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SCENARIO-BASED SIMULATION OF TREATMENT PROCESSES FOR MINIMIZATION OF SLUDGE PRODUCTION FROM AL-SAAD WASTEWATER TREATMENT PLANT

by

Omar Gamil Abdelmajeed Hussien

Faculty Advisor

Mohamed Hamouda, Department of Civil and Environmental Engineering

College of Engineering

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Abstract

The biological activated sludge treatment process is the most widely used approach to treat domestic wastewater. It involves the transformation of soluble and particulate organic matter to gases and large amounts of settleable biomass (produced sludge). This sludge is considered one of the most pressing management challenges since its treatment represents approximately 50 to 60% of the total operational cost of a wastewater treatment plant (WWTP). The traditional management of excess sludge is by disposal to landfills, incineration, or agriculture reuse in the form of fertilizers but due to energy and environmental concerns, many jurisdictions developed strict policies and regulations for managing excess sludge. Therefore, this calls for the investigation of novel approaches to reduce the amount of generated sludge as the benefits would then be two-fold, environmental as well as economic. Sludge can be reduced through two main approaches which are post-treatment of produced sludge or in-situ activated sludge reduction. Post-treatment is an approach where treatment will take place after sludge is produced in the plant. Whereas in-situ activated sludge reduction will reduce the amount of produced sludge from the source itself. In this thesis, the in-situ activated sludge reduction without effluent quality deterioration is investigated for an existing full-scale WWTP which generates approximately 15 tons of sludge each day (Al Saad WWTP in Al Ain, UAE).

The complex combination of WWTP processes makes the investigation of their performance and interactions on bench and pilot scales technically challenging and costly. This is exacerbated when the scope of investigation attempts to experiment with different operating parameters and/or unit processes. Therefore, a simulation approach was adopted in this study using BioWin™ 6.0 software. The challenge with the simulation approach is that it requires model calibration. Calibration entails the adaptation of some model parameters until the model prediction matches specific observed data of the plant stream quality characteristics. There are four different model calibration protocols proposed in the literature, the water environmental research foundation (WERF) is the one applied in this study. Routine historical data about the Al-Saad WWTP was gathered but were not enough to develop the model; therefore, a sampling campaign was conducted for further parameters characterization, particularly for determining the fractions of chemical oxygen demand (COD) and total Kjeldahl nitrogen (TKN). After the model of Al-Saad WWTP was developed and calibrated, several scenarios were structured to represent the application of variations of the oxic-settling-anaerobic (OSA) process which appears in literature as a sludge reduction retrofit. The OSA process was modeled by inserting a sludge holding tank (SHT) on the recirculation activated sludge stream between the secondary settling tank and the aeration tank. The results revealed a reduction in the amount of produced sludge ranged from 4.04% to 5.76% when the hydraulic retention time (HRT) of the OSA tank ranged from 2 to 12 hours. Selecting the optimum HRT is governed by the available area, the initial cost of SHT and sludge treatment cost. This reduction was attributed to the stressful conditions that recycled biomass from secondary settling tank faces inside the OSA process resulting in an increase in the sludge anaerobic decay coefficient. This result is consistent with previous studies that investigated anaerobic side stream reactor (a process similar to OSA) on a full-scale WWTP. This study concluded that the OSA process is a simple adjustment in existing/new WWTPs that can potentially reduce the amount of excess sludge without deteriorating the effluent quality. The contribution of this study lies in detailing the model calibration process; and demonstrating the use of the calibrated model in examining the performance of plant retrofit alternatives. Further research is required to identify the mechanism behind the OSA process and to define the design principles for OSA.

Keywords: Wastewater Simulation, OSA, ASM, Activated Sludge, Al Saad Wastewater Treatment Plant, Model Calibration, Sludge Reduction, BioWin.