Modeling of the baffled membrane bioreactor

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Abstract

The main research activities developed during the past six months in the COE project is concisely described is this report. These activities involve an exhaustive research of the baffled membrane bioreactor (B-MBR) using modeling approaches. The obtained results are going to be submitted to a conference and/or journal as soon as they are experimentally validated.

Activity descriptions

An in-depth research of the B-MBR (Figure 1) has been performed and a model designed for chemical oxygen demand (COD) and nitrogen removal has been developed based on the activated sludge model no. 3 (ASM3) [1,2]. The degradation rates from the ASM3 were incorporated into the mass balance equation for each component assuming the bioreactor as a cascade of five continuous stirred tank reactor - CSTRs (see Figure 2). The mixing characteristics and fluxes were established based on the bioreactor physical structure and wastewater level variations. The model takes into account 13 state variables for each bioreactor and 12 biological processes. Experiments of respirometry have been carried out in order to quantify these variables at Soseigawa treatment plant. Some results have been obtained but they must be validated with experimental data. All coding has been carried out in MATLAB.

Efforts to understand, control and optimize the B-MBR process are going to be performed using also bench-scale experiments linked through numerical modeling. Therefore, an experimental design [3] for this bioreactor has been proposed. Fourteen controlled parameters were analyzed and, according their importance, eight were maintained in a design of resolution IV. The synthetic wastewater composition has been defined based on the literature [4-6] and the reported data of Soseigawa treatment plant. In resume, acetic acid is used as carbon source, ammonium chloride sulfate and peptone are used as nitrogen sources and yeast extract is the nutrient. F/M ratios of 1.3 to 8 are considered.

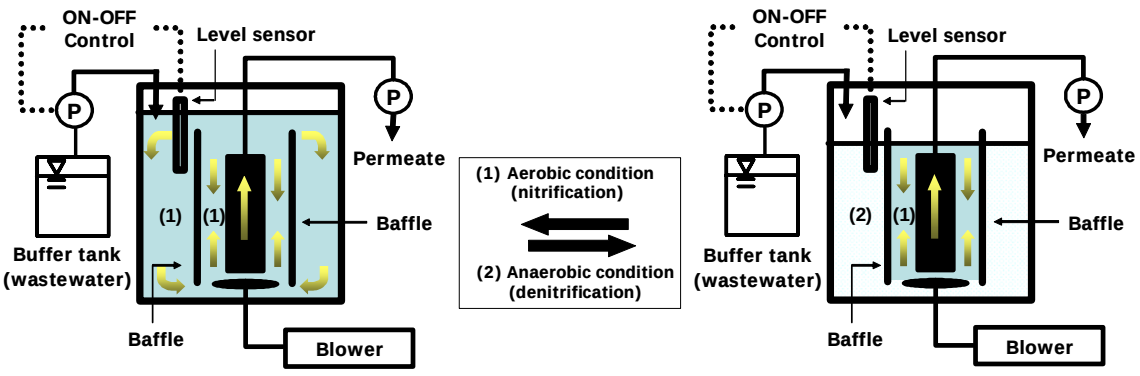

Figure 1: Schematic representation of the B-MBR.

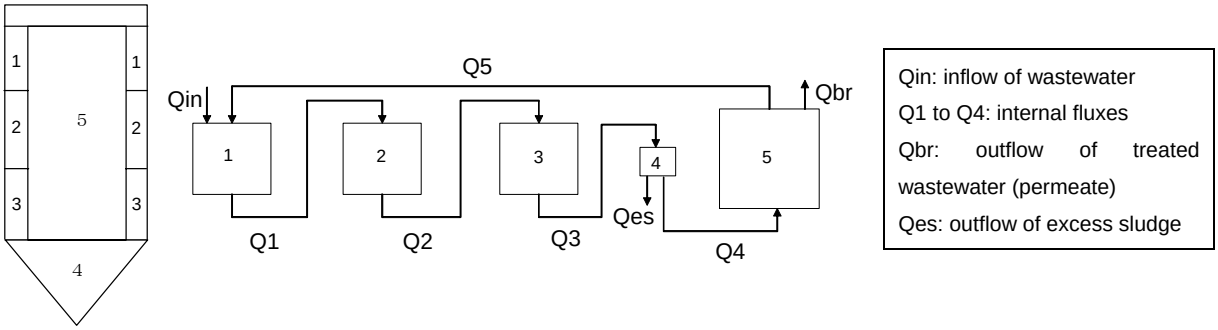

Figure 1: Approximation of the B-MBR in a cascade of CSTRs.

Besides the aforementioned activities, there are: (a) project of the bench-scale bioreactor; (b) statistical analysis of the B-MBR historical data and, (c) preparation of a manual of operation of the B-MBR pilot plant.

Final considerations

This study demonstrates that the outlined modeling concept based on the ASM3 can be applied to describe the biological status of the B-MBR. In order to characterize the decrease of membrane permeability, a model describing the B-MBR filtration performance will be developed as well. On a long term, a close connection between process control and simulation is envisaged to derive methods to optimize the B-MBR design and operation.

It is expected that the bench-scale experiments overcome many of the limitations of field-scale experiments by allowing replicate experiments, evaluation of wide ranges of parameters at comparatively low cost, and a better representation of the biological processes and operational conditions using modeling approaches.

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