A model based study: Revisiting conventional BNR configurations with advanced aeration control

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Keywords: mainstream deammonification, nitrogen removal, aeration control, nitrite-shunt

What are the main purpose and conclusion of your work?

The main purpose of this study is to challenge existing design approach of aeration control strategies where BNR configuration itself is not considered to be modified to leverage full benefits of a given aeration control strategy.

INTRODUCTION

Advanced aeration control based on on-line measurements of nutrients and process parameters such as dissolved oxygen in biological nutrient removal (BNR) systems is gaining a lot interest from utilities looking to save chemicals and energy associated with nutrient removal. Consequently, process engineers tasked with the optimization of BNR processes are often tasked with developing case-specific aeration control strategies. However, there are many aspects of aeration control design and implementation that still lack overarching guidelines. Over the last four decades there has been exhaustive efforts to develop most efficient BNR process configurations and flow schemes. As a result, today, we have multitude of conventional BNR process configurations targeting different aspects of nutrient removal. So far, implementation of aeration control involves modification of strategies to fit a given process configuration. However, simple modifications of the BNR process configuration to enhance the strength of a given aeration control strategy is often not considered.

In this model based study, we explore BNR processes where advanced aeration control and process configurations are optimized as necessary to achieve the most efficient performance. Given the experience of the author, ammonia vs NOx (AvN) (as described by Regmi et al. (2014)) is considered in two of the simplest BNR process configurations – MLE and AO.

METHODS AND MATERIALS

An MLE BNR process with the ability to be operated as an AO process is presented in Figure 1, and modeled in this study. The anoxic volume of this process ~ 20% of the overall reactor volume. The permitted capacity of the facility is 76 MLD. On average, the influent COD/TKN ratio is around 8.5 and temperature of wastewater is 22 C.

BioWin™ version 5.2 is used for the process modeling effort. BioWin Controller which is a module that interface with main process simulator was to test advanced aeration control and test real time process control strategies. It is important to note that aeration control strategies with

BioWin controller can only be tested with dynamic input and simulation. Accordingly, fully calibrated model of the facility with historical dynamic data was used in this study.

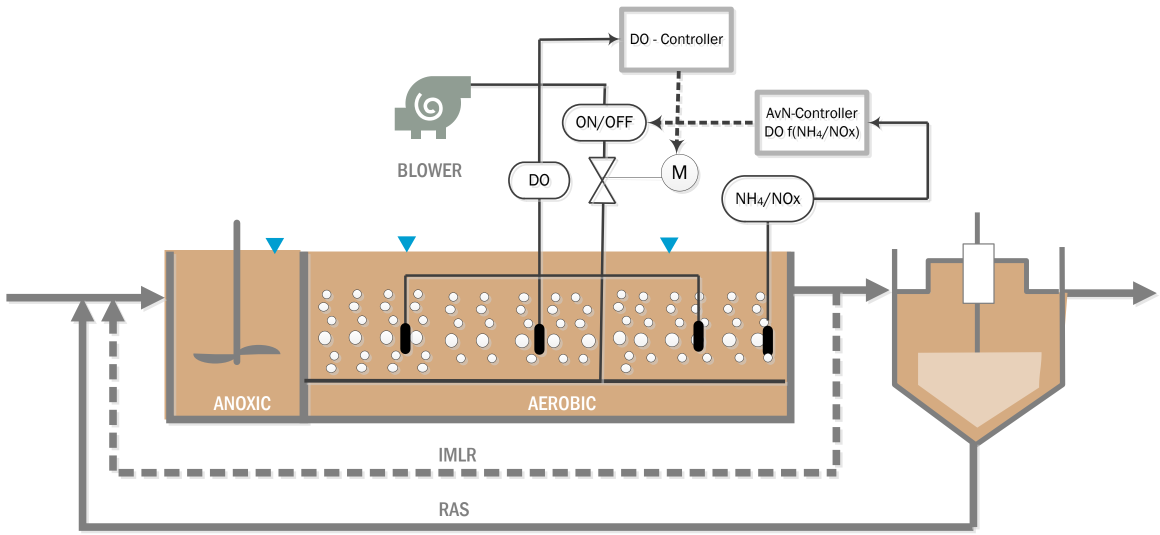

Figure 1 AO/MLE process with AvN control.

AvN aeration control: The first component of AvN control is the aerobic duration controller with the goal of maintaining equal effluent NH4-N and NOx-N (NOx-N/NH4-N = 1) always. The other component of the AvN control is the DO controller, which maintains the DO at the desired set-point during the aerated period. Under the AvN strategy, NH4-N is compared to the sum of NO2-N and NO3-N concentrations (NOx-N). First, the cycle duration (aerobic time + anoxic time) has a defined minimum and maximum aerobic time. The cycle duration is kept constant at 20 minutes. When the NH4-N concentration is greater than NOx-N concentration, the aerobic time is increased and the aerobic time is decreased when the NOx-N concentration is greater than NH4-N concentration while maintaining the cycle duration constant. The aerobic time is allowed to fluctuate between the minimum and maximum set-points by a PID controller. When aerated, another PID controller maintains the target DO set-point of 1.6 mg O2/L by manipulating the position of the automatic valve. This exact control was developed in BioWin controller to test AvN control strategy.

RESULTS AND DISCUSSION

AvN aeration control was modeled using previously calibrated model with a BioWin controller. The aeration control simulation was conducted with historical plant data for ~ 3.5 months. The findings of the simulation with AvN aeration control implemented in the MLE configuration is shown in Figure 2. AvN control resulted effluent TIN of <5 mg/L. Effluent ammonia ranges between 2- 3.5 mg/L as was the effluent NOx concentration which demonstrates the finely tuned AvN controller. Due to low NOx recycle by IMLR to the anoxic zone, the anoxic zones become anaerobic. This results in anaerobic P release due to enhanced PAO activity. Consequently, bioP was observed with effluent P below 0.5 mg/L. With AvN control, this process can be operated in an AO mode without the IMLR since recycled NOx-N are very low. On the flip side, PAO activity were to be inhibited, the N removal can be further enhanced by shunting away the influent carbon towards denitrification in anoxic as well as aerobic zone (via intermittent aeration). Low NOB/AOB ratios < 0.45 (NOB population: AOB population as mgCOD/L) and substantial effluent NO2-N suggests some NOB out-selection was occurring. Hence, high TIN removal performance might have been enhanced by nitrite-shunt pathway.

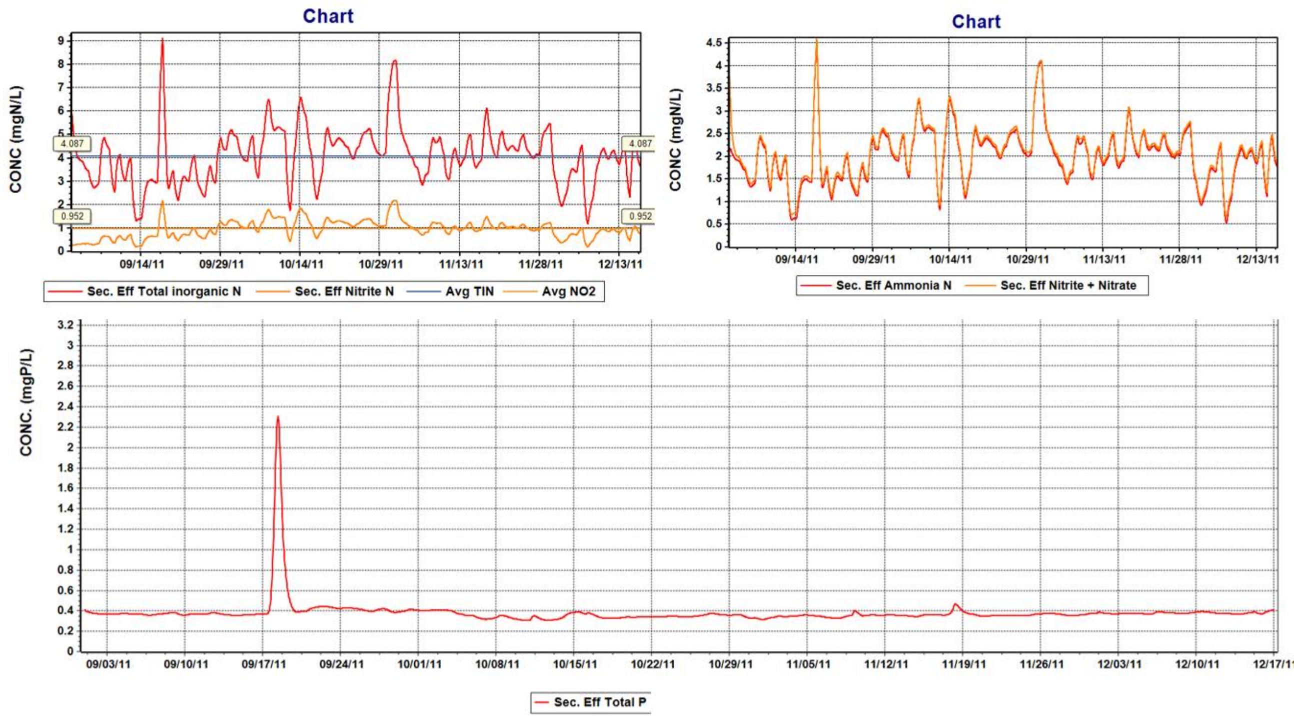

Figure 2 Reactor performance of the AvN controlled MLE process

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