NUTRIENTREMOVAL

CSR: THE RIGHT PATH FOR ROTH LANE

By Ayman R. Shawwa

Wastewater treatment plant upgrades to meet stringent nutrient limits

ARTICLE SUMMARY

Challenge: Roth Lane WWTP at Hampden Township, Pa., is required to meet stringent nutrient limits associated with the Chesapeake Bay Nutrient Reduction Strategy.

Solution: The plant utilized a continuously sequencing reactor equipped with advanced control system for biological nitrogen and phosphorus removal.

Conclusion: Hampden Township was able to generate total nitrogen and total phosphorus credits that could be sold on the nutrient trading market.

The Roth Lane Wastewater Treatment Plant (WWTP) in Mechanicsburg, Pa., is owned and operated by Hampden Township Sewer Authority. The 4.82-million-gal-per-day WWTP was constructed in 1982 and upgraded in 2010 to meet the more stringent nutrient limits associated with Pennsylvania Commonwealth's Chesapeake Bay Nutrient Reduction Strategy.

The WWTP consists of five screens, a spiral flow aerated grit and grease removal system, two continuously sequencing reactors (CSRs), three final clarifiers and UV disinfection. An alum feed system also is available for additional chemical precipitation of phosphorus. The current National Pollutant Discharge Elimination System (NPDES) permit for the Roth Lane WWTP has average monthly discharge limits of 30 mg/L for total suspended solids, 15 mg/L for the carbonaceous component of biological oxygen demand, 1.8 mg/L for ammonia nitrogen (from May 1 to Oct. 31) and 5.4 mg/L (from Nov. 1 to March 31), and 2.0 mg/L for total phosphorus. The NPDES also includes an annual total nitrogen and total phosphorus mass load limits of 101,997 and 12,359 lb, respectively, which are enforced on a 12-month compliance year, from Oct. 1 to Sept. 30.

The CSR developed by Schreiber LLC is a low-rate cyclic activated sludge process that employs intermittent aeration in a single continuous flow reactor where air is turned on and off to provide aerobic (oxic), anoxic, and anaerobic conditions needed for biological nutrient removal (BNR). The CSR reactor is a circular tank equipped with fine-bubble membrane diffusers suspended from a peripherally driven rotating aeration bridge. The rotating bridge travels at a speed of 3 fps, providing energy for mixing (approximately 3 hp/mg) without the need for aeration, resulting in large energy savings. This provides an advantage for cyclical operations because the reactor mixing is independent from aeration.

There are several basic concepts related to the CSR process:

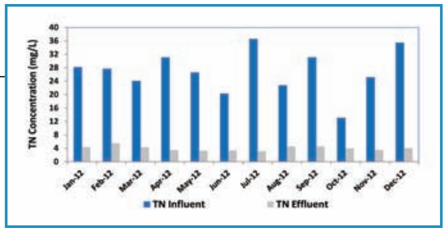
- The three process phases occur in the same basin, but not at the same time;
- The entire basin experiences each process phase fully (e.g., the entire basin is aerobic when the CSR is in the aerobic phase);
- The process phases occur sequentially and always in the same order of oxic, anoxic and anaerobic; and
- The time duration of each phase can vary from cycle to cycle depending on the loading and the degree of treatment desired.

The application of CSR process for BNR provides several benefits due to its single reactor process. The need for internal mixed liquor suspended solids recycling, which is characteristic of most other BNR systems, is eliminated, and therefore capital and energy costs for additional equipment are reduced. Because the denitrification process recovers oxygen and alkalinity, the CSR process is more economical to operate than conventional activated sludge processes. Also, the CSR process is more stable, as the nitrogen cycle is completed rather than terminated at the end of the nitrification phase.

System Breakdown

There are two CSRs; each has a diameter of 111.5 ft and side water depth of 16.4 ft. The reactor is designed based on food to microorganism ratio of 0.1 day to 1 and solid retention time of 16 days. Each reactor is equipped

Figure 1. Roth Lane WWTP Total Nitrogen Removal



There are 480 stationary diffusers mounted 8 in. above the floor on retrievable rack assemblies attached to the tank wall.

with 562 tube diffusers, which are mounted on a retrievable rack assembly and suspended from the rotating bridge. These diffusers are termed "rotating diffusers" because they rotate with the bridge. There also are 480 tube diffusers mounted 8 in. above the floor on retrievable rack assemblies attached to the tank's wall. These diffusers are termed "stationary diffusers" and have a clearance of 1 ft and 8 in. with the rotating diffusers.

There are three positive displacement blowers, each equipped with variable frequency drives dedicated to each bioreactor. The operating air flow for each blower ranges from 540 to 1,740 scfm. For each bioreactor, one of the blowers is dedicated to the stationary diffusers and is designated the primary blower. The second blower is dedicated to the rotating diffusers and is designated the secondary blower. The third blower serves as a redundant standby blower for either the rotating or stationary diffusers.

Process Control System

The process control system at Roth Lane WWTP is capable of monitoring, on a continuous basis, dissolved oxygen (DO) concentration with a Hach LDO probe and nitrate concentration with a Nitratax probe. The 4-20 mA output signals from each reactor are sent to a programmable logic controller (PLC) to establish process phasing through oxic, anoxic and anaerobic cycles. A proportional-integral-derivative control loop is used to modulate blower's speed in each reactor to maintain the DO setpoint. To allow operational flexibility, the PLC allows the user to adjust the DO setpoint and stage timers for each phase. The following is a simple description of the sequence of operation through oxic, anoxic and anaerobic cycle:

1. The oxic phase is initiated when the anaerobic stage timer is met (15 minutes). The primary blower is energized and the oxic stage minimum and maximum timers are started. The primary blower speed will modulate to maintain the desired DO setpoint (1.2 mg/L) by increasing the air flow to the stationary diffusers. When the primary blower speed reaches 85%, the secondary blower is energized and the speed of both blowers stabilizes to deliver 50% of the air flow and will modulate to meet the DO setpoint. When the primary blower speed drops below 30%, as oxygen demand decreases, the secondary blower is de-energized.
2. The anoxic phase is initiated when the oxic stage maximum timer (120 minutes) is met, or when the oxic stage minimum timer (90 minutes) and nitrate high setpoint (10 mg/L) are met. All blowers are turned off and the anoxic stage minimum and maximum timers are started.
3. The anaerobic phase is initiated when the anoxic stage maximum timer (60 minutes) is met, or when the anoxic stage minimum timer (45 minutes) and nitrate low setpoint (1 mg/L) are met. The anaerobic stage timer is started. During this stage, all blowers are turned off.

Successful Performance

The Roth Lane WWTP consistently met its NPDES's effluent limits. Based on 2012 operational data, the influent carbonaceous component of biological oxygen demand averaged 165 mg/L and the final effluent was 2.9 mg/L, resulting in carbonaceous component of biological oxygen demand removal efficiency of 98.2%. The influent ammonia nitrogen averaged 23.6 mg/L and the final effluent was 0.44 mg/L, resulting in ammonia removal efficiency of 98.1%. The maximum final effluent ammonia nitrogen in the summer was 0.51 mg/L, which is well below the discharge limit. The influent phosphorus averaged 3.8 mg/L, and the final effluent was 0.81 mg/L, resulting in phosphorus removal efficiency of 79%. In addition, the WWTP consistently produced low-effluent total nitrogen concentrations with an annual average of 4.0 mg/L (Figure 1).

The capability of the CSR process in achieving low total nitrogen and total phosphorus in the final effluent also was evident in the annual total nitrogen and total phosphorus mass loadings for Compliance Year 2012. A total nitrogen mass load of 43,187 lb was reported, which is 42% of the NPDES's limit. Likewise, a total phosphorus mass load of 7,888 lb was reported, which is about 64% of the NPDES's limit. The generated total nitrogen and total phosphorus mass load credits could be sold by Hampden Township to other municipal WWTPs on the nutrient trading market.

The operational flexibility and reliability of the CSR process at Roth Lane enabled Hampden Township to meet its NPDES permit. According to Jeff Klahre, operation supervisor, "The results that Hampden Township gets from [this] CSR speak for themselves. The CSR system is extremely operator friendly and low maintenance." WWD

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