EENV 341 Project 2

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Experiment

- Experiment:
  - Raw water and sludge from Bozeman Water Treatment Plant was collected to subject to series of test with the following goals in mind.
- Goals:
  - Determine optimal dosage of coagulant added to raw water to remove maximum amount of suspended solids in the water column
  - Determine effectiveness of backwash water addition in flocculation process
  - Determine the optimal dosage of polymer to optimize the sludge treatment time, sludge settling compactness and the overall cost of treatment.

Procedure for Flocculation Tests

Raw water from the BWTP was collected and subjected to coagulant doses of 0,1,2,3,4,5,10,15 and 20 mg/L.

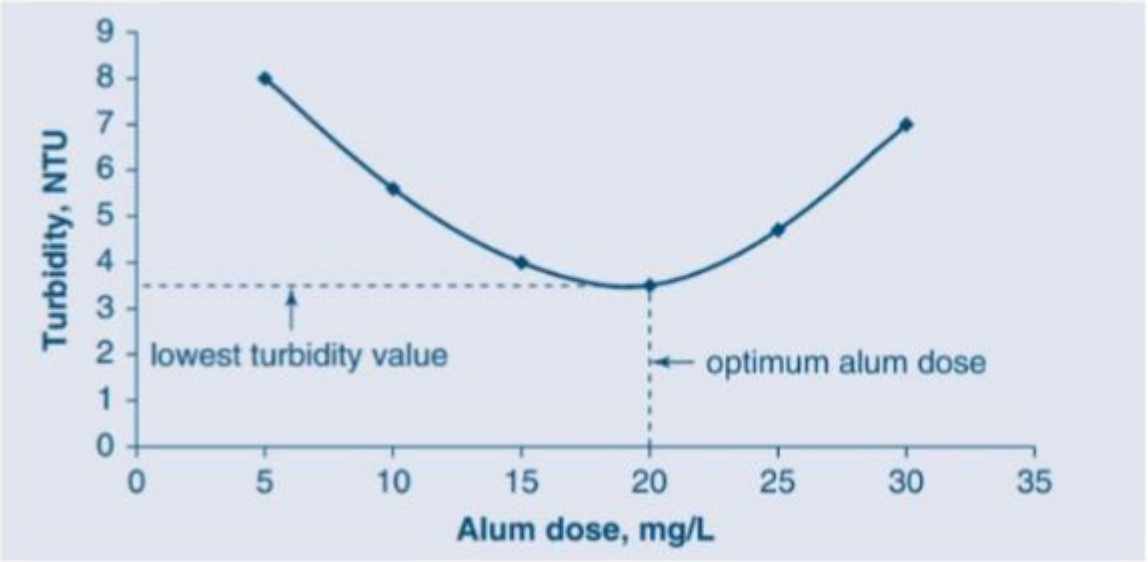
All samples were subjected to identical mixing and agitation with the goal of replicating G-values the raw water experiences during treatment at the BWTP.

Identical tests were conducted at two separate temperatures of 20℃ and 5℃ to better understand how temperature affects the flocculation process and efficiency.

Half the samples were also subjected to the addition of backwash water at 4% of the total volume of the sample. This was done to compare final turbidity of the backwash and no backwash samples to understand how to addition of backwash effects final turbidity at a given coagulant dosage and water temperature.

Predictions

- Goal was to have data that followed a U shaped trendline.
- BWTP has been using on average 0.77 mg/L of Alum per NTU of raw water turbidity.



Analysis of Flocculation Data: Coldroom

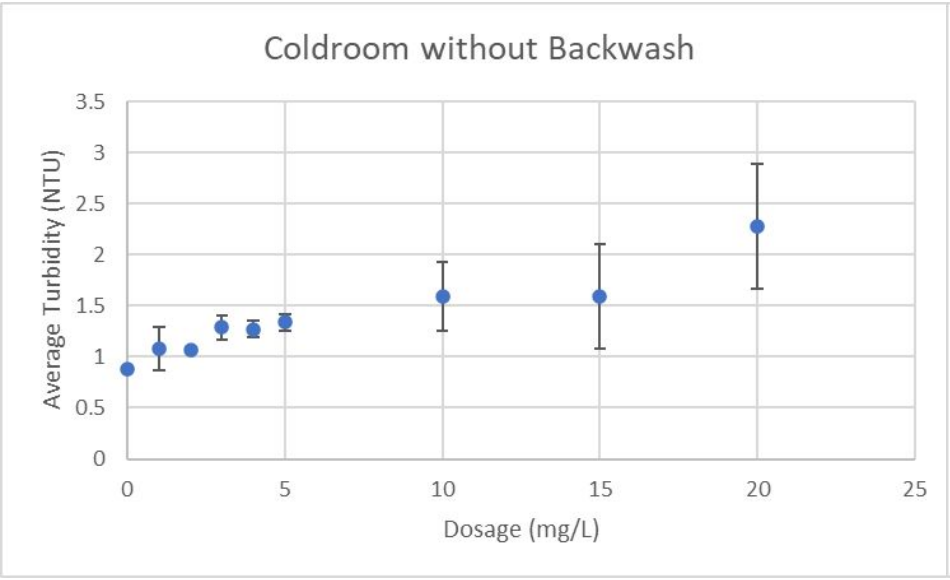
Cold Room Without Backwash

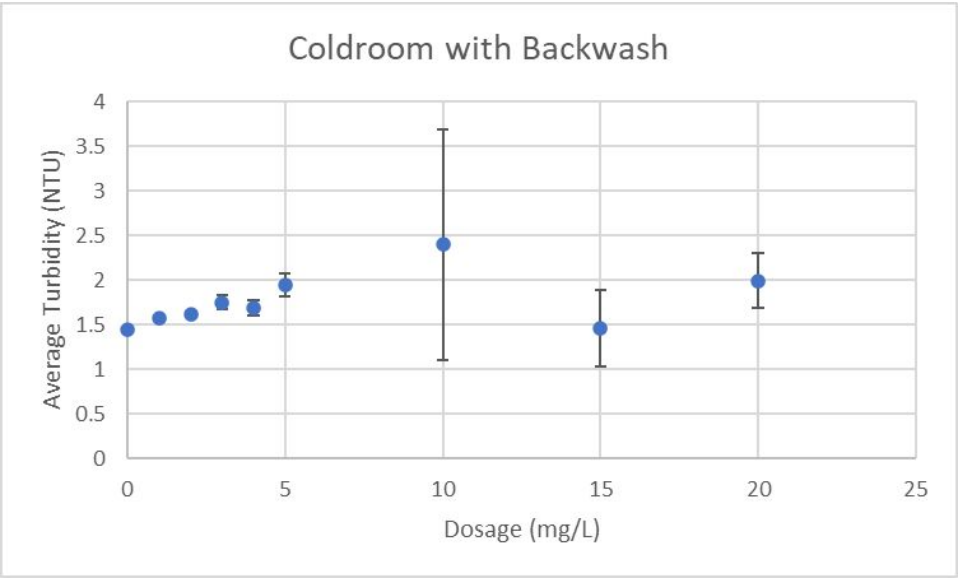
Dose of ACH mg/L	Average Cold Room Turbidity (NTU)	Standard Deviation	Standard Error
0	0.885	0.005	0.003536
1	1.08	0.21	0.148492
2	1.07	0.02	0.014142
3	1.29	0.12	0.084853
4	1.27	0.08	0.056569
5	1.34	0.08	0.056569
10	1.59	0.34	0.17
15	1.59	0.51	0.255
20	2.2775	0.6125	0.30625

Cold Room with backwash

Dose of ACH mg/L	Average Cold Room with Backwash Turbidity (NTU)	Standard deviation	Standard Error
0	1.45	0.02	0.014142
1	1.575	0.005	0.003536
2	1.625	0.025	0.017678
3	1.75	0.08	0.056569
4	1.69	0.09	0.06364
5	1.95	0.13	0.091924
10	2.4	1.29	0.645
15	1.46	0.425	0.2125
20	1.995	0.3075	0.15375

Analysis of Flocculation Data: Coldroom





- Backwash samples had higher turbidity readings than no backwash samples.
- Data indicates that adding coagulant increases turbidity.
- Higher doses of coagulant have higher S.D.
    - Due to the large amounts of data for 10-20 mg/L.

Analysis of Flocculation Data: Warmroom

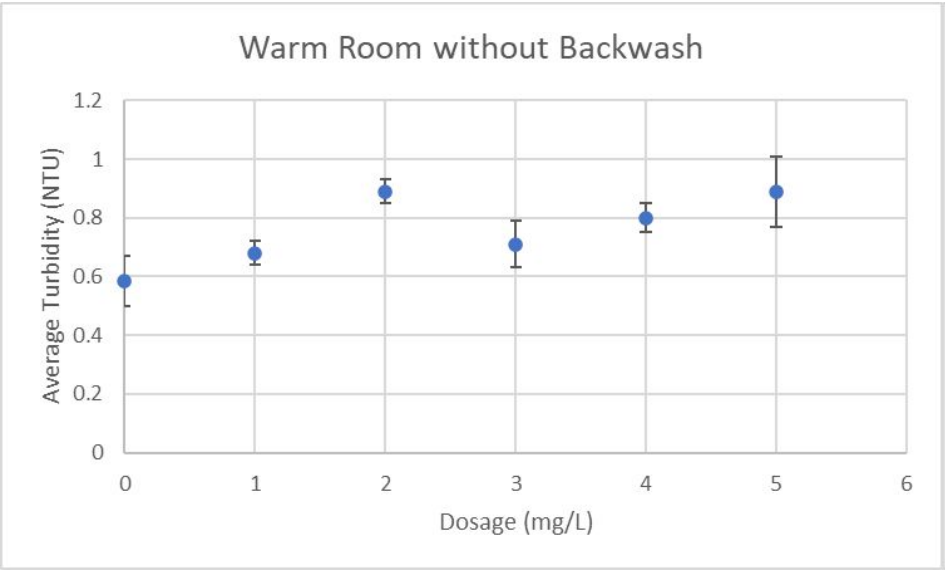
Warmroom Without Backwash

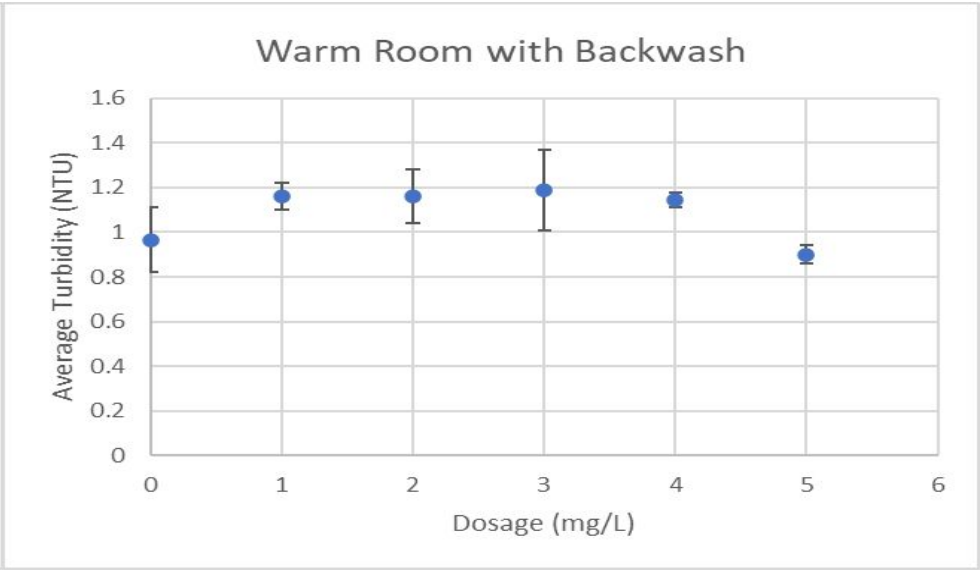
Dose of ACH mg/L	Average Room Turbidity (NTU)	Standard deviation	Standard Error
0	0.585	0.085	0.060104
1	0.68	0.04	0.028284
2	0.89	0.04	0.028284
3	0.71	0.08	0.056569
4	0.8	0.05	0.035355
5	0.89	0.12	0.084853

Warm room with backwash

Dose of ACH mg/L	Average Room Backwash Turbidity (NTU)	Standard deviation	Standard Error
0	0.965	0.145	0.10253
1	1.16	0.06	0.042426
2	1.16	0.12	0.084853
3	1.19	0.18	0.127279
4	1.145	0.035	0.024749
5	0.9	0.04	0.028284

Analysis of Flocculation Data: Warm Room

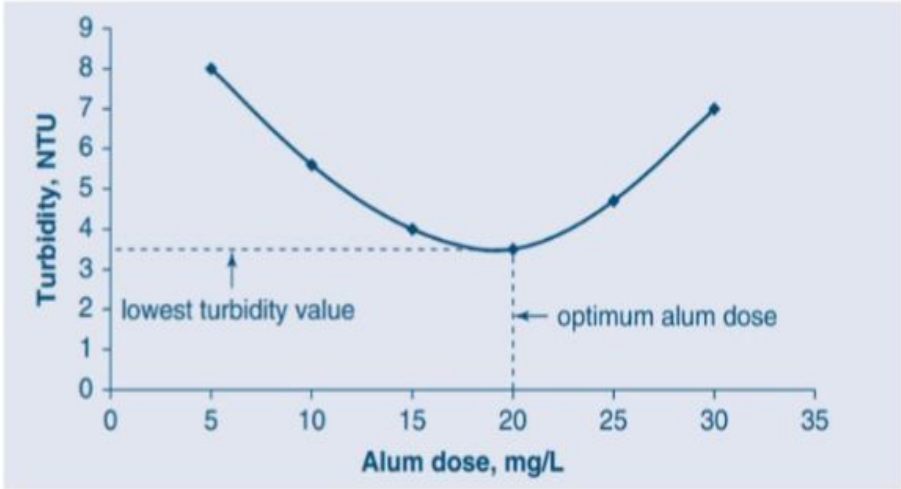




- Overall turbidity of Backwash samples was higher.
- Neither data displaces anticipated trends.
- S.D. of both data sets is similar in size and variety.
- Adding backwash does not seem to help the coagulation phase.

Recommendations

- BWTP uses 0.77 mg/L coagulant per NTU of raw water
- Raw water samples in experiment had NTU readings from 0.5-1.5
- BWTP would treat these samples with around 0.5-1 mg/L of coagulant
- Samples in the experiment were treated with 1-20 mg/L
- It is likely that data was on right side of U curve as it generally increases turbidity from raw water to 20 mg/L and NTU values of 1-2 mg/L were generally the lowest.
- Additional testing should be done using much lower coagulant concentrations.
- Backwash data increases overall turbidity and allows possibly harmful pathogens to re-enter water treatment process



Procedure for Sludge Treatment

- Untreated sludge water from BWTP was treated with polymer doses of 0 (control), 2, 5, 10, 15, and 20 mg/L.
- Samples were then mixed at a rate to replicate sludge treatment at the BWTP. -
- After mixing, samples were allowed to settle.
- After 4 minutes of settling the settling volume of a each sample was recorded.
    - If the settling volume was below 500 mL, the dose passed.
- After an additional 60 min of settling the final compactness and settling volume of each sample was recorded.
- After determining which of the dosages settled the fastest and were the most compact, a more refined test was done with 5 samples, each with a 1 mg/L difference in concentration from the next.

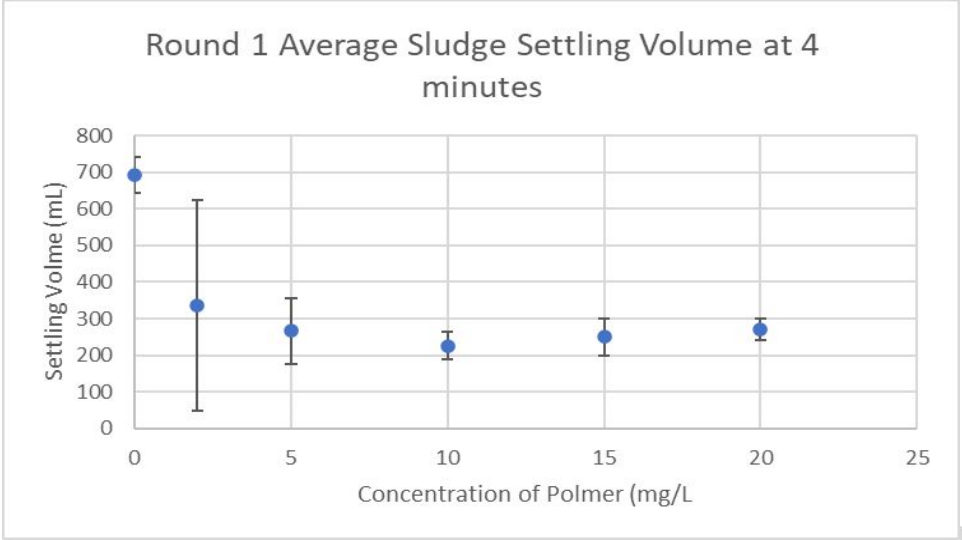
Analysis of Sludge Settling Data

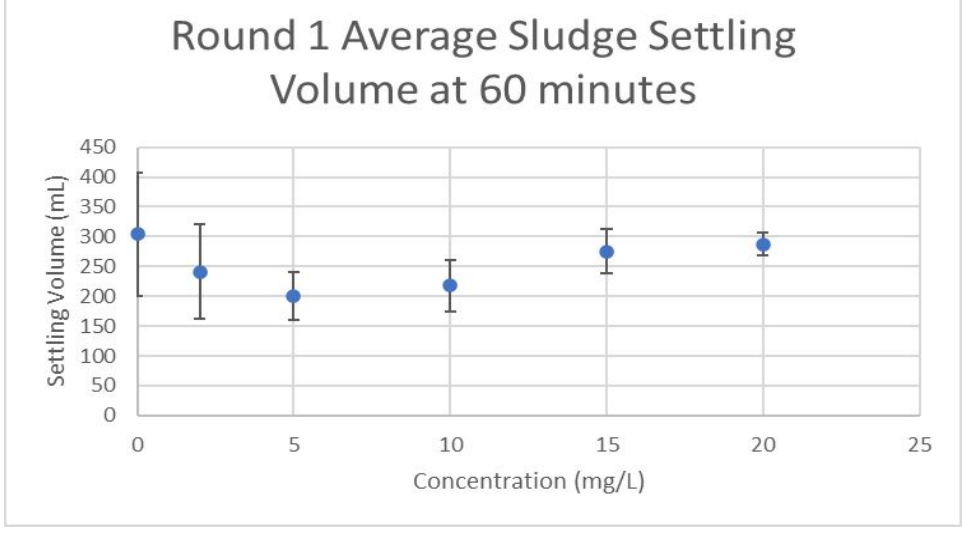
- 2-6 mg/L doses have more compact settling volumes
  - Most did not pass initial 4 min settling test
- 5 mg/L doses have most compact settling volume for dosages that pass the test consistently.

	Polymer	MODE Pass/ Fail	4 Minute	Standard Deviation of Average 4 minute settling time	60 Minute	Standard Deviation of Average 60 min settling time
	Concentration (mg/L)		Average Settling (mL)		Average Settling (mL)	
Round 1	0	Fail	692.5	48.88889	303.75	103.75
	2	50/50	337.5	287.5	241.25	78.75
	5	Pass	266.25	88.75	200	40
	10	Pass	226.25	38.75	217.5	42.5
	15	Pass	250	50	275	37.5
	20	Pass	270	30	287.5	18.75
Round 2	1	fail	730	0	280	0
	2	fail	560	0	250	0
	3	50/50	500	0	265	15
	4	50/50	440	0	265	15
	5	Pass	406.25	46.875	258.75	21.25
	6	Pass	372.5	63.75	257.5	32.5
	7	Pass	320	20	290	13.33333
	8	Pass	337.5	87.5	282.5	125.5556
	9	Pass	345	45	305	135.5556
	10	Pass	305	55	280	140

ROUND 1 TESTING

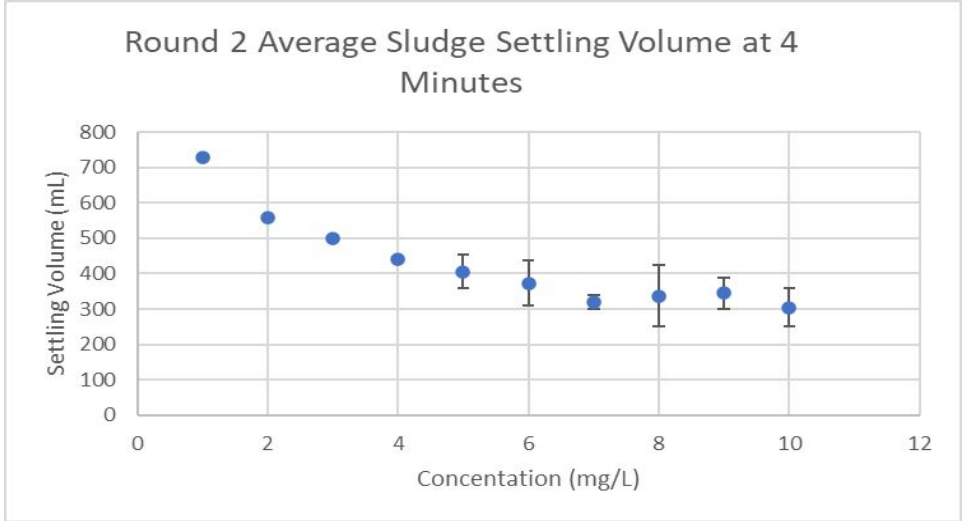
- Higher concentrations of polymer settle faster
  - Higher concentrations are less compact at 60 min
- Most lab sections concluded that 5-10 mg/L was best for round 2 test
  - Lower concentrations were compact but had inconclusive data during 4 minute test

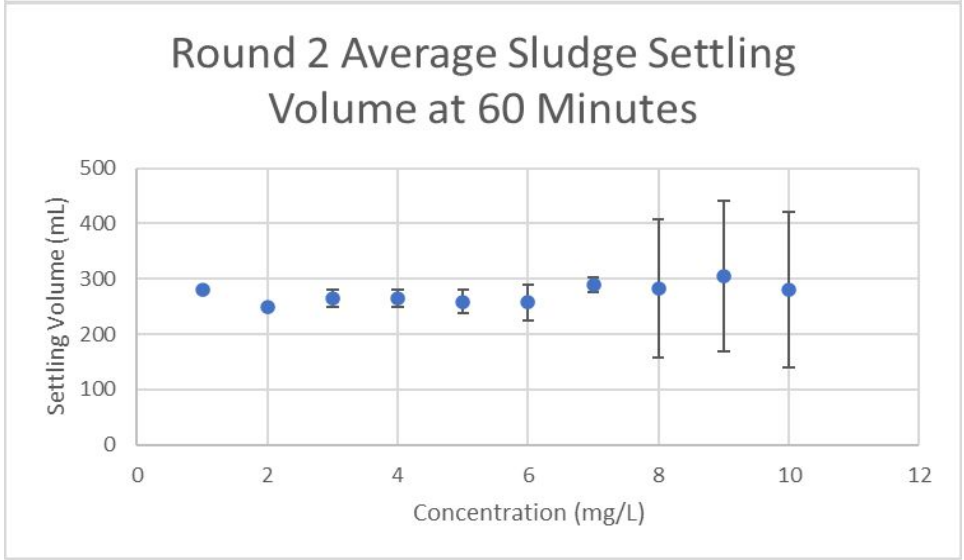




ROUND 2 TESTING

- 1-4 mg/L data for 4 minute test does not have S.D. due to only 1 data set
- 4 minute settling trends from round 2 are similar to round 1
- S.D. variability increases as dosage increase
    - Possibly due to increased amount of data sets
- Round 2 60 min data is less conclusive than rest of rounds





Sludge Settling Recommendations

- Increasing the dose to 5 mg/L polymer
- $68.68 per year increase
- 3% smaller sludge cake over 4 mg/L polymer
- Improved 4 minute settling

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