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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 m^3/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

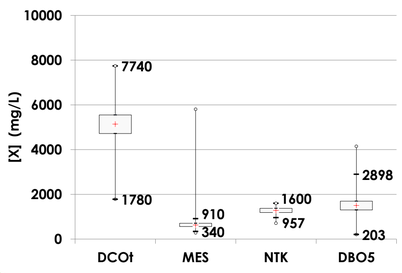

Fig 2. Example of box plots for outlier detection

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[a]
  - ⇨ Fuzzy partition of inputs/output and rules definition

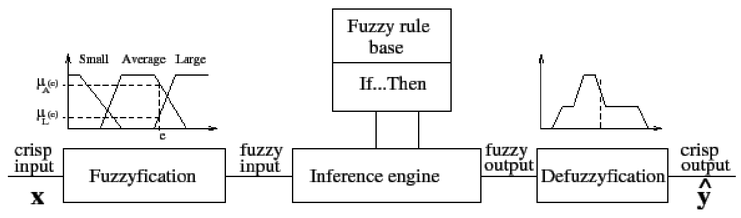

Fig 4. Example of a Fuzzy Inference System

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} > ΔCOD

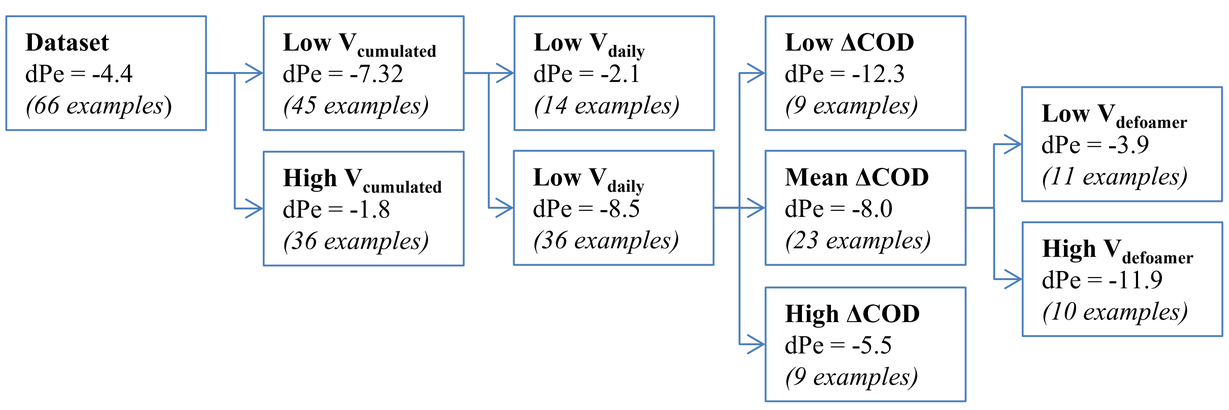

Fig 5. Fuzzy decision tree [dPe = daily permeability evolution ($L/m^2/h/bar$)/ $V_{cumulated}$ = cumulated filtrated volume since last chemical cleaning / V_{daily} = daily filtrated volume / ΔCOD = difference between the supernatant COD in membrane tank and the permeate COD / $V_{defoamer}$ = the daily added defoamer volume]

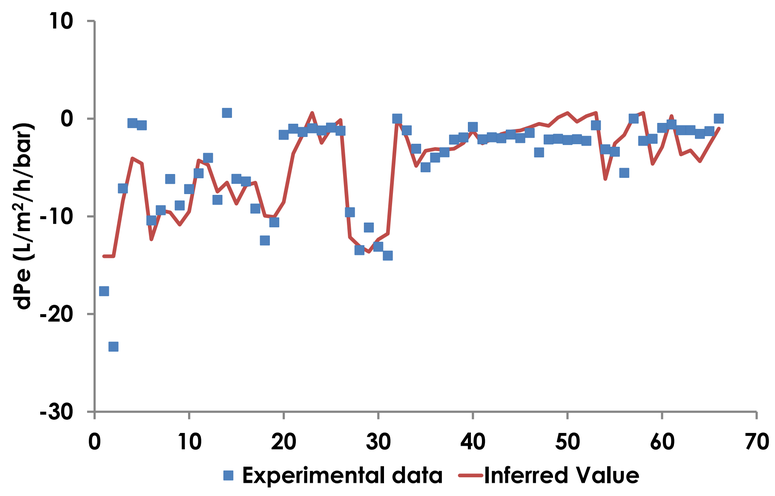

Fig 6. Comparison between experimental and inferred value s of the daily permeability evolution (non continuous data)

- ❑ **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***

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[a] Fuzzy Inference System Professional (https://www7.inra.fr/mia/M/fispro/fispro2013_en.html)