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Elodie Suard, Yannick Fayolle, Claire Albasi, Sabrina Guérin, Vincent Rocher, et al.. Statistical modelling of a semi-industrial membrane bioreactor using fuzzy inference methods. Mempro 7, Jun 2022, Montpellier, France. hal-04806973

HAL Id: hal-04806973

<https://hal.science/hal-04806973v1>

Submitted on 27 Nov 2024

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Limitation du colmatage dans les bioréacteurs à membranes à l'échelle industrielle : Modélisation et caractérisation de l'hydrodynamique

Statistical modelling of a semi-industrial membrane bioreactor using fuzzy inference methods

Elodie Suard^{1,3}, Y. Fayolle¹, C. Albasi^{3*}, S. Guérin², V. Rocher², S. Gillot⁴, M. Alliet³



Context and Objectives

Context: Membrane bioreactors

- Coupling biological treatment & physical separation
- + Good and constant quality of the effluent
- Membrane fouling and linked operating costs
- Interest of modelling to predict and optimise the operation of such treatment unit at large scales

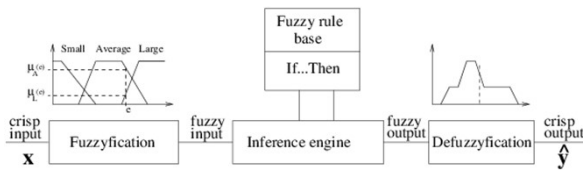


Objectives

- ❑ Develop a fuzzy logic procedure adapted for the simulation of a semi-industrial filtration pilot coupled with a full scale MBR
- ❑ Simulate the evolution of the permeability for a 4.5 months campaign on a semi-industrial filtration pilot
- ❑ Analyse coupled impact of filtration operating parameters and functioning conditions on fouling

Material and methods

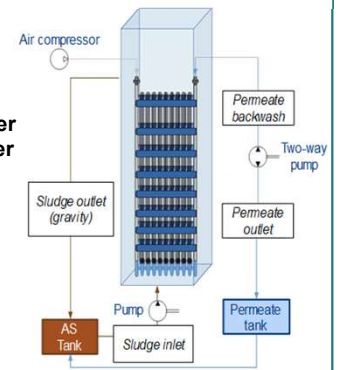
Fuzzy Inference System (FIS) design and optimisation



- **Principle:** Machine Learning (ML) simulation of physical and biological systems using simple rules (If ... Then) with input variables distributed in fuzzy sets
- In the Fispro software:
 - Partition of variables in fuzzy sets using the Hierarchical Fuzzy Partitioning (HFP) and the K-means clustering algorithm

Experimental database

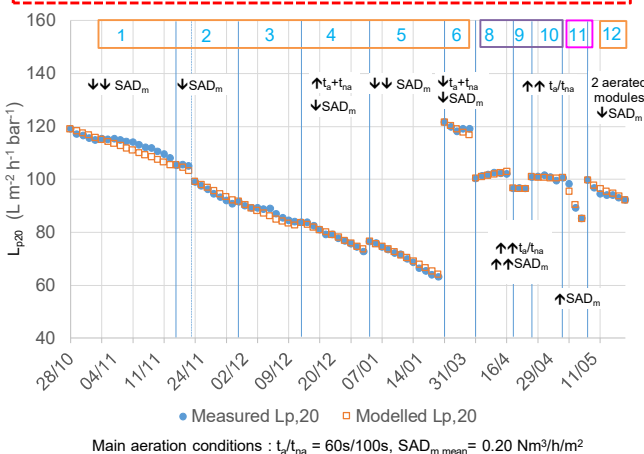
- Semi-industrial filtration pilot (2 m³, 3 modules KMS Puron®)
- **Continuous feed with mixed liquor (TDJ unit: MBR treating rejection water from digested sludge dewatering after thermic treatment (10,000 m³/d))**
- **11 operating conditions**
 - Variation of operating parameters: air flowrate, number of aerated modules and sequencing of aeration
 - Two main filtration modes
 - Filtration/backwash : 480s/90s
 - Filtration/relaxation : 98s/121s, 121s/98s
- Supervising permeability (Lp) and properties of mixed liquor and of permeate



Results

Development of a predictive model

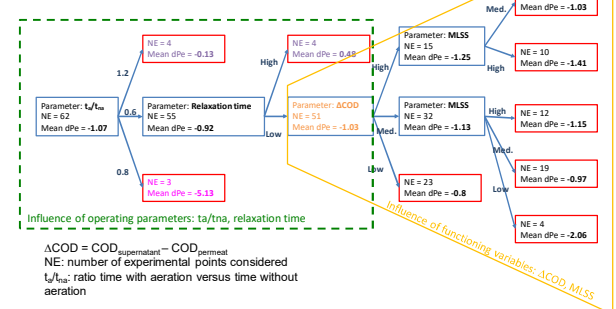
- ❑ Inferring the permeability drop $dPe = Lp_{j+1} - Lp_j$
- ❑ Lp initialised at the beginning of each new operating condition



- ❑ Interest of FIS for the prediction of the evolution of fouling

Fuzzy decision tree

- ❑ Limitation to 9 rules = 9 leaves



- ❑ Major influence of the operating parameters t_a/t_{na} and Relaxation time
 - ⇒ Since operating parameters varied around a main condition, this part of the tree includes a main trunk
- ❑ Influence of operating variables ΔCOD and MLSS
 - ⇒ Branched tree
 - ⇒ Very non-linear influence of MLSS

Conclusions and Perspectives

- ❑ Efficient modelling of all experimental trends: for the different operating conditions, with a limited number of rules
- ❑ Development of an interpretable model:
 - ❑ Ranking of the impact of operating parameters and functioning variables on fouling evolution (filtration mode > mixed liquor properties > aeration parameters)
 - ❑ Non-linear evolution of fouling with MLSS → Understanding the influence of MLSS concentration on fouling
- Further research: Modelling the full scale plant with the same approach