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Modeling of the Biodegradation Performance of a Membrane Bioreactor to Enhance Water Reuse in Agri-food Industry - Poultry Slaughterhouse as an Example

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Abstract : Mathematical modeling has become an essential tool for sustainable wastewater management, particularly for the simulation and the optimization of complex processes involved in activated sludge systems. In this context, the activated sludge model (ASM3h) was used for the simulation of a Biological Membrane Reactor (MBR) as it includes the integration of biological wastewater treatment and physical separation by membrane filtration. In this study, the MBR with a useful volume of 12.5 L was fed continuously with poultry slaughterhouse wastewater (PSWW) for 50 days at a feed rate of 2 L/h and for a hydraulic retention time (HRT) of 6.25h. Throughout its operation, High removal efficiency was observed for the removal of organic pollutants in terms of COD with 84% of efficiency. Moreover, the MBR has generated a treated effluent which fits with the limits of discharge into the public sewer according to the Tunisian standards which were set in March 2018. In fact, for the nitrogenous compounds, average concentrations of nitrate and nitrite in the permeat reached 0.26±0.3 mg. L-1 and 2.2±2.53 mg. L-1, respectively. The simulation of the MBR process was performed using SIMBA software v 5.0. The state variables employed in the steady state calibration of the ASM3h were determined using physical and respirometric methods. The model calibration was performed using experimental data obtained during the first 20 days of the MBR operation. Afterwards, kinetic parameters of the model were adjusted and the simulated values of COD, N-NH4+and N- NOx were compared with those reported from the experiment. A good prediction was observed for the COD, N-NH4+and N- NOx concentrations with 467 g COD/m³, 110.2 g N/m³, 3.2 g N/m³ compared to the experimental data which were 436.4 g COD/m³, 114.7 g N/m³ and 3 g N/m³, respectively. For the validation of the model under dynamic simulation, the results of the experiments obtained during the second treatment phase of 30 days were used. It was demonstrated that the model simulated the conditions accurately by yielding a similar pattern on the variation of the COD concentration. On the other hand, an underestimation of the N-NH4+ concentration was observed during the simulation compared to the experimental results and the measured N-NO3 concentrations were lower than the predicted ones, this difference could be explained by the fact that the ASM models were mainly designed for the simulation of biological processes in the activated sludge systems. In addition, more treatment time could be required by the autotrophic bacteria to achieve a complete and stable nitrification. Overall, this study demonstrated the effectiveness of mathematical modeling in the prediction of the performance of the MBR systems with respect to organic pollution, the model can be further improved for the simulation of nutrients removal for a longer treatment period.

Keywords : activated sludge model (ASM3h), membrane bioreactor (MBR), poultry slaughter wastewater (PSWW), reuse
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