

Statistical Modelling of Fouling of Membrane Bioreactors for wastewater treatment Using Fuzzy Inference Methods

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Membrane Bioreactors (MBR) and fouling control

- Membrane Bioreactors = Biological treatment followed by membrane separation
- High quality of treatment but **filtration capacity is limited by membrane fouling**
- Models are needed to **optimize the operation** of such unit at industrial cases to limit energy consumption and to maintain production capacity
- Statistical approaches could represent an efficient alternative to complex mechanistic modelling

➔ **Development of interpretable models of daily permeability evolution (characteristic of membrane fouling) using fuzzy inference methods**



Fig 1. Extracted membrane module from full-scale MBR

Studied WRRF and data collection

- Seine Aval WRRF (1,700,000 m³/d) / MBRs treating rejection water from digested sludge dewatering
- 4 biological tanks and 6 separated membrane tanks
- Dataset of **1,5 years of monitoring** (daily data)
- Data validation using hydraulic balances and statistical analysis

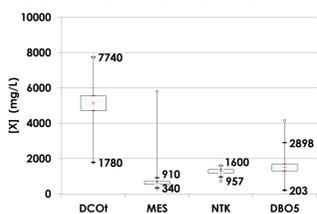


Fig 2. Example of box plots for outlier detection



Fig 3. Filtration zone of studied full-scale MBR

Fuzzy inference method

- Principle : To simulate physical or biological systems using simple rules (If ... Then ...)
- Using statistical analysis to find out most relevant input parameters
- Building fuzzy inference system** using the Fispro program[®]
 - ⇒ Fuzzy partition of inputs/output and rules definition

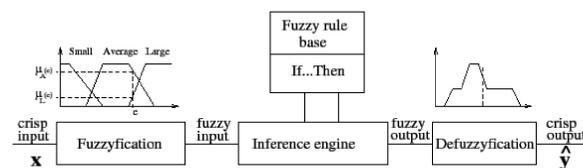


Fig 4. Example of a Fuzzy Inference System



Model development and validation

- Partitions and rules were manually adjusted
- Obtained simplified **fuzzy decision tree** is composed of 6 rules for this dataset
- Most relevant parameters** : $V_{cumulated} > V_{daily} > \Delta COD$

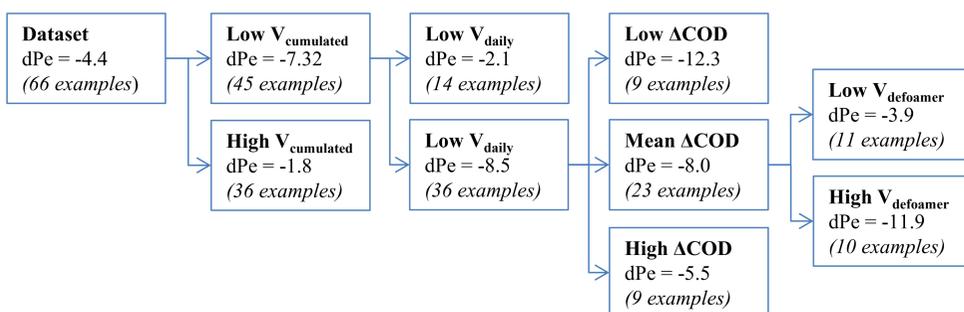


Fig 5. Fuzzy decision tree [dPe = daily permeability evolution (L/m²/h/bar) / $V_{cumulated}$ = cumulated filtrated volume since last chemical cleaning / V_{daily} = daily filtrated volume / ΔCOD = difference between the supernatant COD in membrane tank and the permeate COD / $V_{defoamer}$ = the daily added defoamer volume]

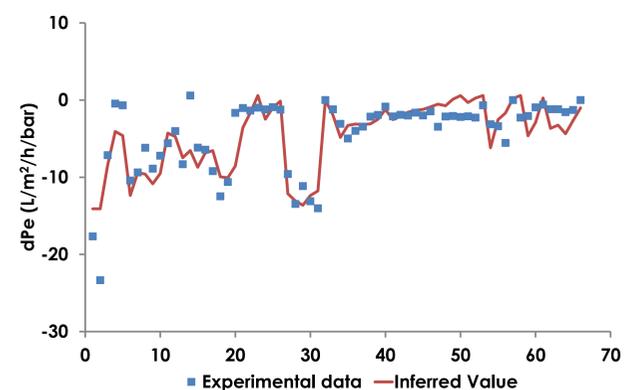


Fig 6. Comparison between experimental and inferred values of the daily permeability evolution (non continuous data)

- Good reproduction of experimental data** using developed model (correlation coefficient = 0.7)
- Developed model is specific to the studied treatment unit

Conclusions and future outlook

- Fuzzy Inference Methods are **efficient for complex system modeling** as membrane fouling
- Such models are essential to optimize the operation of MBRs (modification of operating parameters, chemical cleanings)
- Another period (1 year) and specific event periods (chemical cleaning, uncommon relaxation periods) will be integrated in the dataset to **increase the performance of the model**

