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page 26
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- Allows for nutrient removal in a single basin
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Future permit limits are a genuine concern for those in wastewater treatment—especially total nitrogen (TN) limits. Most forecasters predict TN limits will be cut from the current 5 to 10 mg/L range down to somewhere around 3 mg/L. However, TN removal is not new; development of treatment systems has been underway for more than 40 years.

The Clayton County (Ga.) Water Authority (CCWA) has an interesting TN removal history. Located in the southern part of metro Atlanta, the county has experienced tremendous growth over the past two decades. Having long been a pioneer in land application and reuse, in 1986 the CCWA became the first water utility in the state to implement biological nutrient removal (BNR). Starting with the Modified Ludzack-Ettinger (MLE) process, they progressed to the Continuously Sequencing Reactor (CSR) process used today.

The earliest BNR water reclamation facility in Clayton County used MLE. A circular version was installed at the CCWA Northeast Water Reclamation Facility (WRF) in 1986. As reported in the April
Advanced control systems

The Northeast Water Reclamation Facility (WRF) control configuration uses a dissolved oxygen (DO) monitor and adjustable timers, which control how long the blowers are on or off. The DO monitor determines how many blowers are needed during aeration to prevent overaerating.

The newer Shoal Creek WRF uses the SchreiberFlex process control system. In addition to a DO monitor, it includes parameter concentration monitors for ammonia, nitrates, and phosphates. It also has two dosing systems: one for the addition of a carbon source, another for metal salts. The programmable logic controller (PLC) serves as the “brain” of the system.

Fortunately, the older CSR plant does not need investment in massive, expensive structural additions to accommodate the projected lower total nitrogen (TN) permits. All that will be needed is an inexpensive control system upgrade.

At the Northeast WRF, when a timer times out, the system moves on to the next stage. During the aerobic stage, blowers are on and the basin is in the nitrification process; the blowers turn off at the end of the period, with the system continuously alternating between on and off.

While the blowers are on, aeration occurs. “Free” oxygen is supplied to the mixed liquor suspended solids by the blowers to sustain nitrification. Once the blowers have been turned off, free oxygen is quickly consumed by organisms in the basin, making it possible for denitrification to occur. Once the blowers are off long enough, anaerobic conditions occur, necessary in achieving biological phosphorus removal.

Using only time periods as duration controlling parameters poses some problems. First, these time limits are preset, best-guess estimates; the time frames will almost always be too long or too short. Secondly, no provisions exist for making adjustments in response to the actual conditions. Even if these best-guess estimates are fairly accurate, changes in the influent render the guess inadequate, necessitating re-adjustment of the parameters. Also, with timers alone, there is no way to determine if the biological objectives of each phase are being met, or if one phase is receiving more time or energy than needed.

These shortcomings can be categorized into two areas: questions regarding the effectiveness of the process, and about its efficiency. At the Northeast WRF, timer-based challenges have been handled through personnel’s knowledge of the process, diligence, and attention to detail.

1988 issue of Public Works, the process yielded better-than-expected results, attaining an 84% removal rate; TN values reported in the first year averaged 4.2 mg/L.

Schreiber LLC, Trussville, Ala., supplied the circular MLE as a version of its counter-current aeration (CCA) system. The single reactor was a 171 foot diameter, 3.1 million gallon basin with a concentric circular baffle wall separating it into a center 1/2 million gallon denitrification zone—the anoxic “center basin” and an outer 2.6 million gallon aerated zone (the aerobic “annular ring”). The diffused aeration system consisted of ceramic diffusers mounted on an aeration bridge, which continuously rotated about the basin. The movement of the diffuser assemblies through the water by the aeration bridge provided mixing for the reactor and allowed the aeration to be completely independent of mixing.

In the late 1980s, development of the membrane diffuser offered new options. Unlike with ceramics, the diffusers now could be turned completely off without fouling, allowing creation of anoxic and anaerobic conditions within the basin. This allowed the circular CCA basin to be transformed into a CSR.

In the early 1990s, plans were underway to double the capacity of the original Northeast WRF. However, instead of just adding a copy of the existing circular MLE, engineers decided to test Schreiber’s newly developed CSR design. They constructed the new train in the CSR configuration, then ran the original circular MLE and new CSR side by side. The experiment demonstrated that the new CSR configuration was superior, and the original MLE then was reconfigured to a CSR.

Further population growth in the county called for additional treatment capacity. In 2002, a dual-train CSR plant was commissioned at the new Shoal Creek WRF. Although the two plants both now operate CSRs, the results are quite different, primarily because of the new facility’s enhanced automated control systems.

The Shoal Creek facility on average produces an effluent with TN concentrations of less than 2.5 mg/L—within the anticipated future permit limits in the 3 mg/L to 4 mg/L range. Although the older plant produces an excellent effluent, its typical TN runs from 4 to 6 mg/L. Data from the Shoal Creek CSR plant demonstrates that a single-sludge system can achieve very low TN levels. Historically, single-sludge systems were thought to be incapable of such results.

UNMANDATED TN EXCELLENCE

Ironically, there are currently no TN permit limits on wastewater treatment plants in Georgia. One might ask why CCWA plants strive to produce effluents with such low TN values when it is not mandated.

The first answer is an economic one. Attaining excellence in TN removal offers the economic benefit of recovering both alkalinity and oxygen. Secondly, such performance demonstrates an environmental stewardship mindset, which translates into good public relations.

There is also an educational benefit. By voluntarily operating these plants to achieve a superior effluent, personnel will
be better prepared to respond to TN permit limits if and when they are mandated.

Also, the county water system practices "indirect reuse." Effluent from the two plants goes into either a waterway or wetlands, eventually discharging into the CCWA's drinking water reservoir. The Northeast WRF point discharges into a creek 7 miles upstream of the area's drinking water plant. The Shoal Creek WRF has a land-application discharge permit. It discharges into a constructed wetlands, then to the Shoal Creek drinking water reservoir. Because of this indirect reuse, the CCWA is concerned about the nitrate levels in the effluent affecting drinking water in the region.

PROCESS DETAILS

As an activated sludge process, the Schreiber CSR uses the normal three phases— aerobic, anoxic, and anaerobic—but provides all three in a single basin via process cycling, or sequencing. First, with the aeration on, the basin is aerobic, typically for several hours at a time. Then the blowers are turned off, and for the next 30 to 90 minutes, the basin is anoxic. Finally, as the blowers remain off, the basin undergoes anaerobic conditions for 15 to 45 minutes. Significantly, the actual duration of each phase depends on biological loadings.

Conditions that control when the CSR system moves from one phase to the next are called phase duration controlling parameters. For the older Northeast WRF, this is largely decided by timers, while at the Shoal Creek WRF, the controlling element is the analyzers. The CSR process is optimized when the system minimizes the time required to finish an entire sequence of aerobic, anoxic, and anaerobic process phases while completely fulfilling the biological objectives of each phase. A CSR system under normal conditions will exhibit a range of 3 to 12 cycles per day.

CONTROL VIA ANALYZERS

The Shoal Creek plant employs analyzers in its process control strategy. The system continuously monitors the soluble nutrient parameters in the mixed liquors of the reactor basins. Analyzers measure concentrations of ammonia, nitrates, and phosphates at all times during the three phases. Since these concentrations all vary in a predictable manner in each of the three phases, the data measured can be used to monitor and control the process.

The process prevents a phase from ending until it has been completed. The system's ability to bring each phase to completion is limited by the accuracy and repeatability of the monitoring devices. The SchreiberFlex control system optimizes each phase and initiates preemptive actions to ensure each phase reaches completion.

The control system has a series of other "watchdog" components and programmable logic controllers that protect the process from errant analyzers and other practical concerns, but the fundamental concept of the system is to use the ammonia/nitrate/phosphate analyzer data and, when necessary, dosing systems to drive each phase toward biological completion, then promptly move the process into the next phase.

This analyzer-based strategy addresses the twin concerns of efficiency
A three-day effluent trending chart from the plant’s supervisory control and data acquisition system shows that the nitrate concentrations are typically less than 2 parts per million (ppm), and that only four times in that span of days did nitrate levels exceed 2.5 ppm; even those excursions were limited in duration. During the three-day span, phosphorus remained consistently around 1 ppm, with only one excursion approaching 2 ppm. Also, the SchreiberFlex system consistently maintained the effluent ammonia at less than 0.5 ppm, reaching 2.25 ppm for only one short period. The analyzers require some operator attention, but the extra effort appears to be well worthwhile.

**IMPLICATIONS FOR THE FUTURE**

Some areas of the country have adopted goals for TN limits. Goals are not permit limits. However, the plants operating in areas in which goals have been established are directed to voluntarily strive to meet these goals. Although a plant may have a current TN permit of 10 mg/L, operators will work to meet a much more stringent target or goal.

TN limits of 3 to 4 mg/L already have been established as a goal in California, Florida, and the Chesapeake Bay area. Such goals often serve as precursors to future permit limits. Once it has been proven that a particular goal is achievable, it eventually will be established as an actual regulated limit for future permits.

Consequently, as wastewater treatment professionals, we should anticipate that our future TN permit limits will be set somewhere in the 3 to 4 mg/L range. CCWA, already having a rich history of TN removal, is prepared for such TN requirements.

One of the most intriguing aspects evolving from this historical review is that the relatively inexpensive solution of upgrading a control system should not be overlooked in our rush to meet new requirements. Often by simply installing a more advanced concept control system in existing facilities, we can meet the challenge of tighter requirements—without making huge investments in additional structures.

**PW**

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