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A Hybrid of BioWin and Computational Fluid Dynamics Based Modeling of Biological Wastewater Treatment Plants for Model-Based Control

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Abstract : Modeling of Biological Wastewater Treatment Plants requires several parameters for kinetic rate expressions, thermo-physical properties, and hydrodynamic behavior. The kinetics and associated mechanisms become complex due to several biological processes taking place in wastewater treatment plants at varying times and spatial scales. A dynamic process model that incorporated the complex model for activated sludge kinetics was developed using the BioWin software platform for an Advanced Wastewater Treatment Plant in Valrico, Florida. Due to the extensive number of tunable parameters, an experimental design was employed for judicious selection of the most influential parameter sets and their bounds. The model was tuned using both the influent and effluent plant data to reconcile and rectify the forecasted results from the BioWin Model. Amount of mixed liquor suspended solids in the oxidation ditch, aeration rates and recycle rates were adjusted accordingly. The experimental analysis and plant SCADA data were used to predict influent wastewater rates and composition profiles as a function of time for extended periods. The lumped dynamic model development process was coupled with Computational Fluid Dynamics (CFD) modeling of the key units such as oxidation ditches in the plant. Several CFD models that incorporate the nitrification-denitrification kinetics, as well as, hydrodynamics was developed and being tested using ANSYS Fluent software platform. These realistic and verified models developed using BioWin and ANSYS were used to plan beforehand the operating policies and control strategies for the biological wastewater plant accordingly that further allows regulatory compliance at minimum operational cost. These models, with a little bit of tuning, can be used for other biological wastewater treatment plants as well. The BioWin model mimics the existing performance of the Valrico Plant which allowed the operators and engineers to predict effluent behavior and take control actions to meet the discharge limits of the plant. Also, with the help of this model, we were able to find out the key kinetic and stoichiometric parameters which are significantly more important for modeling of biological wastewater treatment plants. One of the other important findings from this model were the effects of mixed liquor suspended solids and recycle ratios on the effluent concentration of various parameters such as total nitrogen, ammonia, nitrate, nitrite, etc. The ANSYS model allowed the abstraction of information such as the formation of dead zones increases through the length of the oxidation ditches as compared to near the aerators. These profiles were also very useful in studying the behavior of mixing patterns, effect of aerator speed, and use of baffles which in turn helps in optimizing the plant performance.

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