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WISCONSIN: PHOSPHORUS REMOVAL DRIVEN BY OPERATOR INGENUITY

No plant is too small to optimize

At many publicly owned treatment works (POTWs), operators reduce costs and benefit from improved nutrient removal through optimization. In Winter 2020, EPA's **National Study of Nutrient Removal and Secondary Technologies**, along with EPA Region 5 and Wisconsin Department of Natural Resources (WI DNR), hosted a free webinar training series, *Reducing Phosphorus Discharges Through Low-Cost Operational Changes*. Operators across the state learned from Grant Weaver, of CleanWaterOps, about optimizing biological phosphorus removal (BPR) in activated sludge systems.

During the final session, volunteers presented their plants and received suggestions from Grant and their peers on how to improve their plants' performances. Vic Krzykowski, the sole operator of the Blenker-Sherry POTW, told a compelling story of resourcefulness and creativity, captured in this fact sheet.

Blenker-Sherry POTW

The Blenker-Sherry POTW, located in Sherry, WI, is a small plant with a design capacity flow of 28,000 gallons per day (GPD) and an average daily flow of 10,000 GPD. The plant has a single-track oxidation ditch with a secondary clarifier and UV disinfection. No chemicals are added for phosphorus removal. The ditch has two rotors, one positioned at each end, both equipped with variable-frequency drives (VFDs).

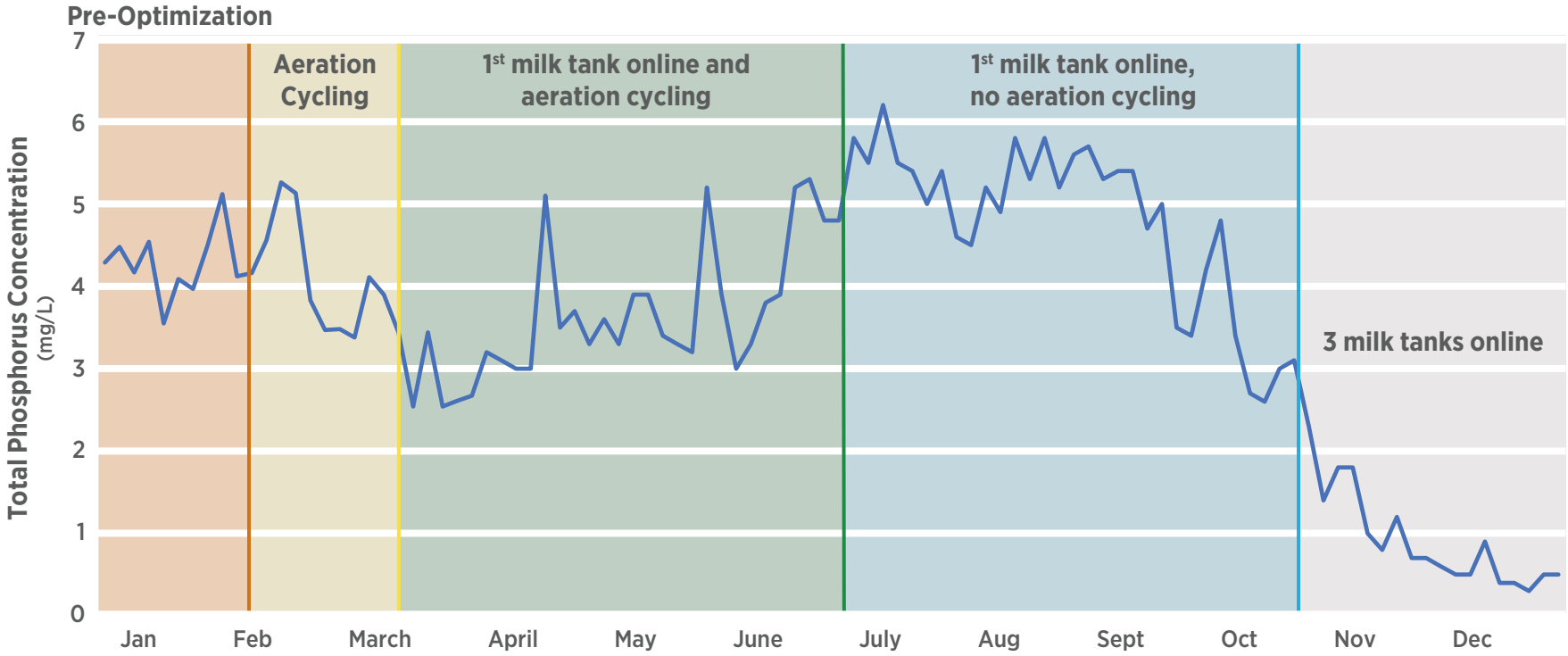
The plant has a limited automatic control system built by Vic, which uses data collected by oxidation-reduction potential (ORP) and dissolved oxygen (DO) probes to maintain aeration. DO probes are mounted on the western side of the ditch directly across from each other, one on each side of the racetrack, with the southern probe set to maintain DO around 2.1 mg/L. One ORP probe is mounted at the eastern end of the ditch, and a second ORP probe is mounted near the DO probe on the southern side of the ditch. A third portable ORP probe usually monitors the clarifier.

Blenker-Sherry POTW

In Fall 2014, Blenker-Sherry POTW was required to begin monitoring effluent total phosphorus (TP) discharges. Vic began studying nutrient removal and found chemical precipitation would be cost-prohibitive for the small plant's limited annual operating budget, even requiring construction of a heated building to store chemicals that must be bought in bulk. Vic then dove into learning about BPR, visiting neighboring plants and collaborating with more than 30 local operators he met at state conferences, learning about solutions his neighbors employed.

> "Just get out there and do it. Be open minded, think outside the box, and give it a shot."
>
> —Vic Krzykowski

Blenker-Sherry POTW 2016 Effluent Total Phosphorus



Vic realized that his system would benefit from a pre-anoxic zone ahead of the ditch that would allow volatile fatty acid (VFA) growth and uptake by phosphate accumulating organisms (PAOs), and he designed a quick and cheap reconfiguration. Located in the heart of the nation's dairy land, he made use of readily available materials – a spare 1,000-gallon bulk milk storage tank. Equipped with an internal mixer in the center, the tank created an ideal anoxic zone.

After installing the single milk tank in February 2016, Vic began aeration cycling experiments in the ditch to further reduce nutrient discharges. Although cycling improved effluent TP concentrations, it ultimately did not achieve desired levels due to process control limitations. By the start of that summer, Vic stopped cycling and focused on refining the operation of the pre-anoxic zone.

Still short of his TP discharge goal, in November 2016, Vic made one more system reconfiguration. He increased the capacity of the makeshift pre-anoxic zone to 1,800 gallons by adding two more milk tanks, connecting the three tanks in series using PVC pipe for connections. Return activated sludge (RAS) is returned from the clarifier to the first tank using a garden hose.

> After expanding the pre-anoxic zone, the effluent TP concentration dropped by half almost overnight, and within a month was consistently below 1.0 mg/L. The winter before beginning optimization efforts, the plant's effluent TP averaged 4.5 mg/L.

Since implementing the pre-anoxic zone, Vic operates only the one ditch rotor that precedes the setpoint-programmed DO probe

Blenker-Sherry POTW's Milk Tank Pre-Anoxic Zone

and operates the clarifier without a sludge blanket. A fourth ORP probe is now mounted in the third milk tank, where ORP levels range between -200 and -450 mV. Vic set his monitoring system to take ORP readings frequently, at least daily, to keep a close eye on the pre-anoxic system. If the system upsets, Vic measures nitrate concentrations in the tanks at least twice a week, with a target concentration below 1 mg/L, and adjusts RAS rates to manage denitrification. Lacking onsite laboratory services, Vic monitors TP performance indirectly by measuring orthophosphorus with a simple handheld colorimeter. Testing for compliance, including effluent TP, is completed by an outside laboratory.

Years after implementing the pre-anoxic zone, the plant's average effluent TP concentration is still consistently below 1 mg/L, averaging 0.81 mg/L over 2020. However, the plant does see spikes as high as 7 mg/L in the warmest summer months, and smaller spikes when the system decants and phosphorus is released. During the winter 2020 training, Grant suggested these hot spikes may result from an insufficient carbon/BOD ratio in the ditch that is unable to foster strong PAO growth. A possible solution may be taking one or two of the pre-anoxic tanks offline during hot weather, reducing the zone capacity.

> "Operators are just trying to make it better, and you can always try to make it better."
>
> —Vic Krzykowski

Vic continued to collaborate with Grant after the training series, and after reviewing many months of monitoring data, they identified a possible correlation between effluent TP and mixed liquor suspended solids (MLSS) concentrations. Blenker-Sherry POTW seems to produce the best and most stable effluent TP concentrations when the MLSS concentration is maintained between 2,500 and 3,500 mg/L. Vic intends to keep experimenting with MLSS concentrations, optimizing the plant's nitrification process, and seasonally reducing the capacity of the pre-anoxic zone to keep driving the plant's nutrient discharges lower. In the four months since the training, Blenker-Sherry POTW's effluent TP concentration averaged 0.28 mg/L.

Blenker-Sherry Operator, Vic Krzykowski

Optimization Opportunities and Benefits

Small treatment system operators may feel isolated, but training and peer-to-peer support are available and can be invaluable in their efforts to reach nutrient reduction goals. Optimizing biological nutrient removal in small treatment systems not only helps protect the environment but also helps some facilities avoid expensive advanced treatment technology upgrades and pursue more sustainable, and economical, treatment.

Acknowledgements

Nutrient monitoring data were collected from internal plant records.