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Development of a decision tree for the integrated operation of nutrient removal MBRs based on simulation studies and expert knowledge

Montserrat Dalmau [a], Ignasi Rodriguez-Roda [a,b], Eduardo Ayesa [c], Juan Odriozola [c], Luís Sancho [c], Joaquim Comas [a,*]

[a] LEQUIA, Laboratory of Chemical and Environmental Engineering, University of Girona, Campus de Montilivi, E-17071 Girona, Catalonia, Spain
[b] ICRA (Catalan Institute for Water Research), Scientific and Technological Park of the University of Girona, H2O Building c/Emili Grahit 101, E17003 Girona, Catalonia, Spain
[c] Section of Environmental Engineering, CEIT and Tecnun (University of Navarra), Paseo de Manuel Lardizábal 15, E-20018 Donostia-San Sebastian, Spain

HIGHLIGHTS

- Modelling and simulation of biological and physical processes of a UCT-MBR.
- The most influential operational parameters are found out through sensitive analyses.
- A scenario analysis enables to optimize the set points of the operational parameters.
- An decision tree for the integrated control of MBR is developed.

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ABSTRACT

The combination of simulation studies and expert knowledge allows the development of a decision tree for the integrated operation of nutrient removal as well as filtration processes in membrane bioreactors (MBRs). In order to do it, a model-based methodology, including model development and use of system analysis tools, was followed to identify the best operational strategies for good filtration performance and efficient biological nutrient removal at lower costs in a University Cape Town (UCT)-MBR pilot plant. Activated sludge no. 2 and a series resistance model were used to simulate the biological and filtration processes, respectively. A sensitivity analysis was carried out for the identification of the most sensitive operational parameters, and then, their best setpoint ranges/values were identified through a scenario analysis. Simulation results were supplemented with expert process knowledge to overcome the current limitations of biological and filtration models. The results were organized in the form of a decision tree. The most sensitive parameters, and thus the first branch to explore, were operational parameters related to the filtration processes (i.e. flux and relaxation time). Based on expert knowledge, membrane–air scour was the following control action to check. Then, the decision tree evaluates the biological nutrient removal processes and modifies the necessary operational parameters, ranked according to their sensitivity. The most sensitive were aerobic and membrane aeration, aerobic and anoxic recirculations and carbon dosage. The last branch takes into account the operational cost, directly related to aeration and carbon addition.

1. Introduction

Membrane bioreactors (MBRs) have become increasingly popular in wastewater treatment due to unique advantages like high quality effluent and a small footprint [1]. The major limitations of MBR are fouling and high energy consumption, which add to the costs of this technology.

The mathematical modelling and simulations of wastewater treatment plants (WWTPs) have become very useful since their introduction in the mid-1990s as a support tool to select the appropriate design and operational parameters [2]. This is due, on one hand, to the publication of the well-known mathematical models for the different unit-processes, the Activated Sludge Model (ASM) family [3]. On the other hand, the development of new computational platforms, with efficient methods for the numerical analysis of models [4,5] and the progressive elaboration of systematic procedures for the experimental calibration of the most

* Corresponding author. Tel.: +34 972 41 83 55.
E-mail addresses: montse.dalmau@lequia.udg.cat (M. Dalmau), irodriguezroda@icra.cat, ignasi@lequia.udg.cat (I. Rodriguez-Roda), eayesa@ceit.es (E. Ayesa), jodriozola@ceit.es (J. Odriozola), lsancho@ceit.es (L. Sancho), quim@lequia.udg.cat (J. Comas).

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