The Proof is in the Polymer: Batching with Tempered Water = Savings

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THE PROBLEM

Historically, the South Burlington Water Quality Facility at Airport Parkway has difficulty using their centrifuge to process sludge with consistent parameters throughout the year's seasons. In summer, dewatering is typically easier due to warmer plant water used to batch polymer combined with lower incoming solids (%). Colder effluent temperatures in the winter mean the polymer is batched with colder water, affecting the polymer chains' activation. Cold temperatures, combined with a higher percentage of incoming solids, always caused a considerable increase in the amount of polymer used. Clean Waters Technical Service Representative Ryan Peebles always suggests batching polymer with tempered water when possible.

By November 2019, plant water had decreased to 11°C (52°F), and the centrate had a higher concentration of fine particulates. The outgoing cake percent had also dropped, yielding a wetter cake. The dewatering process was slowed down to one trailer a week to clear up the side water and improve the cake (% dry solids), both slowly decreasing in quality over the month.

Ryan Peebles visited to perform a jar test to ensure the summer polymer (282) was still the most effective. It was decided that the polymer was still the best choice, although it wasn't working as well as it had been a few weeks prior.

Since 282 Polymer is a high-branching polymer, the cold plant water may affect its capability and effectiveness. Even though the incoming solids percent had increased, it was apparent that the polymer was decreasing in effectiveness due to the reduced quality in cake % and sidewater.

Polymer concentration was switched from 0.45% to 0.43% to see if the process improved under the same conditions. The change in polymer concentration showed increased side water quality while cake % remained the same.

BACKGROUND

The dewatering process at the Airport Parkway WWTF in the City of South Burlington has been anything but smooth and consistent. Dewatering as a process rarely is.

Polymer can be described as a compound made up of many chains. When delivered, the polymer is dormant and must be batched with water to be "activated." This activated polymer is mixed with incoming sludge and acts as a flocculant to bring solids together and allow water to be "squeezed, " yielding the soil-like "cake" that can be used as fertilizer on farms. The more water that can be removed, the more efficient the process and the more money saved. Polymer is sold in totes containing 275 gallons, costing $5,500.00 each. Making polymer more efficient will yield significant savings.

During the summer, the centrifuge runs approximately 120 gallons of incoming sludge per minute with about a 30% mix of polymer at 0.45% concentration with water, yielding between 23.5-25% dry cake. At this rate, the trailer can be filled in roughly 12-16 hours, which makes it easy to haul 2 trailers a week. During the winter, there is a seasonal change where the centrifuge can only handle about 80 gallons of incoming sludge per minute with nearly 50% mix of polymer at 0.43% concentration. This much change in the process only yields about 19-20% dry cake and the slower production means only about one trailer can go out a week.

THE THEORY

This experiment was designed to test the use of tempered water to batch the polymer and record the results. The theory is that tempered water would increase polymer effectiveness so that less polymer could be used, improve the conditions of the centrate and produce a drier cake. The ultimate goal is to identify what is causing the seasonal change in the dewatering process and to devise a successful control so that dewatering can be run consistently throughout the calendar year. This is crucial as less polymer can be used, and less money can be spent on materials and resources to create a dry cake. The drier the cake, the more solids are transported in a single load from the plant, which means less money is spent on removal transportation and less time is spent dewatering overall. In short -- an effective solution to this problem is an effective money-saving strategy.

THE SETUP

Tempered water was used to batch a 900-gallon polymer tank. Each full tank consumed counted as one Trial. Five Trials were completed. The polymer batches were mixed at 0.43% and 0.45% concentrations with tempered water between 18.5 - 23°C (65.3°F-73.4°F) (see Table). Different combinations of polymer concentrations, polymer injection points, and tempered water temperatures were used and noted to identify the most effective combination. Cake (% dry solids), polymer dose, and side water quality were noted with every process change.

Cake samples were analyzed in two moisture analyzers for each Trial when possible. Incoming sludge % solids were also analyzed to better compare polymer use. If incoming sludge % solids increased, the polymer demand would also increase.

CONSTRAINTS

1. To batch polymer with domestic tempered water, the plant water had to be shut off to the entire building so that the warm water could overcome the plant water pressure and be sent to the polymer mixing unit and batching tank. This meant that the centrifuge would be shut down between trials.
2. Domestic tempered water was insufficient to reach a demand of 1100 gallons per hour. Filling the batching tank was slower, around 300 gallons per hour, which meant filling sometimes had to be stretched over more than one day. Extra and/or limited batching times might affect polymer activation.
3. Side water is measured by sight with no visual guide. This parameter is reported using operator notes and observations only; no concrete figure for comparison is provided.
4. The elevated incoming sludge increased polymer use, so the batching tank was used quickly. Therefore, every Trial typically lasted less than 2 hours.

RESULTS

VISUAL & PHYSICAL

The physical nature of the polymer batch is different from tempered water. The polymer batch is more even in color with no white and tan ribbons or marbling, which is typical when batching with colder water. With cooler water, the mixture dripped off the sampling spoon in globs and chunks. With the tempered water, the mixture drips in long, thin threads off the spoon. This indicates that the chains are damaged and broken with colder water while the chains are still intact with the tempered water.

ANALYTICAL

End of summer 2019, two trailer loads a week were being produced at 23.5% 24.5% dry cake from about 1.7%-1.9% incoming sludge. At this time, the effluent temperature was at or over 20°C (68 °F)

As the effluent temperature slowly decreases from the end of summer 2019 to November 2019, we can see a trend where the outgoing cake becomes wetter, and the polymer use increases drastically (Chart 1). Although colder temperatures make incoming sludge thicker (Chart 2), the increasing polymer demand is not enough to explain such a drastic increase in polymer use.

Therefore, it is observable that as plant water temperature decreases, polymer activation is affected. The polymer becomes less activated, and the chains are not effectively unfurled from its dormant state, which means more polymer is needed, although in most cases, increasing the dose will only create a reasonable quality cake.

Generally, when batching the polymer with tempered water, the cake was drier, the side water was cleaner, and less polymer was used (Table 1). The sludge feed was also increased close to its maximum gallons per minute, typically only possible in the summer.

In addition, the polymer injection point was changed back to its summer seasonal position because less mixing with the incoming sludge was needed to create enough flocculation for a dry cake. This indicates that the tempered water more thoroughly activated the polymer chains, and therefore, the tempered water significantly impacted the polymer's activation.

Batching the polymer with tempered water impacted polymer effectiveness, so the dam plates had to be changed in the centrifuge. This is typically only required seasonally when the nature of the incoming sludge, water temperature, and outside temperature changes between Spring/Summer and Summer/Fall.

It was also noted that when batching with tempered water, the polymer concentration had to be changed back to the seasonal summer concentration to remain effective.

THE CONCLUSION

Overall, the difference in polymer use between summer and winter is drastic. Even though Trials 1-5 in this study lasted less than 2 hours each (it typically takes 12-16 hours under optimal conditions to load a full trailer), the results were profound and promising. During the scope of this experiment in February, all processes reverted to nearly summer conditions and yielded cake that could only be produced during those optimal conditions experienced during summer months.

If a hot water heater was installed, it would only need to heat the water a couple of degrees depending on the season and effluent water temperature to get up to about 20 degrees Celsius. If this change were made, savings may add up over time. More dry cake (~25%) can be loaded into a trailer than wet cake (~20%) for more efficient transportation.

Quantifying all possible savings related to batching polymer with tempered water is difficult because so many factors are present. Still, the most direct savings that can be accurately calculated is hauling trailer loads of cake out of the plant. If 78 trailers a year are filled to different volumes because of seasonal constraints, then we are paying more to haul more loads out of the plant. For about half the year, we can only send out one load a week filled to 80,000 gallons because the cake is wetter and heavier. If we could put out at least 100,000 gallons with every load (we can typically fit up to 110,000 gallons), depending on storage tank availability and other indirect plant processes yielding more sludge, we would only have to put out 72 trailers a year. Cutting the amount of trailer loads pulled every year by only six loads at $28.00/wet ton saves the Water Quality budget about $70,000 annually. If we consistently fit 110,000 gallons in each trailer, we only need to haul 66 trailers annually. This cuts annual trailer loads by 11 trailers, which equals a savings of $141,500. This does not include the savings of using less polymer annually or the time saved by having a consistent and reliably running centrifuge, saving in breakdown costs, maintenance costs, solvent use, and partially freeing up a full-time employee's responsibilities.

FIGURES

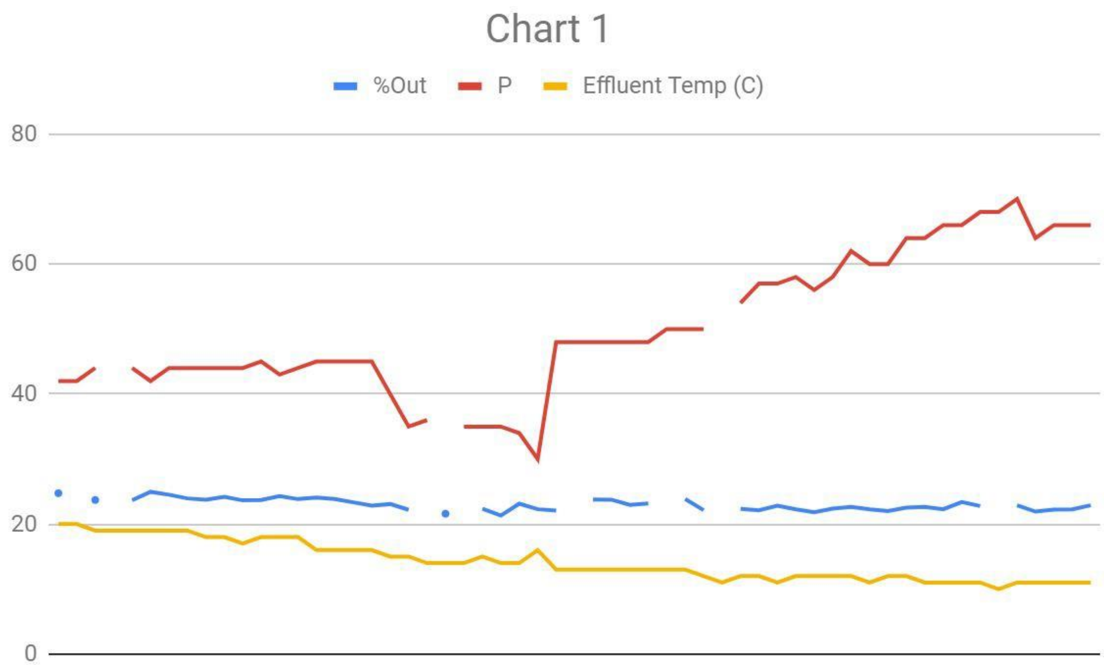
Chart 1
%Out
P
Effluent Temp (C)
80
60
40
20
0

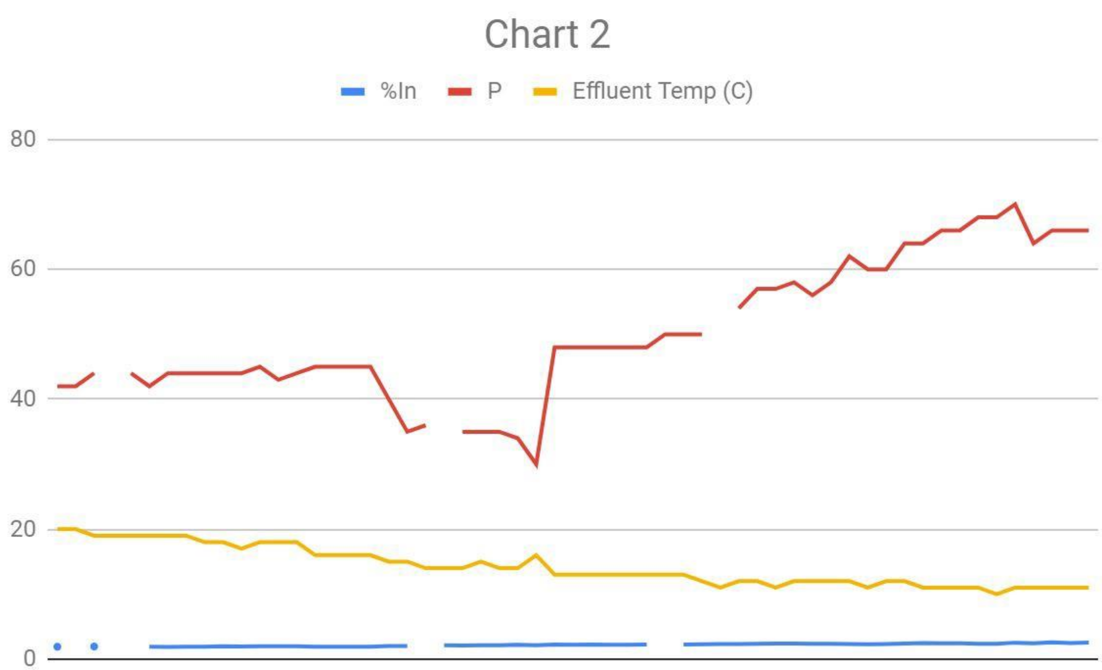
Chart 2
%In
P
Effluent Temp (C)
80
60
40
20
0

Table 1

Date	Trial	Feed	Temp (C)	(F)	P Conc.	P Feed %	Out %	In %	SP	Notes	P gal/min	Inj. Point
2/19	Pre Trial	85	11	52	0.43	51	19-20	2.6	47		8.721	Lower
2/20	1	85	18.5	65	0.43	36	19-20	2.69	47		6.156	Lower
2/20	2	70	18.5	65	0.45	30	19.99	2.69	46		5.2	upper elbow
2/20	2	75	18.5	65	0.45	33	21.07	2.69	48	best sidewater	5.7	upper elbow
2/24	2	80	18.5	65	0.45	36	20.5-22			best sidewater		
2/24	2	85	18.5	65	0.45	39	20.5-22	2.61	47-49		6.669	upper elbow
2/24	3	80	19	66	0.45	36	21.32	2.61	48			upper elbow
2/25	4	80	23	73	0.45	36	-	2.72	50	plugged		upper elbow
2/25	4	80	23	73	0.45	39	22.2	2.72		DP changed > 127		upper elbow
2/25	4	90	23	73	0.45	46	22.2	2.72				upper elbow
2/25	4	95	23	73	0.45	50	22.2	2.72				upper elbow
2/26	Post Trial	100	11	52	0.43	63.5	23.5	2.57				upper elbow
2/27	5	100	19.5	67	0.45	50	24.29	2.52	55			upper elbow
2/27	5	100	19.5	67	0.45	50	20.11	2.52	44			upper elbow
2/27	5	100	19.5	67	0.45	50	ERR	2.52	50	analyzer error		upper elbow