Minnesota Pollution Control Agency

WWTF Optimization for Phosphorus Removal

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Municipal Division

Wastewater Program

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Introduction

It may be possible to improve the phosphorus removal capabilities of your wastewater treatment facility (WWTF), regardless of whether phosphorus treatment methods are in use, by optimizing certain operations and practices.

Basic steps

First of all, eliminate sources of infiltration and inflow. Sources of stormwater and ground water that do not need to be routed to the WWTF should be removed from the collection system. While infiltration and inflow generally cause influent phosphorus concentrations to be somewhat diluted, the overall effect of high flows is usually to increase the effluent phosphorus load discharged from the facility.

Secondly, evaluate source reduction opportunities. Discuss cleaning and sanitation chemical usage with industrial, commercial and institutional users of the WWTF. The use of phosphate-free or low-phosphate alternatives can often substantially reduce the load to the WWTF. Reduced influent phosphorus loads will result in reduced effluent phosphorus loads.

Thirdly, optimize solids treatment. Particulate phosphorus can constitute up to 20 percent of the effluent total suspended solids (TSS) load from WWTFs that do not provide phosphorus treatment and five percent of the TSS load from WWTFs that do provide phosphorus treatment. Optimizing solids capture in final clarifiers and effluent filtration units will help reduce effluent phosphorus loads.

Monitoring

Mechanical facilities

Determine individual treatment component efficiency by monitoring influent and effluent concentrations from each treatment component. A series of grab samples should be sufficient to make these determinations. If possible, allow a sufficient interval between the collection times of influent and effluent samples to account for the estimated hydraulic residence time of each component.

If supernatant, centrate, or other dewatering return flows are generated from solids processing units, monitor total phosphorus concentrations and calculate loads returned to the wastewater treatment facility for further treatment. Are these loads represented by the facility’s influent samples (i.e. are supernatant flows returned upstream of the influent sampling point)? If not, you may want to account for these loads in calculating the facility’s removal rate.

Suspended-media

treatment facilities

At suspended media treatment facilities (various types of activated sludge processes), monitor the % phosphorus content of the mixed liquor suspended solids (MLSS). Standard activated sludge organisms should contain 1.5 percent to 2.0 percent total phosphorus. The cell mass of phosphorus accumulating organisms (PAOs) associated with biological phosphorus removal can contain up to 30 percent total phosphorus. If the phosphorus content of the MLSS in your activated sludge processes is substantially higher than 2.0 percent, it may be an indication that some biological phosphorus removal is occurring within your facility and that certain operational strategies may help enhance its efficiency.

How to obtain % phosphorus in an MLSS calculation:

Analyze a MLSS sample for the following parameters:

- Total phosphorus
- Dissolved phosphorus
- Total suspended solids

Formula:

Total phosphorus - dissolved phosphorus = particulate phosphorus

*Particulate phosphorus / total suspended solids * 100 = % phosphorus*

Calculate total % phosphorus removal rates for your WWTF. Refer to MPCA's fact sheet, *Phosphorus Treatment by Minnesota Wastewater Treatment Facilities,* for average, minimum and maximum effluent concentrations and removal efficiencies by facility type. Evaluate your WWTFs performance with respect to other similar types of WWTFs.

If your WWTF's phosphorus removal rates are very low (less than 30 percent) dye studies may help determine whether any unit short-circuiting, leaking valves or unknown bypass piping may be contributing to the problem.

Stabilization Ponds

Increase influent monitoring frequency for a period of time to make a more accurate assessment of influent phosphorus loadings.

Monitor total phosphorus concentrations in both primary and secondary ponds during various seasons and climactic conditions. Analyze patterns to determine whether any operating conditions are conducive to improved phosphorus treatment. For instance: Could ponds be operated in series rather than in parallel? Does increased detention time improve phosphorus removal?

Monitor total phosphorus concentrations in both primary and secondary ponds before and after transfers.

Non-rooted macrophytes, such as coontail (Ceratophyllum demersum), are reported to eliminate problems with elevated TSS levels at some Minnesota pond facilities. It may also have beneficial effects on effluent concentrations of other pollutants such as phosphorus and heavy metals.

Process Control

Combine process control adjustments and monitoring to determine whether unit efficiency can be improved.

Note: Only make one process adjustment at a time to ensure that you will be able to determine which variable is responsible for any observed changes in the behavior of the facility.

Mechanical Facilities

At mechanical facilities, try adjusting recirculation and/or wasting rates and test the efficiency of variations in MLSS concentrations.

Also, test different filamentous bacteria control techniques. Shock chlorination is a frequently employed method to control the growth of filamentous bacteria. While effective, high doses of chlorine are also detrimental to the desirable bacteria in your treatment facility. Smaller, but more frequent doses of chlorine are reported to effectively control the growth of filaments while having a less deleterious effect on the treatment efficiency.

Try adjusting the depth of sludge blankets in clarifiers. Lower solids in secondary clarifiers prevent wash out. Two Minnesota WWTFs recently reported some success in reducing effluent phosphorus concentrations by increasing sludge blanket depths in their primary clarifiers and allowing them to become anoxic. Facility operators assume that under these conditions the clarifiers are acting as anaerobic selector cells for biological phosphorus removal.

WWTF operators also report some degree of success in creating conditions that favor biological phosphorus removal by creating anaerobic conditions at the inlet to the aeration process. A one-hour anaerobic detention time is thought to be optimal. Return activated sludge (RAS) should be routed back to anaerobic zone unless your facility nitrifies (is designed for ammonia removal). If the facility is set up for nitrification, RAS should be routed to an anoxic zone where nitrates can be depleted prior to the aeration process.

If solids dewatering (supernatant, etc.) phosphorus loads are significant, consider alternate handling options. Slower or off-peak return rates may allow the loads to be more thoroughly treated. If feasible, chemical treatment and settling of the return flows prior to reintroduction to the main treatment train may be a cost-effective phosphorus removal technique.

Minimize build-up of solids beyond secondary clarification units. Keep disinfection, re-aeration or other final polishing units clear of solids.

Stabilization Ponds

There are several potential process control changes for stabilization ponds. First, avoid discharging during periods of low receiving water flow. Secondly, determine whether phosphorus removal is more efficient when ponds are operated in parallel or in series. Finally, determine whether any non-rooted macrophytes (such as coontail) present in any of your ponds have any discernible impact on phosphorus removal. Harvesting macrophytes prior to fall discharges is recommended to remove the nutrients and other pollutants that have been incorporated into their biomass from the system.

Note**:** Some aquatic macrophytes are considered invasive species and their release to the environment *must be avoided*.