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OPTIMIZING BIOLOGICAL PHOSPHORUS REMOVAL IN MINNESOTA

Optimizing advanced treatment systems reduces nutrients and saves money

Optimization efforts are often focused on improving nutrient removal in conventional systems, but operators of advanced systems can optimize their plants' performance, too. This fact sheet describes the collaborative approach employed by Metropolitan Council Environmental Services (MCES) and its operators to improve nutrient removal and reduce chemical costs through low-cost operational changes at two of MCES's nine publicly owned treatment works (POTWs).

The first MCES plants to experiment, Eagles Point and Empire, located near Minneapolis, are both designed for enhanced biological phosphorus removal (EBPR) and both have a 12-month moving average effluent total phosphorus (TP) permit limit of 1 mg/L. Staff successfully reduced TP discharges, stabilized effluent concentrations, and eliminated expensive chemical addition.

Eagles Point POTW

The Eagles Point POTW has a design capacity flow of 10 million gallons per day (MGD) and an average daily flow of 5 MGD. The plant has two primary clarifiers, four activated sludge aeration basins, two secondary clarifiers, UV disinfection, and one gravity thickener. In the aeration basins, flow first enters a pre-anoxic zone, where return activated sludge (RAS) is fed; followed by an anaerobic zone; and then three aerobic zones in series. Process control consists of automatic air control using dissolved oxygen (DO) probes in the aeration basins. Although the Eagles Point POTW was designed for EBPR, the effluent TP concentration could not be maintained below 1.0 mg/l without adding aluminum sulfate to the primary influent.

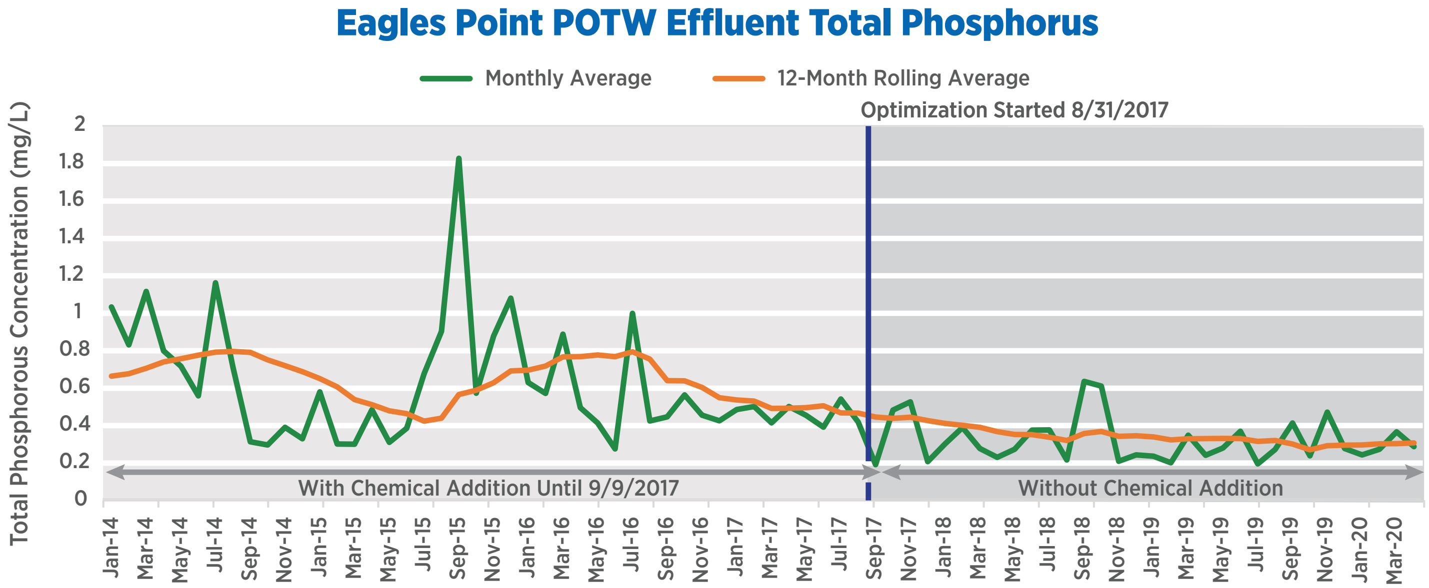
Eagles Point POTW

MCES suspected that high nitrate loads in the RAS were hindering performance by impeding growth of phosphate accumulating organisms (PAOs) in the anaerobic zone. They devised a three-step experiment to improve EPBR performance and reduce aluminum sulfate addition.

1. Gradually decrease the RAS rate from 50% to ~30% to reduce nitrate loads from the RAS to the pre-anoxic zone and carry over into the anaerobic zone.
2. Turn off the aluminum sulfate addition system.
3. Monitor phosphorus release at the end of the anaerobic zone and effluent TP concentration while maintaining clarifier performance.

To maintain clarifier performance, staff set targets for a sludge blanket depth less than 2 ft and a sludge volume index (SVI) of 100 mL/g, while monitoring total suspended solids (TSS) concentrations in the RAS.

Operators began experimenting on August 31, 2017 and were able to stop chemical addition on September 9, 2017.



Eliminating chemical addition not only reduced operating and maintenance labor, but also **saved the plant about $100,000 per year in chemical costs**.

Since making the changes, the 12-month rolling average effluent TP concentration reached an historical low of 0.3 mg/L.

Empire POTW

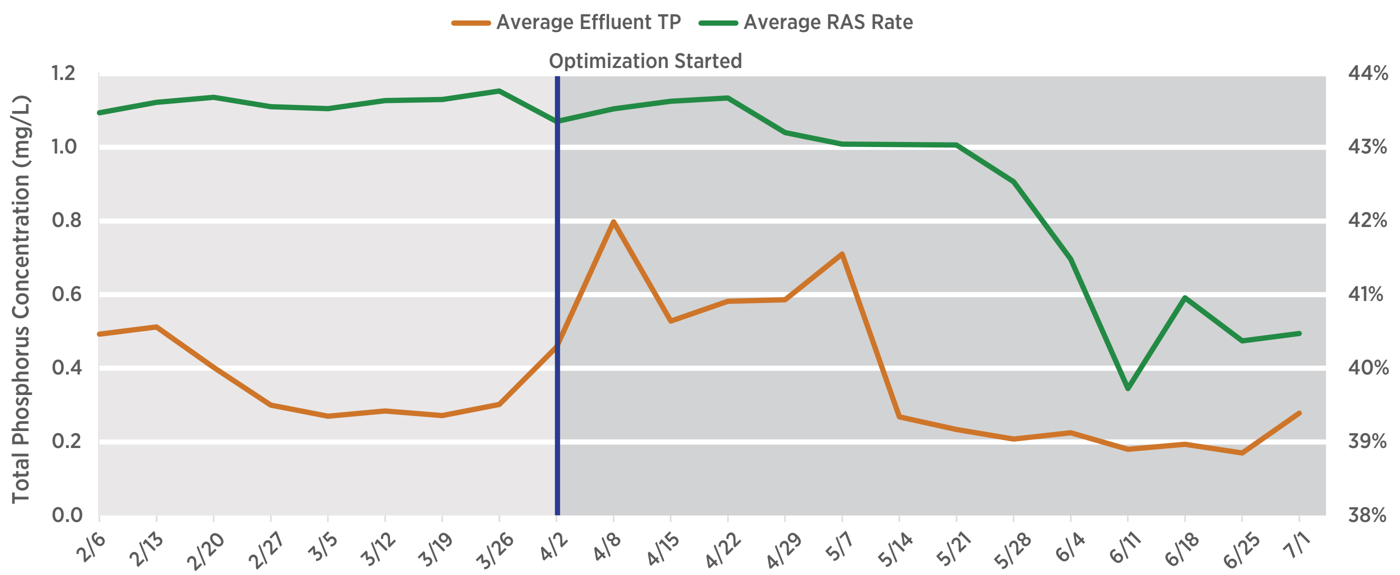
The Empire POTW has a design capacity flow of 24 MGD and an average daily flow of 11.5 MGD. The plant has six primary clarifiers, five activated sludge aeration basins (three normally in use), four secondary clarifiers, UV disinfection, and two gravity thickeners. The activated sludge system begins with a pre-anoxic zone with RAS feed; followed by four anaerobic zones in series, the second of which receives primary clarifier effluent; and then six aerobic zones in series. Process control consists of automatic air control using DO probes in the aeration basins. Despite being designed for EBPR, the plant produced high and variable effluent TP concentrations during the few warm months of the year.

MCES again suspected that high RAS nitrate loads were hindering EPBR performance. Starting in April 2016, Empire staff began decreasing the average sludge return rate from 44% to 41%, in 1 - 2% increments, while closely maintaining secondary clarifier performance, using the same targets as Eagles Point, and monitoring TP release in the anaerobic zone.

After reducing the RAS rate, Empire operators quickly saw lower and more consistent effluent TP concentrations. In just six months, Empire POTW cut its average effluent TP concentration in half, from 0.4 mg to 0.2 mg/L.

Empire POTW

Empire 2016 Effluent Total Phosphorus versus Return Activated Sludge (RAS) Rate



Advice for Operators: EBPR Troubleshooting Checklist

Through experience at Eagles Point and Empire POTWs, MCES developed a Process Troubleshooting Checklist for Enhanced Biological Phosphorus Removal to guide other MCES plants. Operators interested in troubleshooting biological phosphorus removal at their plant should start by ensuring that high effluent TP concentrations are in fact related to poor EBPR performance and not some other cause, such as a new influent contribution, high solids in the effluent (since phosphorus can be in particulate form), or new chemicals entering sewers that can inhibit the EBPR process.

MCES advises operators to gather operating data when the plant is running well to establish a baseline. Knowing your plant's "normal" makes field test results easier to interpret, as all plants are different.

Suggestions from the checklist for troubleshooting EBPR performance include:

- Review influent conditions (e.g., BOD and COD concentrations; BOD:TP and BOD:TN ratios) to confirm flow has sufficient carbon to support PAO growth and denitrification. Don't assume; sample.
- Review aeration basin and secondary clarifier DO and TP profiles to identify potential secondary phosphorus releases. If needed, reduce the secondary clarifier sludge blanket depth to maintain clarifier performance.
- If high nitrate loads are impeding PAO growth, determine if you can lower the RAS ratio.
- Examine anoxic/anaerobic zone conditions for potential to reduce or cycle mixing. This allows some settling and promotes volatile fatty acid (VFA) generation from the RAS.
- Set target DO concentration in the initial aerated zone of at least 1.5 mg/L to support ammonia oxidation.
- If air mixing is used in the anoxic or anaerobic zones, adjust the airflow to ensure the DO levels are as close to zero as possible to encourage VFA uptake by PAOs.
- Increase gravity thickener sludge blanket depths to allow VFA production and increase VFAs in gravity thickener overflow.

Acknowledgements

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