Lagoon based wastewater treatment process provides nitrification in Glencoe, Ontario

By Ken Musyoka, Merle Kroeker and Byron Heppner

The Southwest Middlesex wastewater treatment facility in Glencoe, Ontario, was constructed in 1974-1975, with a rated capacity of 946 m^3/day. This system comprised two facultative lagoons operating in parallel, with discharge into the nearby Newbiggen Creek in early spring and late fall. As of 2005, data showed that the facility was operating at maximum hydraulic capacity.

In March 2011, Nelson Environmental's OPTAER™ wastewater treatment system, with a SAGR® (Submerged Attached Growth Reactor) for nitrification, was commissioned. Overall system process design was a collaborative effort between Nelson Environmental Inc. (NEI) and Genivar, Southwest Middlesex's consulting engineering firm. With a design flow of 1,742 m^3/day, the upgraded system has nearly twice the maximum hydraulic capacity of the previous design.

This increase will meet future demands based on a 30-year design life. The added plant capacity also means that surrounding communities, including the hamlets of Appin and Melbourne, can tie into the system.

In order to attain this increased capacity without constructing additional lagoons, the process was converted from seasonal to continuous discharge, which required that the effluent quality meet permit requirements on a year-round basis.

To protect the receiving stream, the Municipality of Southwest Middlesex wanted to do more than merely meet the discharge effluent quality limits set by Ontario's Ministry of the Environment (MOE). The MOE required a year-round effluent total ammonia limit of 3 mg/L, 13.7 mg/L BOD/TSS, and 0.55 mg/L total phosphorus. Effluent objectives selected for the project were 1 mg/L total ammonia, 7 mg/L BOD/TSS, and 0.3 mg/L total phosphorus. Neither the limits, nor the effluent objectives, would be attainable with conventional lagoon-based treatment.

BOD, TSS and total phosphorus are commonly regulated effluent parameters. Total ammonia (as nitrogen), or TAN, is a measure of the sum of free (NH_3) and ionized (NH_4^+) ammonia concentrations in treated and untreated wastewater. The relative proportions of each are pH- and temperature-dependent. At high pH, the ionized form (free ammonia) predominates, while at low pH the un-ionized is favoured. The ionized form of total ammonia predominates in municipal wastewater, which is typically in the neutral pH range.

Free ammonia in aquatic ecosystems is toxic to fish in low concentrations. To protect receiving waters from ammonia's toxic effects, wastewater treatment plants typically utilize nitrifying bacteria to reduce total ammonia through the biological nitrification process.

Secondary treatment – aerated lagoons

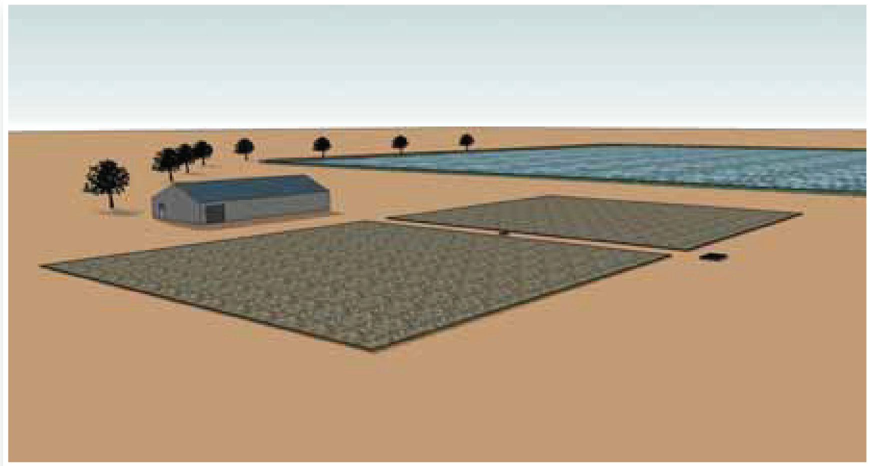
In order to meet the effluent quality objectives, Glencoe's existing eastern facultative cell was taken offline, leaving it for use as a storage facility when needed (e.g., for maintenance or bypass of the western treatment cell). The western cell was divided into three cells, using geomembrane floating baffle curtains to divert flow and effectively maximize the hydraulic retention time by preventing short-circuiting. NEI's fine bubble diffused aeration system was implemented in the partitioned cells to achieve improved year-round BOD and TSS removal, through bacterial degradation and solids settling.

The lagoon aeration diffusers are suspended near the bottom of the cells. They provide oxygen and mixing through the rising action of small air bubbles released in the water. The aeration system also eliminates odour, caused by spring turnover, by maintaining aerobic conditions and mixing throughout the winter.

Tertiary treatment – nitrification

Lagoon-based treatment systems provide some ammonia removal (nitrification) capacity during the summer months, but are generally incapable of meeting low ammonia limits during prolonged periods of low water temperatures. The SAGR tertiary treatment system with FBA® LINEAR Aeration was developed to address this issue without abandoning current lagoon treatment infrastructure. It can be constructed within existing lagoon basins, or as an additional treatment module following a lagoon.

The Glencoe system, consisting of two SAGR beds, was constructed following the three-cell secondary aerated lagoons to facilitate year-round nitrification. Performance parameters and sizing for the process were based on extensive



Glencoe wastewater treatment plant process diagram.

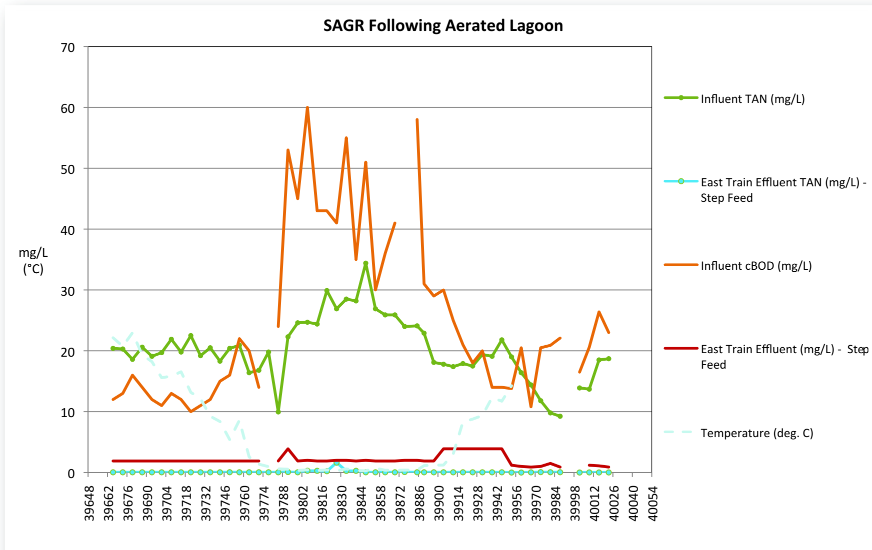


Figure 1: Steinbach SAGR influent and effluent $cBOD_5$ and TAN concentrations (mg/L) and water temperature. The detection limit of the $cBOD_5$ analysis is <2 mg/L. Therefore all results reported as <2 are recorded as 1.9 mg/L in this data set. The detection limit of the TAN analysis is <0.05 mg/L. Therefore all results reported as <0.05 mg/L are recorded as 0.04 mg/L.

testing performed on post-lagoon demonstration systems located in Lloydminster, Saskatchewan, and Steinbach, Manitoba. These sites generated an equivalent total of nine years of effluent data, showing the capability of the process to consistently meet ammonia effluent levels of <1.0 mg/L in summer, and <2.0 mg/L in winter with influent water temperatures as low as 0.5°C (see Figure 1).

In addition to an increased capacity and improved effluent quality, the overall footprint of the Glencoe process was reduced, leaving 50% of the existing lagoon capacity for future expansion.

Treatment process

The SAGR process can be used for nitrification, following any secondary treatment including aerated or facultative lagoons. It is a clean gravel bed with a horizontal flow distribution chamber at the front end to distribute the influent wastewater across the width of the entire cell. The gravel provides the necessary surface area for growth and attachment of a nitrifying biomass within the bed. It is sized to optimize bacterial growth and hydraulic flow.

A horizontal effluent collection cham-

continued overleaf...

Glencoe's completed SAGR with insulating woodchips at grade.

ber at the back end collects all the treated effluent and channels it to the discharge structure. Sizing of the bed is based on influent loading rates and temperature, as well as the required rate of nitrification. For optimal performance, it is preferable (though not limiting) for the influent $cBOD_5$ to be less than 40 mg/L.

To ensure robustness in SAGR system operation, stress-testing was performed on the demonstration system in Steinbach, to simulate possible operational challenges:

1. Flow through the SAGR was stopped for 11 weeks in summer (during the third year of operation) to simulate a fully nitrifying lagoon preceding the process. The objective was to determine biomass resiliency within the reactor bed. Reactor aeration was kept on during the entire period. When 100% design flow was resumed, effluent ammonia levels recovered to below detection by the first weekly sample. This indicates that nitrifiers within the bed remain viable during extended periods with no loading. This is typical of lagoon systems that have sufficient retention time to nitrify during the warm summer months.

2. The upper bounds of hydraulic and mass loading were tested by 200% of design flow throughput. The system was fed at twice the design flow rate for approximately 10 months (beginning June 2009). The observed effluent ammonia was still below detection at twice the design flow rate for much of the year, and excellent nitrification was observed throughout the winter. This indicates that the SAGR is capable of handling surges in flow and mass loading.

3. A simulated power failure provided information on system recovery in the event of a blackout. Blowers providing air to the SAGR process were shut off for 24 hours during the winter, when water temperatures were below 0.5°C. Effluent ammonia during the simulated power outage approximately matched the influent ammonia concentration, as expected, confirming that, at extremely low or no dissolved oxygen, the nitrification process completely stops. When the aeration system was restarted, effluent ammonia levels dropped to below detection by the first weekly effluent sample.

The components and design approach for the Glencoe wastewater treatment process demonstrate the ability to increase hydraulic capacity and provide nutrient removal, while maximizing the use of existing lagoon infrastructure. The system also maintains simplicity of operation, with low O&M costs.

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