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Original research

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Evaluation and optimization of activated sludge model No.1 (ASM1) parameters that are crucial for the efficient operation of wastewater treatment plants (WWTPs). By maximizing large-scale WWTP monitoring data from a subtropical climate in Entebbe, enables us to gain valuable insights into the performance of the treatment system and ability toidentify opportunities for improvement. The ASM1 model is a widely used mathematical model that describes the biokinetics of organic matter and nitrogen removal in activated sludge systems. It consists of several parameters that need to be calibrated based on site-specific conditions to accurately simulate the behavior of the WWTP. These parameters include the maximum specific growth rate of microorganisms, the decay rate of biomass, the half-saturation constants for substrate utilization, and the stoichiometry of the biodegradation reactions.By using monitoring data from a large-scale WWTP in Entebbe, researchers can evaluate the performance of the ASM1 model and identify potential discrepancies between the model predictions and the actual plant operation.

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Editorial System

Evaluation of ASM1 parameters using large-scale WWTP monitoring data from a subtropical climate in Entebbe

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Abstract

Evaluation and optimization of activated sludge model No.1 (ASM1) parameters that are crucial for the efficient operation of wastewater treatment plants (WWTPs). By maximizing large-scale WWTP monitoring data from a subtropical climate in Entebbe, enables us to gain valuable insights into the performance of the treatment system and ability toidentify opportunities for improvement. The ASM1 model is a widely used mathematical model that describes the biokinetics of organic matter and nitrogen removal in activated sludge systems. It consists of several parameters that need to be calibrated based on site-specific conditions to accurately simulate the behavior of the WWTP. These parameters include the maximum specific growth rate of microorganisms, the decay rate of biomass, the half-saturation constants for substrate utilization, and the stoichiometry of the biodegradation reactions.By using monitoring data from a large-scale WWTP in Entebbe, researchers can evaluate the performance of the ASM1 model and identify potential discrepancies between the model predictions and the actual plant operation.

This study aimed at providing a set of optimal kinetic and stoichiometric parameters of ASM1 representative of wastewater from a subtropical climate region of Entebbe. ASM1 was applied on the STOAT program, and the model parameters were evaluated and optimized with sensitivity analysis and Response Surface Methodology (RSM) to reach minimum prediction errors of effluent TSS, COD, and NH3. Six major parameters were used. YH, YA, μA, KNH, bA, and kOA. Predictions of RSM regression models were strongly correlated to the STOAT predictions. YH mainly affected TSS and COD, and the other parameters affected NH3. ASM1 calibration with estimated optimal values of sensitive parameters resulted in approximately null prediction errors for modeling state variables. NH3 presented almost the same results as ASM1 validationespecially around areas of katabi ; meanwhile, TSS and COD presented high errors related to the increase in YH due to the RSM optimization. The optimal parameters, mainly YA, μA, KNH, bA, and kOA, constitute references for other studies on ASM1 modeling using wastewater data from a subtropical climate .

YH optimal value is analysed as well as the effect of sludge wastage methods and the simulation periods.

Highlights

A large-scale WWTP was modeled using standard monitoring data, ASM1, Version 3, and STOAT.Sensitivity analysis and Response Surface Methodology increased calibration.Estimated optimal kinetic and stoichiometric parameters of ASM1 represented wastewater from a subtropical climate region in nakiwogo and katabi including areas of nkumba

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INTRODUCTION

The calibration is one of the most critical steps in the modeling procedure to provide reliable predictions accordingly with the specific conditions of AS process (Rieger et al. 2013). ASM1 modeling and calibration depend on wastewater composition fractionation and model parameters determination, respectively. Such fractionation and determination may need extra laboratory analysis, which is not commonly viable for some plants (Borzooei et al. 2019).

ASM1 modeling using wastewater data from a subtropical climate region. YH optimal value should be evaluated as well as the effect of sludge wastage methods and the simulation periods. Studies have performed an estimation of optimal ASM1 parameters associating the use of monitoring data of a large-scale WWTP within a subtropical climate region with sensitivity analysis and RSM.Therefore, this study aimed at providing a set of optimal kinetic and stoichiometric parameters of ASM1 representative of wastewater from a subtropical climate region in the areas of entebbe

The strategy comprises modeling in association with sensitivity & analysis for parameter selection, and design of experiments and Response Surface and Methodology (RSM) for parameter evaluation and optimization (Kim al. 2009; Lim et al. 2012; Ahn et al. 2014).Most studies on the evaluation and optimization of ASM1 parameters were developed in Europe, North America, and Asia (Hauduc et al. 2011).

Methods

The research was conducted on domestic wastewater generated from nkumba sites WWTP in nakiwogo, all in Entebbe, located in a subtropical climate region (29°59′29″S; 51°11′43.5″W). The average raw-water flow is 0.44 m3/s, corresponding to 150 thousand inhabitants. The wastewater system comprises extended aeration activated sludge with percentage of what we assume to be sewage and waste H2Oaround nakiwoogo and kasenyi

Data collection and reconciliation

Data was collected and confined from areas around nakiwoogo,kasenyi,nkumba katabi and waterfront beach.The following wastewater characteristics were determined: flow, temperature, total suspended solids (TSS), chemical oxygen demand (COD), ammonia (NH3), and pH. Influent and effluent means of these variables were considered after treating missing and censored data, as well as outliers of the WWTP monitoring data set, as described in von Sperling et al. (2020). Annual means of those variables of 2018 and 2019 were used for ASM1 calibration and validation, respectively

Means of wastewater composition for modeling periods InfluentEffluentVariable/Year2018 2019 2018 2019 TSS (mg/l) 119 170 30 21 COD (mg/l) 297 359 52 45 NH3 (mg/l) 45.5 39.5 4.4 3.7 pH 7.2 7.2 6.9 7 Temperature (°C) 22.6 23.8 22.9 24.1 ¼ Treated flow (m3/s) – – 0.077 0.076 respectively

Slug modeling in katabi and kasenyi sites,

The ASM1 and Version 3 models were used, respectively, for the aeration and secondary sedimentation tanks. Both models are available on the STOAT© simulation program and the guidelines of Rieger et al. (2013) and WRC PLC (1994) were considered for modeling conduction. Modeling was developed for one of the four parallels flows of the treatment plant

The modeling state variables were the mean effluent concentrations of TSS, COD, and NH3 . The following runs started from the end of the first simulation from nakiwoogo and waterfront

ASM1 parameters and respective default values are presented as obtained. Some kinetic parameters display different units on STOAT; that is, h−1 for 13 °C (P16°C). By using the temperature coefficients (θ) provided on STOAT for each of those parameters, Equation (s) (Tchobanoglous et al. 2014) was applied to convert the values onto the default unit; that is, d−1 for 20 °C (P20°C). STOAT uses such coefficients to model different wastewater temperatures.These were for applied areas around katabi and kasenyi

Analysis

A one-way sensitivity analysis was performed to indicate the critical parameters of ASM1.This analysis consisted of sequentially varying each parameter while keeping the others constant. A 11-12% increase was applied for each parameter to calculate its sensitivity coefficient (Equation (3)) related to each state variable; where Y is the state variable output, P is the ASM1 parameter value, and the subscripts 0 e1 stand for the default and the changed values, respectively.

Regression models were run and created to each modeling state variable, and ANOVA and standardized effects were used to evaluate the influence of changes in sensitive parameters on prediction errors of effluent TSS, COD, and NH3 [nkumba vs nakiwoogo]

Results and dissemination

The present study identified six sensitive parameters of ASM1 on modeling using domestic wastewater data.The relevant impact of μA*bA interaction ($F(1,79) = 153.17$; $p < 0.001$) indicates the many compounds that may be taken into consideration for such parameters to estimate minimum prediction errors for effluent NH3 . Hauduc et al. (2011) says the variability of values for those parameters. Such a relationship is usually inversely proportional,1/~ as reduction of μA and bA increases and decreases, respectively, ammonia effluent concentration.

Also, an increase in bA may inhibit cell growth and replace nutrients in the system, elevating NH3 concentration. However, the effect of bA is not the most important for effluent NH3 control (Levy 2007).

In the interactions of YA*μA (F(1,799) = 10.243; p = 0.001) and μA*KOA (F(1,90) = 10.05; p = 0.004

Another explanation for the discrepancy observed consists in the differences between effluent concentrations of TSS and COD between 2020 and 2024 used on ASM1 calibration and validation, respectively. The calibration data presented higher values of TSS and COD compared to 2020(7and 9mg/l higher, respectively), requiring an increase

Coclusions,

With sensitive analysis, six disciplines used ASM1, were identified as sensitive to effluent TSS, COD, and NH3 predictions: two stoichiometric (YH and YA) and four kinetics (μA, KNH, bA, and kOA). Sensitive parameters were reviewed,taken into consideration and optimized via RSM targeting minimum prediction errors for modeling state variables in the areas mentioned. YH mainly affected TSS and COD predictions; meanwhile, NH3 predictions were influenced by changes in the other parameters that were sensitive especially in nakiwogo and katabi

Estimated optimal parameters were used on ASM1 calibration resulting in approximately null prediction errors for effluent TSS, COD, and NH3 in waterfront beach. In the ASM1 validation, the same was obtained for NH3, even though high prediction errors were observed for TSS and COD. Such errors are related to an increase in YH through parameter optimization that signifies or highlights the sensitivity of this parameter on ASM1 modeling.

How to go away with the errors..T.S.S/Ut..where TSS/ERRORS could help reduce partially COD /ut can also help to reduce the errors i.e

(T.ss/ut +COD/Ut) resultantly call it

T.ss/ut =A & COD/ut =B

Resultantly; A+B can help reduce or minimize errors by equating both equations

ASM1=0 & A+B=0 and substituting.

Conflict of interest,

The authors declare no conflict of interest upon the submission of this paper

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