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Quorum quenching (QQ) in membrane bioreactors (MBRS): mass transfer characterization for a more efficient biofouling control

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Quorum Quenching (QQ) was recently presented as a new biological paradigm for biofouling mitigation in MBRs1. QQ consists in inhibiting the bacterial communication, Quorum Sensing (QS) that was proved to be involved in biofilm formation on the membrane surface, via the sending of signal molecules, among which Acyl-Homoserine Lactones (AHLs) are prevalent in MBRs. Several QQ implementation techniques were developed and consisted in introducing QQ enzyme or QQ enzyme-producing bacteria that degrade AHLs, preventing biomass from communicating for biofilm formation[2–7]. Thus, QQ is an enzymatic reaction targeting the communication molecules (AHLs), and as every (bio)chemical reaction, the transport phenomena involving the main reagents can be of critical importance for the reaction efficiency. Yet, the transport of the main molecules of the QQ reaction is insufficiently investigated to date. Therefore, the main objective of this study is to provide potential ways of improvement for more efficient QQ application in MBRs, via an in-depth understanding of the mass transfer phenomena, distinguishing three main aspects at different scales. As a first step, the diffusion of AHLs in water at a microscale was experimentally characterized in order to determine a diffusion coefficient. Then, the transport of AHLs from the liquid to the immobilization media, where the QQ reaction takes place, was studied in order to analyze the limiting step for their degradation. Finally, via a bioassay based on a bioluminescence-emitting strain (A.tumefaciens A136) in presence of AHLs, the macroscopic distribution of AHLs in a lab-scale MBR was investigated by quantifying their amount in different regions of the reactor, under different filtration conditions, for identifying potential key-zones to target in priority for a more efficient QQ-based biofouling control. At the end, these results were combined with results on hydrodynamics characterization in order to select operating parameters for QQ optimization in a given membrane reactor.

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