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Modelling of a Novel Side-Stream Technology Combining Short-Cut Nitrogen Removal and Bioplastic Recovery

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Abstract: This work focusses on extending the ASM3 model towards the description of short-cut nitrogen removal and simultaneous polyhydroxyalkanoate (PHA) recovery and the subsequent model application to describe this process currently operated at the pilot-scale in Carbonera, Italy. Results indicated that the calibrated and validated model could describe well the nitritation process, coupled with the aerobic feast/anoxic famine process for the selection of PHA producing organisms. The model will also be applied to test alternative operational strategies designed to maximise PHA recovery.

Keywords: Extended ASM3 model; Nitrite pathway; Short-Cut nitrogen removal and PHA Recovery technology

INTRODUCTION A novel side-stream technology combining short-cut nitrogen removal coupled with the selection and accumulation of PHA producing biomass is being operated at pilot-scale in the wastewater treatment plant (WWTP) of Carbonera, Italy. It consists of an aerobic nitritation sequential batch reactor (SBR) coupled with an aerobic feast/anoxic famine SBR for PHA-biomass selection and denitritation. This PHA-producing biomass will then be used in a subsequent accumulation stage for achieving PHA recovery as bioplastics. Readers are referred to Basset et al., 2016 for more details about the technology.

Mathematical models are useful tools for the optimisation and design of novel wastewater treatment technologies and their integration for resource recovery. The most used models in practice are the activated sludge models (ASM). This work aims to calibrate and validate an extended version of the ASM3 model by applying the model to the operation of this novel technology. It also intends to use the model to predict and optimise the recovery of PHA.

MODEL DESCRIPTION An extended version of the ASM3 model (Kaelin et al., 2009) was implemented in AQUASIM (Riechert, 1994). This model describes the simultaneous removal of COD and N, as well as the production of PHAs. The following modifications were incorporated in the model: two-step nitrification/denitrification was implemented, where the state variable S_{NOx} is separated into S_{NO2} and S_{NO3} and the state variable X_{AUT} is separated into X_{AOB} and X_{NOB}.

MODEL CALIBRATION AND VALIDATION The influents of the nitritation SBR and PHA-biomass selection SBR were characterized through a week-long sampling campaign. The calibration of the extended ASM3 model was performed by adjusting the kinetic parameters of heterotrophic and autotrophic organisms through simulating the experimental results obtained from each process. The model for the nitritation SBR was validated through simulating the recorded measurements from the effluent. The validation of the model in the PHA-biomass selection SBR and PHA accumulation stage is ongoing.

TAKE-HOME MESSAGES The model was successfully calibrated by adjusting only 3 parameters in the nitritation SBR and 8 parameters in the PHA-biomass selection SBR (see Table 1.1 and Figure 1.1). Figure 1.2 shows that the calibrated model was able to describe the long-term operation of the nitritation SBR without any further adjustment of model parameters. This study shows that the extended ASM3 model is a useful tool for the design, optimisation and prediction of PHA production under feast/famine conditions, as well as oxidation of NH_4 in NO_2.

Table 1.1 Calibrated parameters for PHA-biomass selection SBR and the nitritation SBR.

Parameters	Description	Default values from ASM3+BioP	Calibrated for PHA-biomass selection SBR	Calibrated for nitritation SBR
b_{AOB}	Decay rate for AOBs	0.15	-	0.25
μ_{AOB}	Growth rate for AOBs	0.80	-	0.50
Y_{AOB}	Yield coeff. for growth	0.18	-	0.24
b_{H_O2}	Decay rate for OHOS	0.30	0.01	-
b_{STO_O2}	Endog. rate for OHOs	0.30	0.08	-
η_{H_NO2}	Red. factor for denitrif.	0.15	0.25	-
k_{STO}	Max. storage rate	12.00	0.26	-
μ_H	Growth rate for OHOs	3.00	0.10	-
Y_{H_O2}	Yield coeff. for growth	0.80	0.90	-
Y_{H_NO2}	Yield coeff. for growth	0.60	0.25	-
Y_{STO_O2}	Yield coeff. for storage	0.80	0.90	-

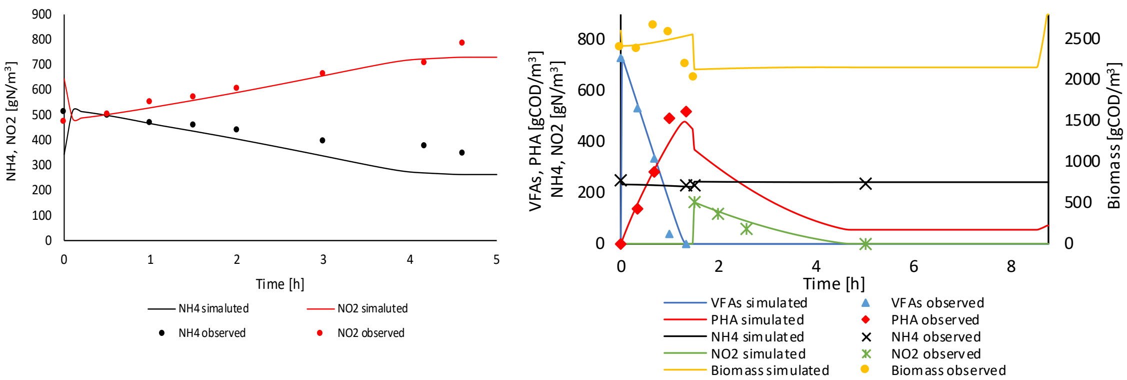

Figure 1.1 Calibration of the nitritation SBR (left) and the PHA-biomass selection SBR (right).

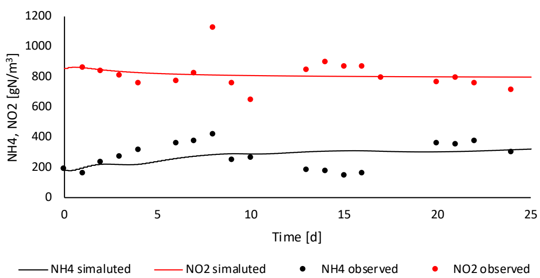

Figure 1.2 Validation of the nitritation SBR.

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REFERENCES

Basset, N, Katsou, E., Frison, N., Malamis, S., Dosta, J. & Fatone, F. 2016 Integrating the selection of PHA storing biomass and nitrogen removal via nitrite in the main wastewater treatment line. *Bioresource Technology* **200**, 820-829.

Kaelin, D., Manser, R., Reiger, L., Eugster, J., Rottermann, K. & Siegrist, H. 2009 Extension of ASM3 for two-step nitrification and denitrification and its calibration and validation with batch tests and pilot scale data. *Water Research* **43**, 1680 – 1692.

Reichart, P. 1994 AQUASIM – A tool for simulation and data analysis of aquatic systems. *Water Science and Technology* **30**, 21–30