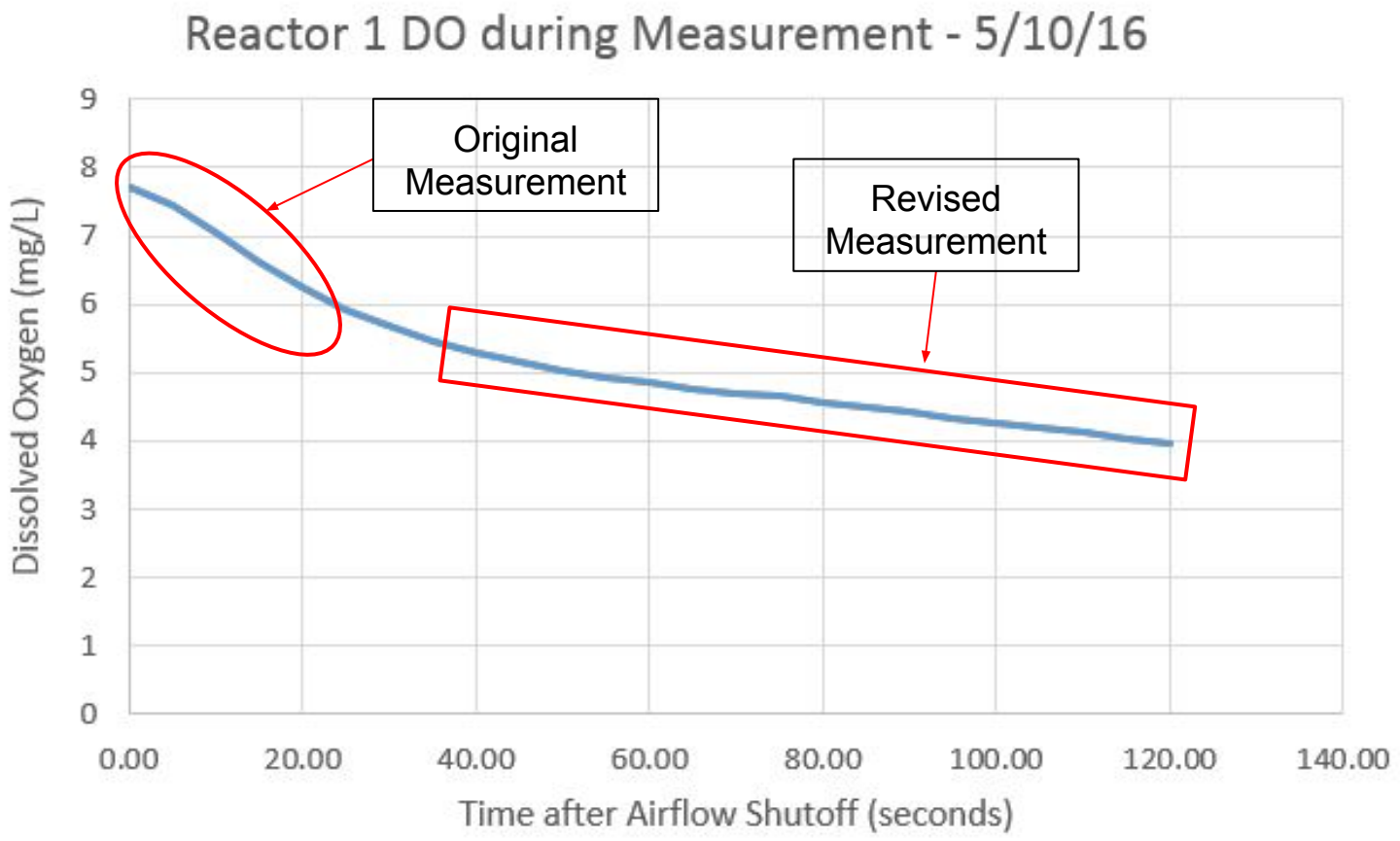
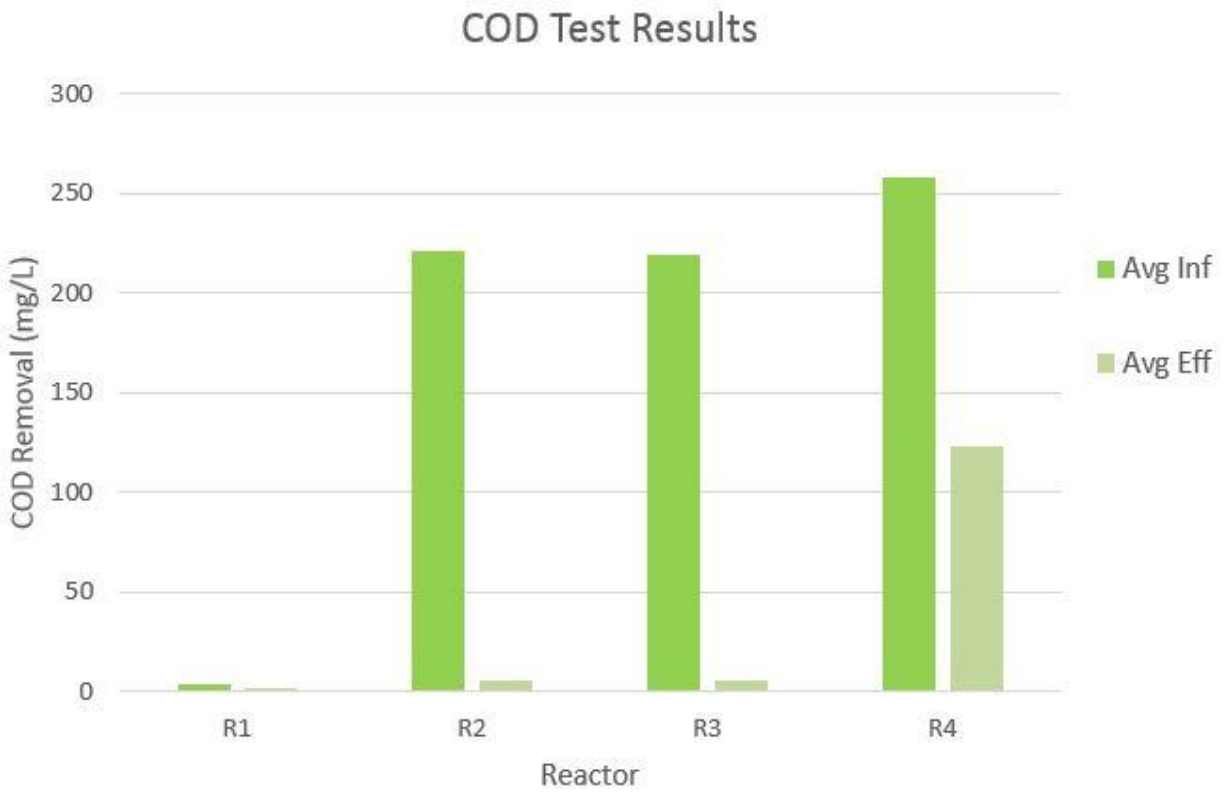
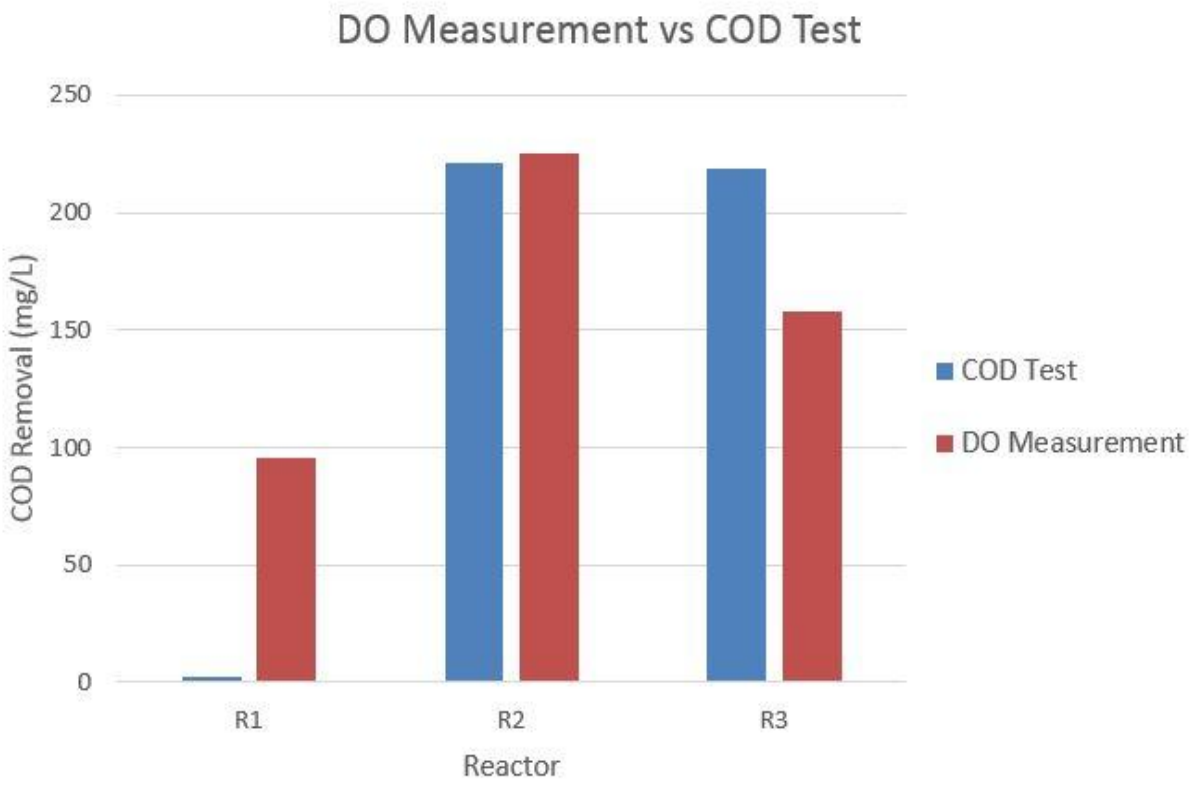


DO Measurement Method

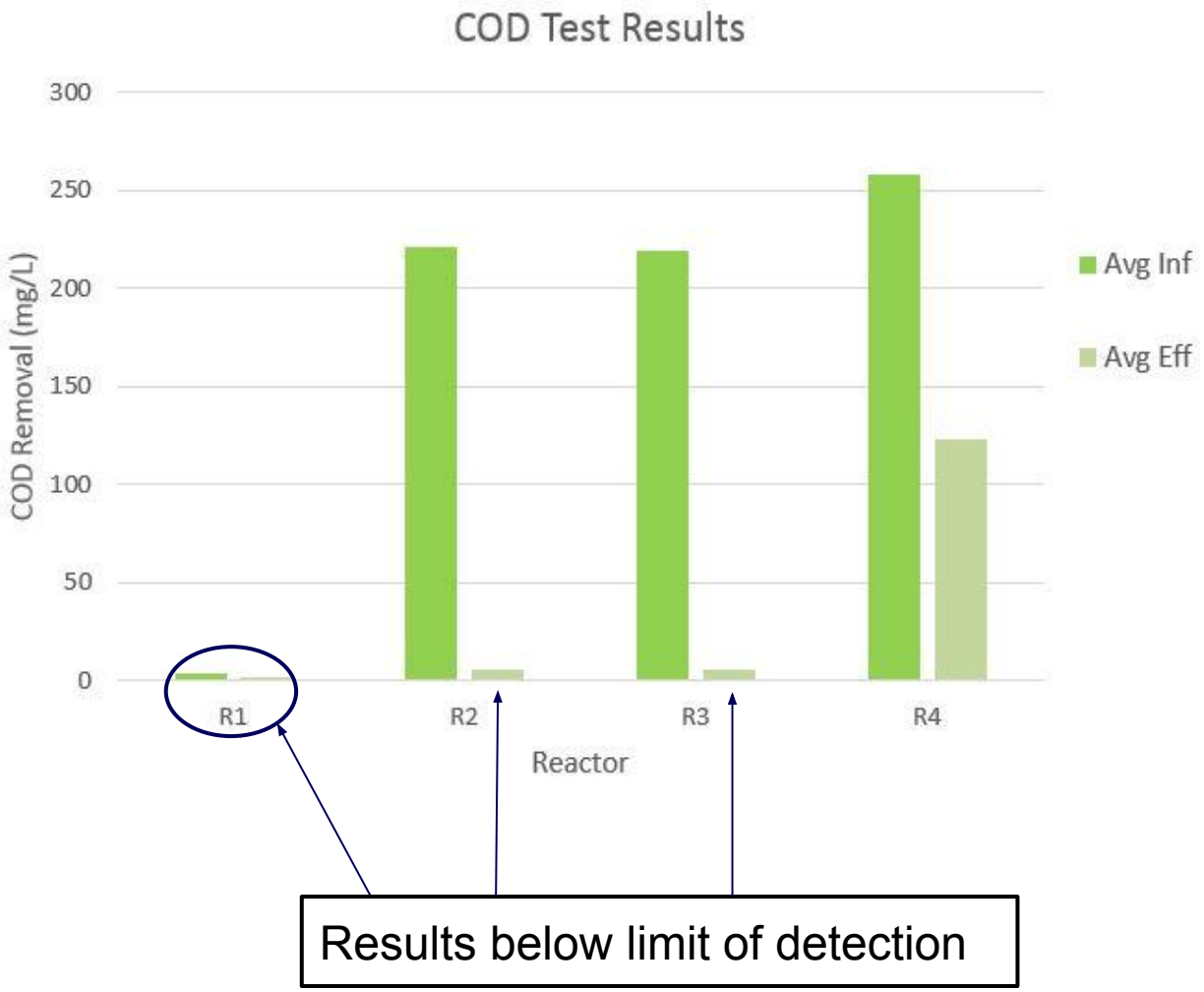


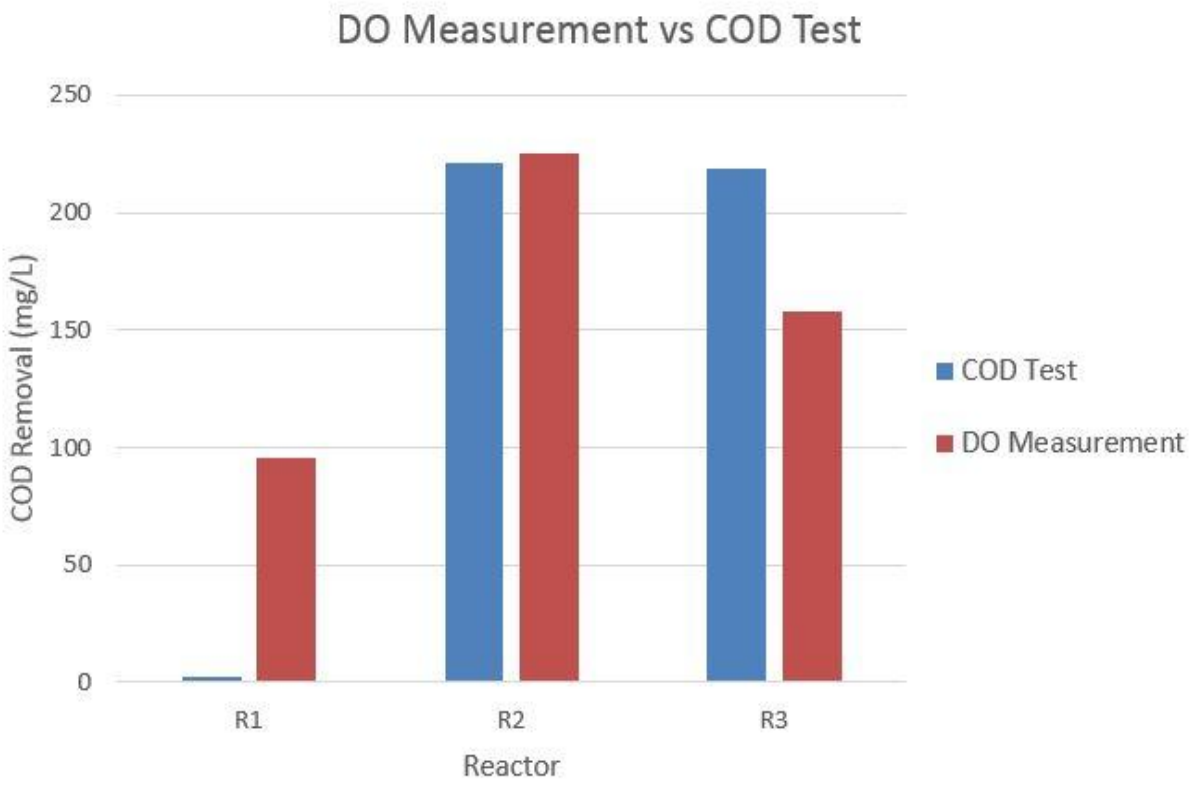
COD Test vs DO Probes



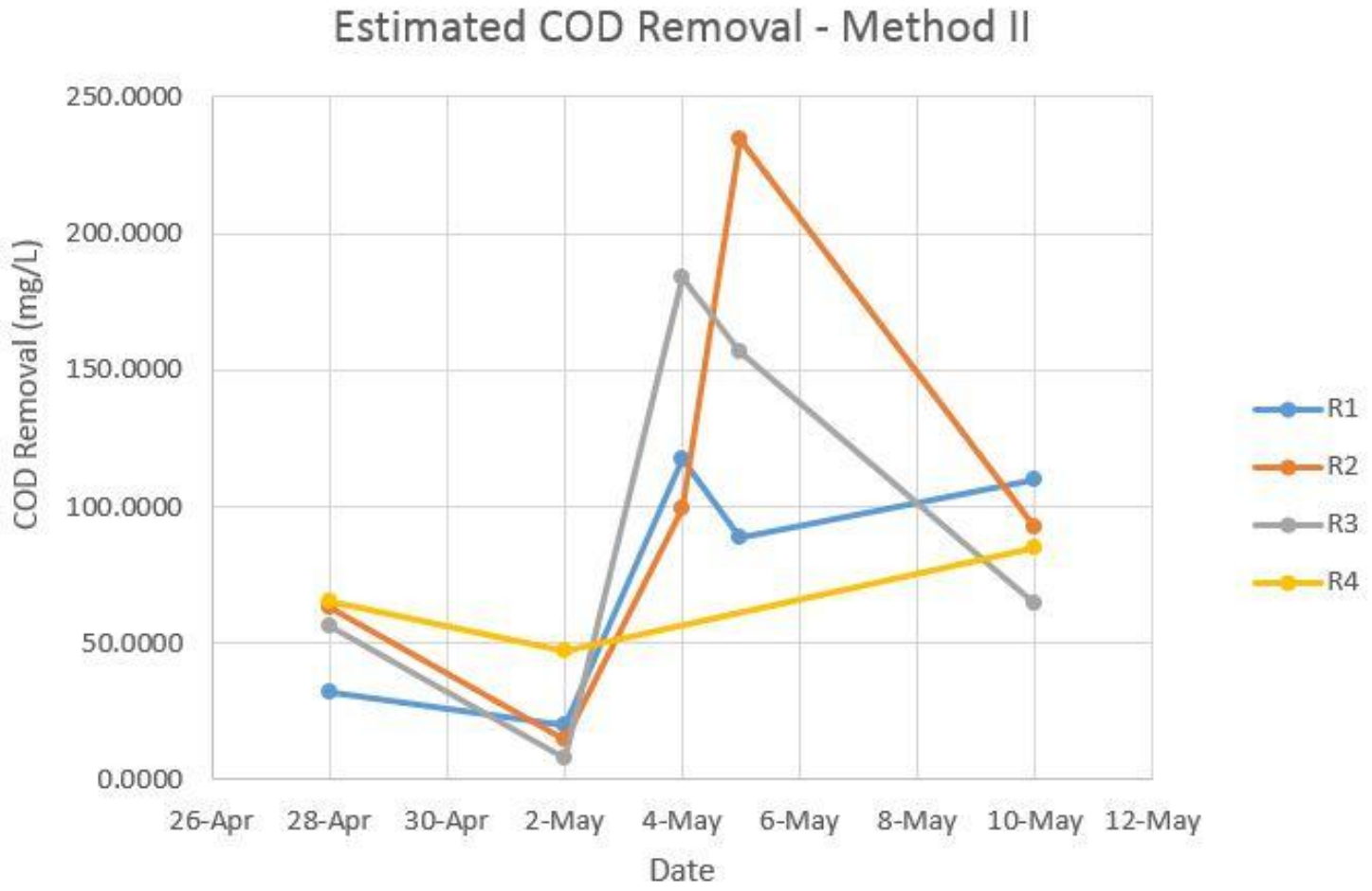


COD Test vs DO Probes

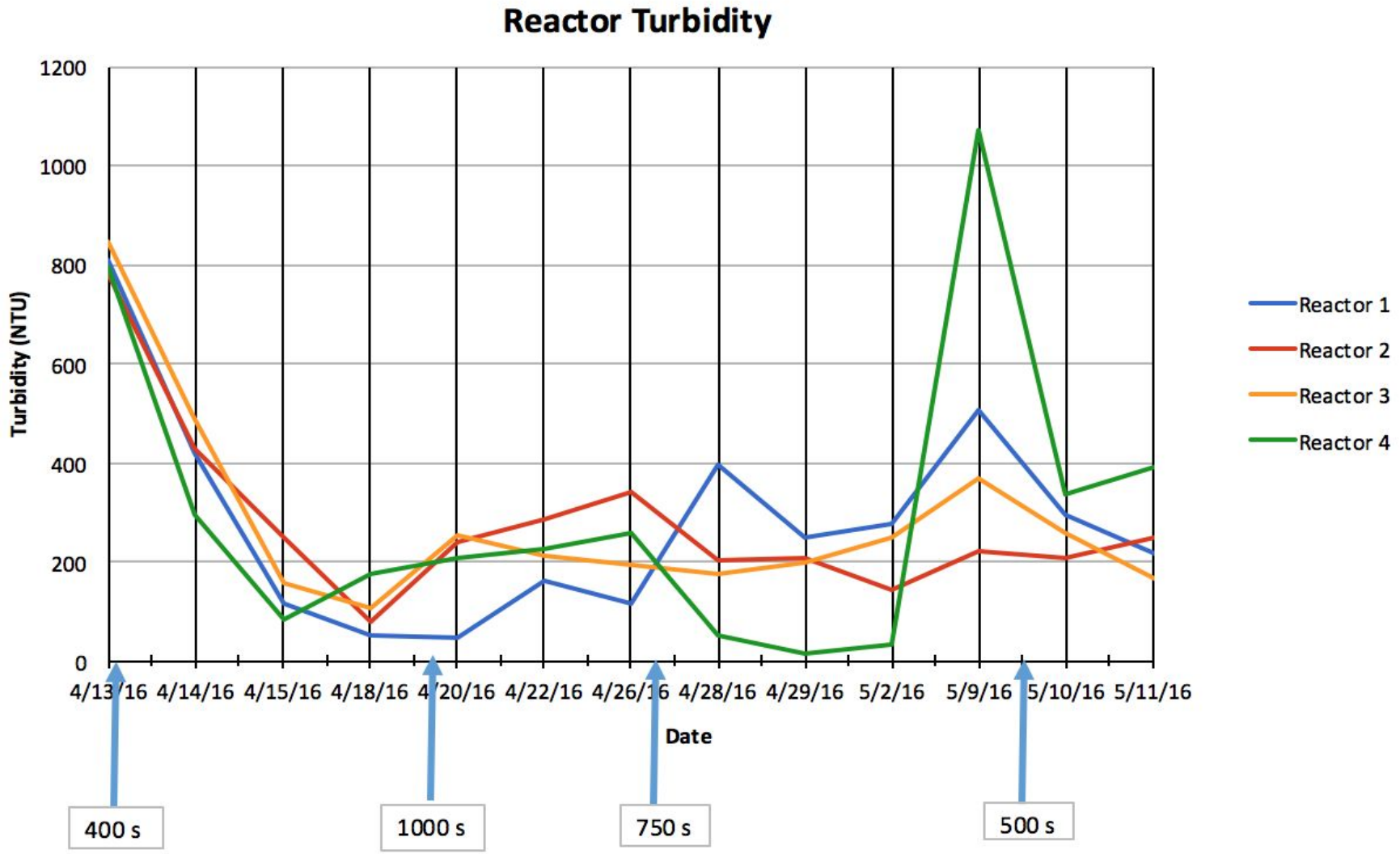




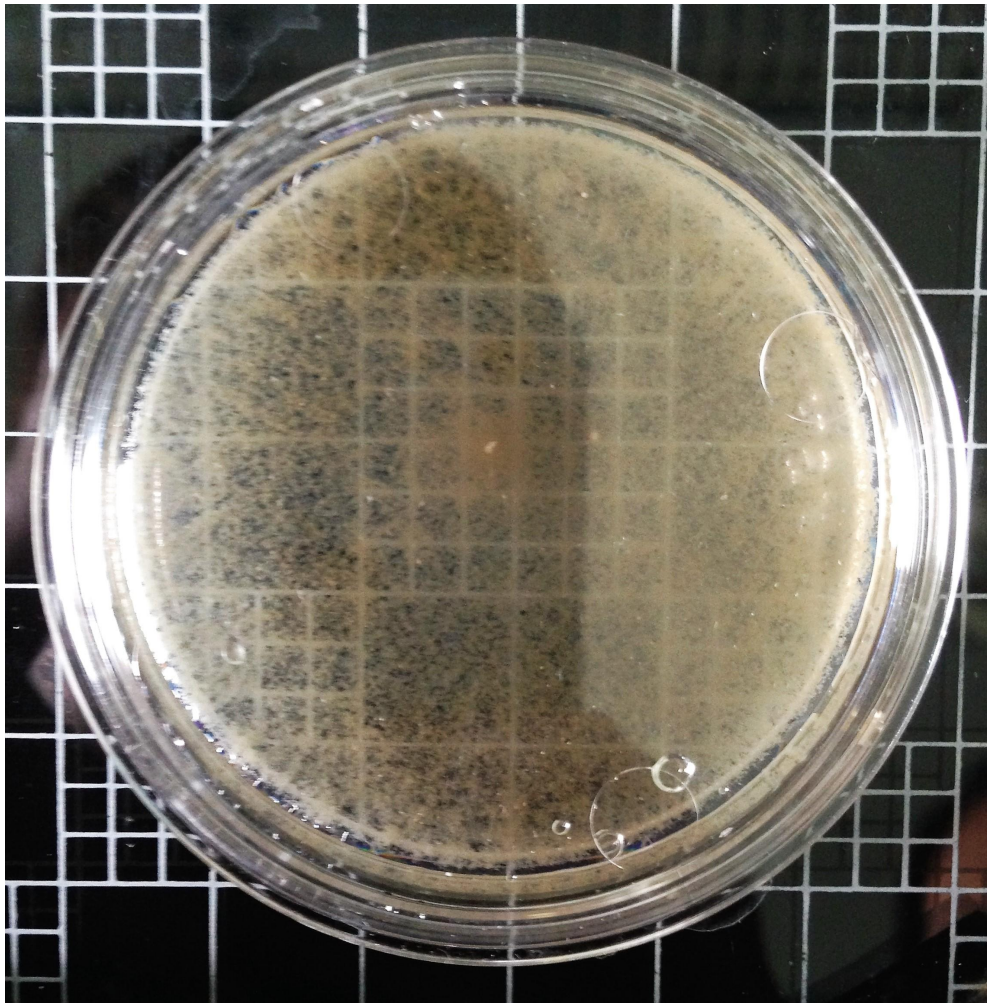
Estimated COD Removal



Turbidity

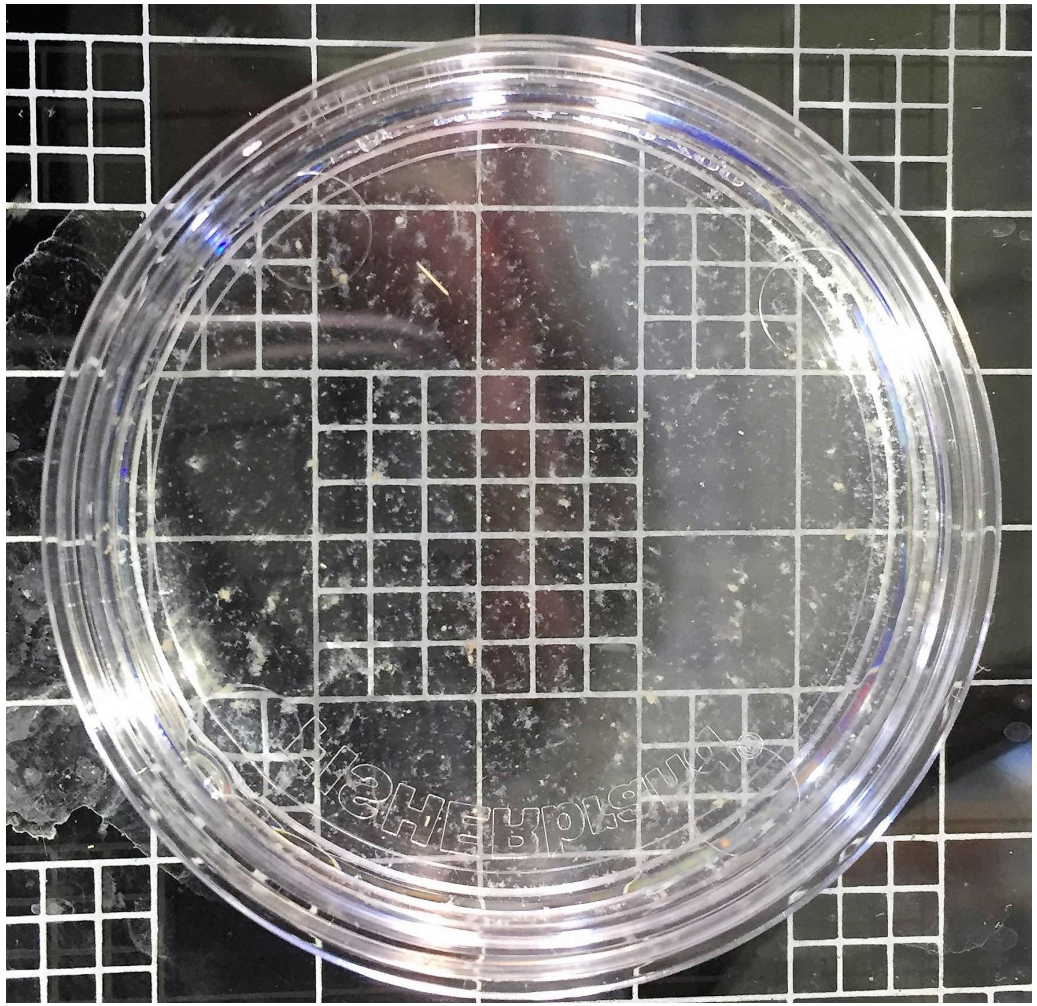

Reactor Turbidity
Turbidity (NTU)
1200
1000
800
600
400
200
0
4/13/16
4/14/16
4/15/16
4/18/16
4/20/16
4/22/16
4/26/16
4/28/16
4/29/16
5/2/16
5/9/16
5/10/16
5/11/16
Date
Reactor 1
Reactor 2
Reactor 3
Reactor 4
400 s
1000 s
750 s
500 s

Biomass Images



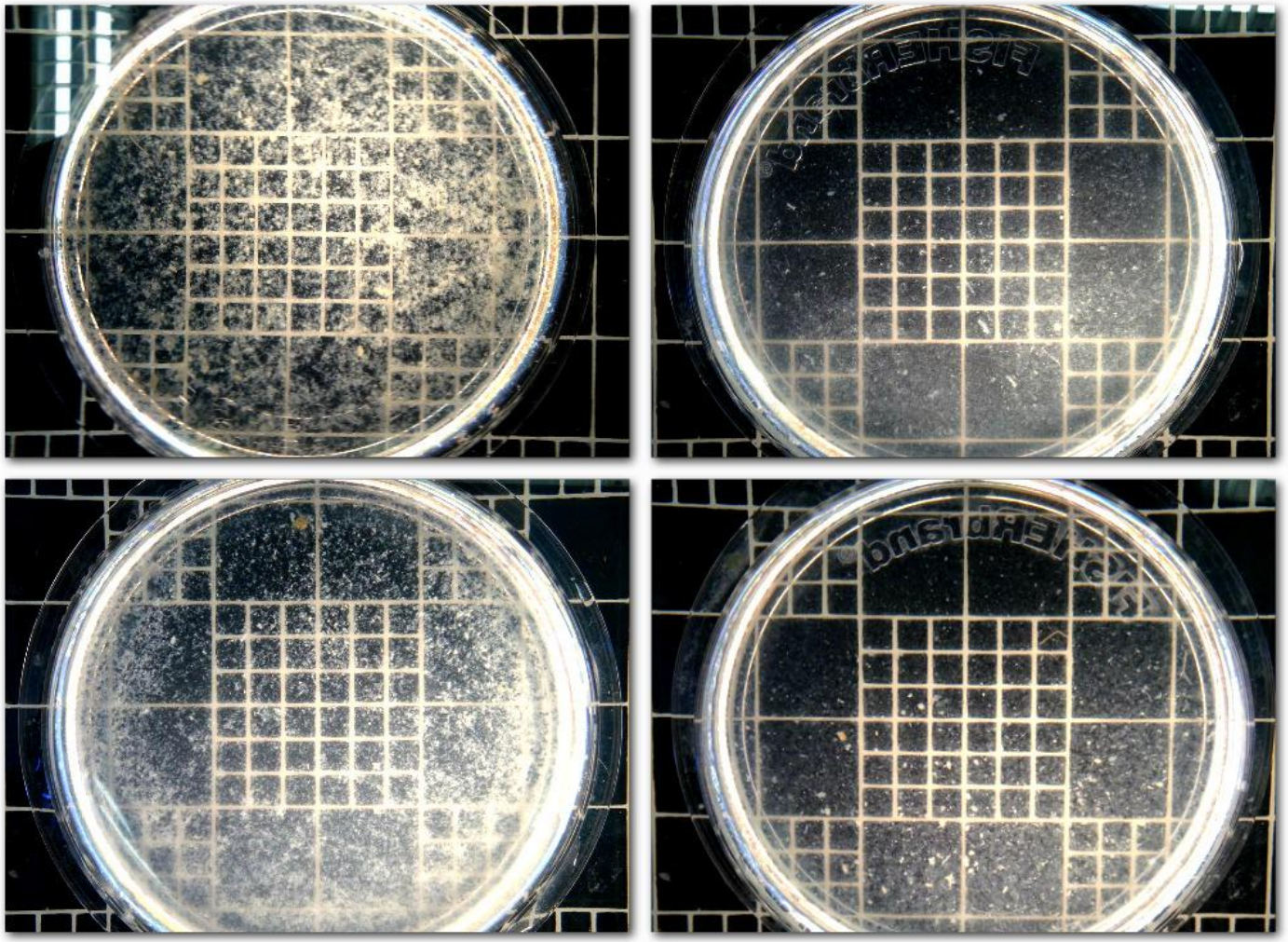
Biomass on inoculation day, April 14, 2016

Scale (approximately):
Small square is 0.3 mm
Large square is 1 cm



Biomass sample taken from reactor 1 on April 18, 2016

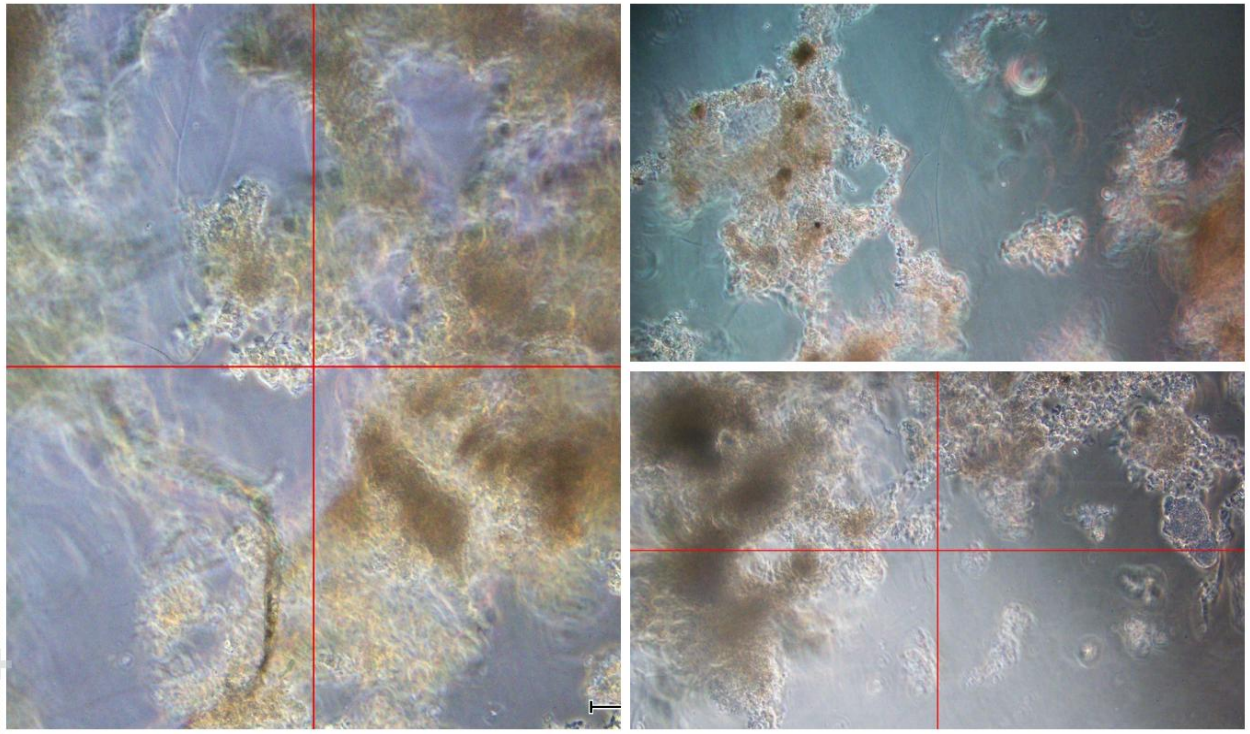
Biomass Images



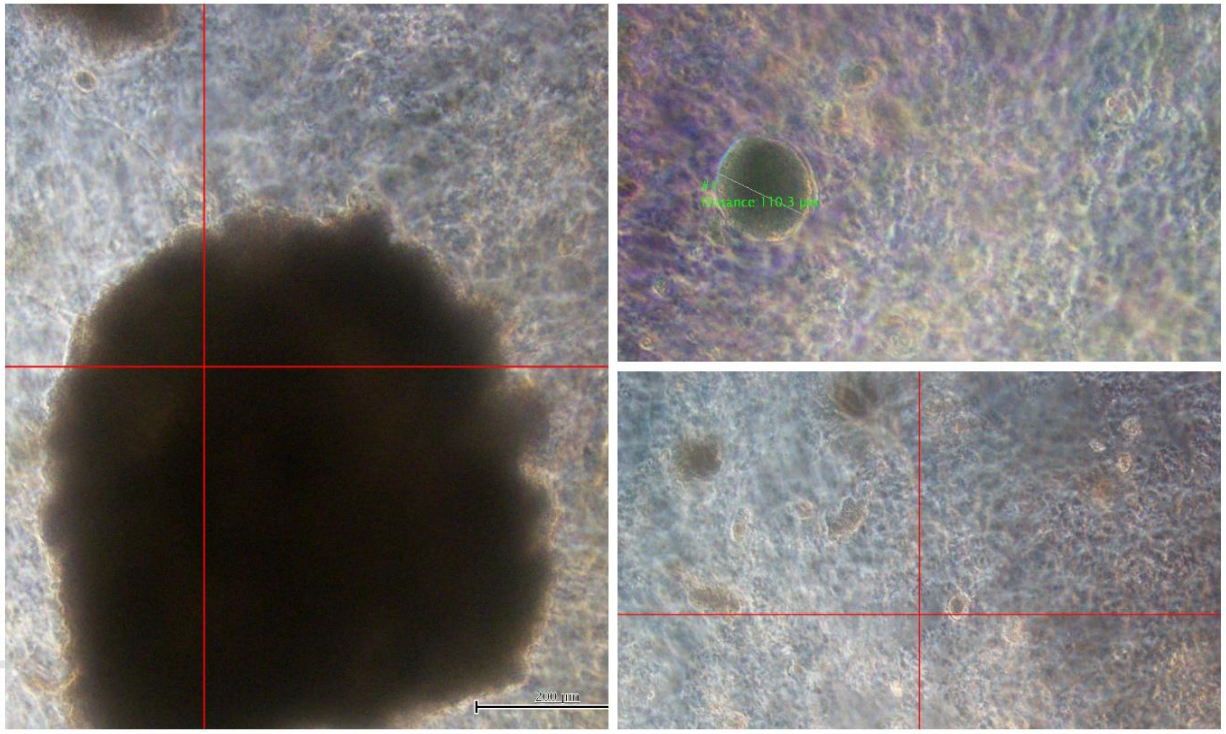
Scale (approximately):
Small square is 0.3 mm
Large square is 1 cm

Biomass from all reactors on May 9 , 2016

Biomass Images



Biomass from reactor 1 seen under a microscope with 100x magnification



Biomass from reactor 2 seen under a microscope with 100x magnification

Conclusions

- Rapid granulation did not result from PACl augmentation
  - No turbidity improvement
  - Limited granulation within five week experiment
- Some improvements in Reactors 2 and 3 over control
- COD removal by DO probe is feasible with accurate DO probes
  - Needs refining -- Must measure influent
- More work needed in understanding factors for granulation!

Future Work

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- Look into possibility of replacing COD test by OUR entirely.
- Test factors which affect granulation (shear, settling time, etc.)
- Application of GSBR to high-strength wastewater
- Pairing up with UASB

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Questions and Recommendations

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Appendix Slides

1. "File:ReactorSBR.JPG." - *Wikimedia Commons*. N.p., n.d. Web. 20 May 2016. <https://commons.wikimedia.org/w/index.php?curid=4094911>.o
2. “File: COD <http://www.envirotech-online.com/news/water-wastewater/9/bioscience_inc/rapid_cod_tests_predict_treatment_plant_upsets/5264/>
3.