UNIVERSITEIT GENT

BIOMATH

Department of Applied Mathematics, Biometrics and Process Control

Modeling the performance (effluent quality and membrane fouling) of a membrane bioreactor

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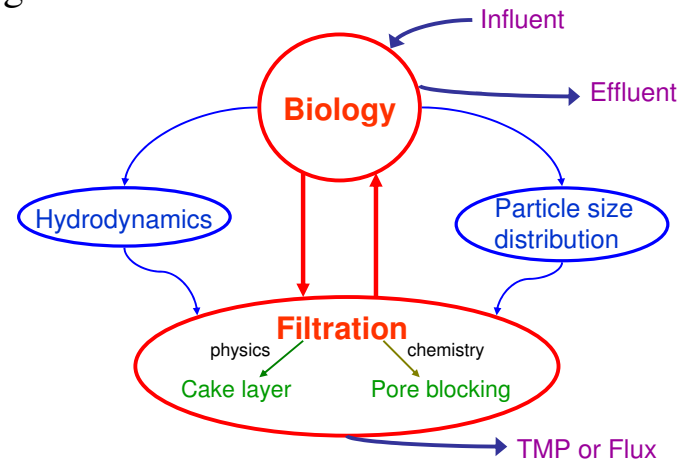
Overview

1. BIOMATH goal
2. Labscale reactor
3. Particle sizing
4. SMP – Fouling
5. Conclusions

1. BIOMATH goal

Integral Mechanistic Model



1. BIOMATH goal

Build a model

Calibration and validation

Experimental data

Labscale MBR

measurements { online, offline }

Overview

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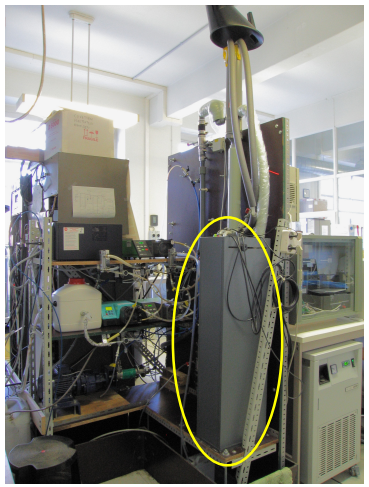
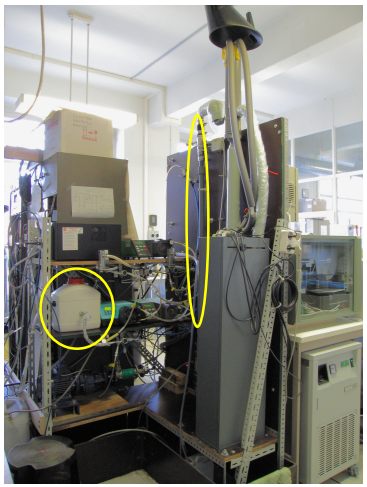
2. Labscale MBR



Bioreactor

- **Anaerobic**
- **Aerobic**
- **Anoxic**

2. Labscale MBR



Bioreactor

Membrane

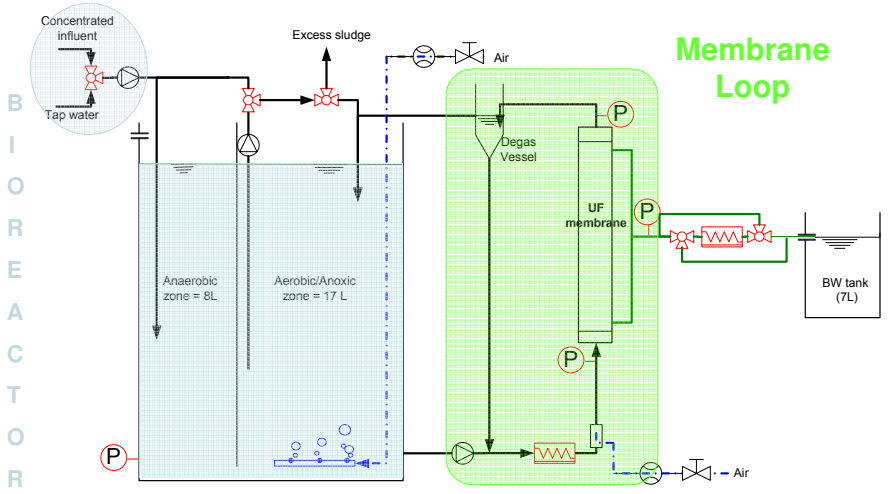
-side stream

-tubular: X-flow (Norit)

-pore size: 30 nm

Effluent/Backwashing Tank

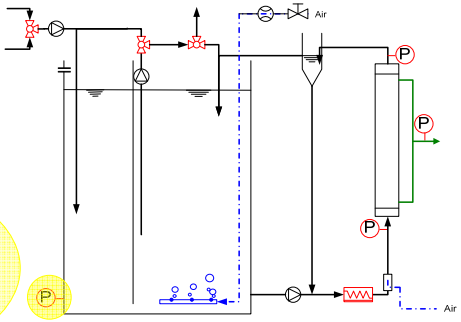
2. Labscale MBR



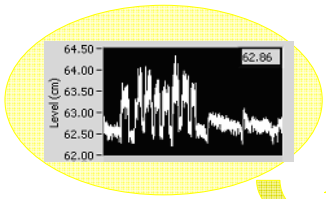
2. Labscale MBR

Online measurements:

Pressure sensors



LEVEL

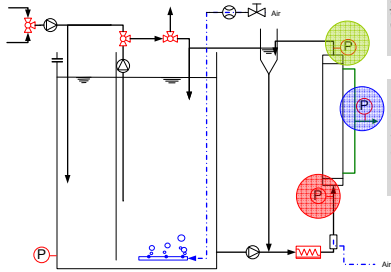


Used for level control

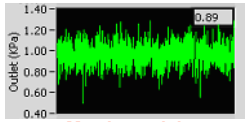
2. Labscale MBR

Online measurements:

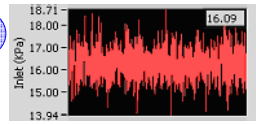
Pressure sensors



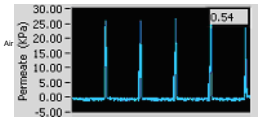
Membraan outlet



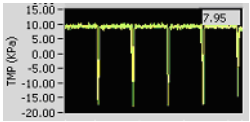
Membraan inlet



Permeate side



Transmembrane pressure



Monitor degree of fouling

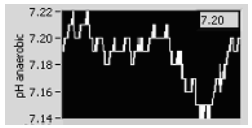
2. Labscale MBR

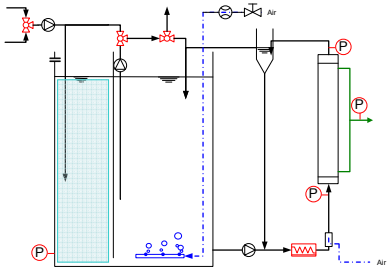
Online measurements:

Sensors: process parameters

Anaerobic

pH



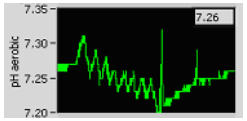


2. Labscale MBR

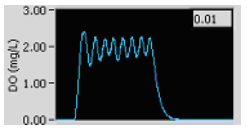
Online measurements:

Sensors: process parameters

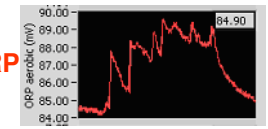
pH

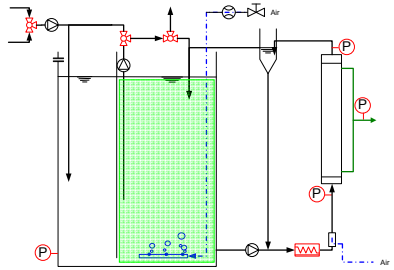


DO



ORP





Aerobic/Anoxic

2. Labscale MBR

Offline measurements:

Effluent

-COD; BOD
-TN; NO3-N; NO2-N; NH4-N
-TP; PO4-P
-SMP = proteins + polysaccharide + COD

Activated sludge (bioreactor + membrane loop)

-MLSS; MLVSS
-SMP = proteins + polysaccharide + COD
-EPS = proteins + polysaccharide + COD
-microscopy
-viscosity

Overview

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3. Particle sizing: technics

Light scattering devices:

scattering pattern

↓

size distribution

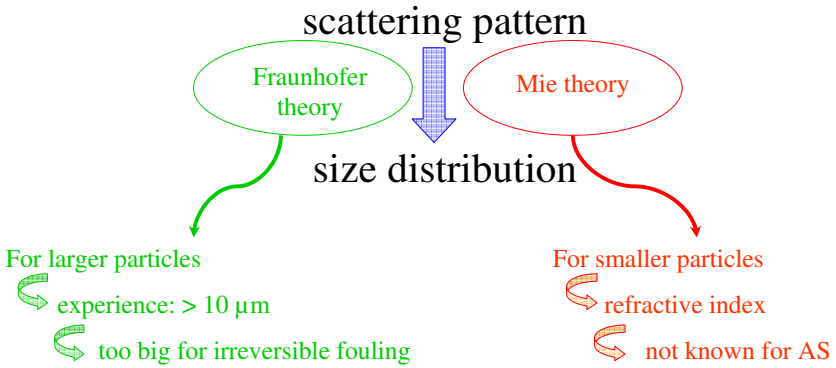
\+ Broad range

⇒ 0.04 µm to 2,000 µm

Examples: Mastersizer, Beckman Coulter, ...

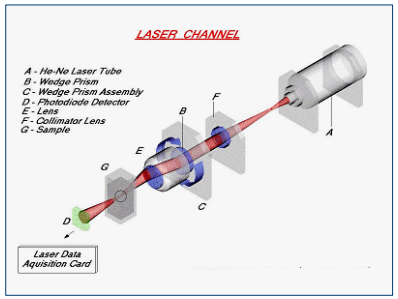
3. Particle sizing: technics

Disadvantages:



3. Particle sizing: technics

CIS-100
(ANKERSMID)



TOT

Image analysis

Not based on scattering pattern

3. Particle sizing: technics

TOT

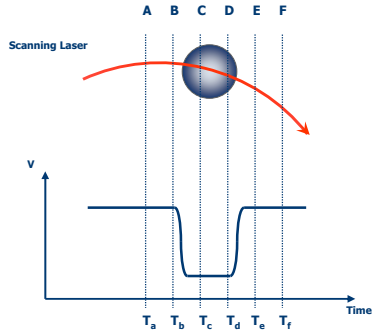
+ no refractive index

- small range: > 1µm

- dilution needed

  permeate

- air bubbles



3. Particle sizing: technics

Image analysis

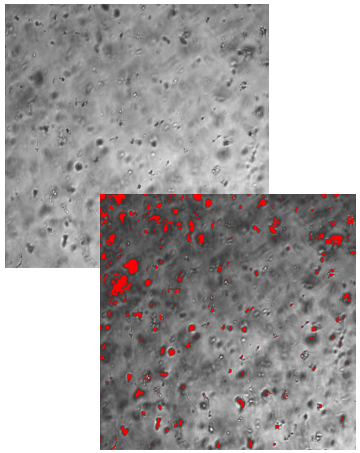
+ no refractive index

- small range: > 10µm

- dilution needed

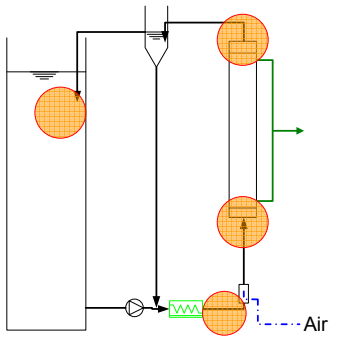
  permeate

+ air bubbles eliminated



3. Particle sizing: data

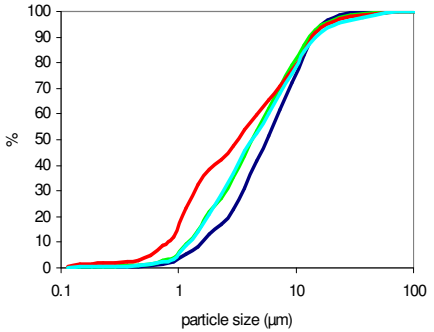
PSD measured at different places:



1. Bioreactor (+ air)
2. Inlet of the membrane (+ air)
3. Outlet of the membrane (+ air)
4. After recirculation pump

3. Particle sizing: data

TOT



PSD in bioreactor is shifted

↓

breakage flocs in the membrane loop

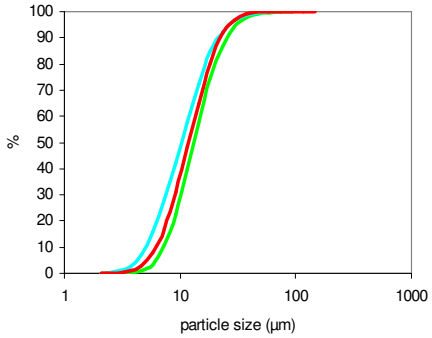
PSD inlet >PSD outlet

↓

breakage flocs in membrane

3. Particle sizing: data

Image analysis



PSD inlet >PSD outlet

↓

breakage flocs in membrane

PSD difference is smaller

↓

Smaller particles are not measured as well as with TOT

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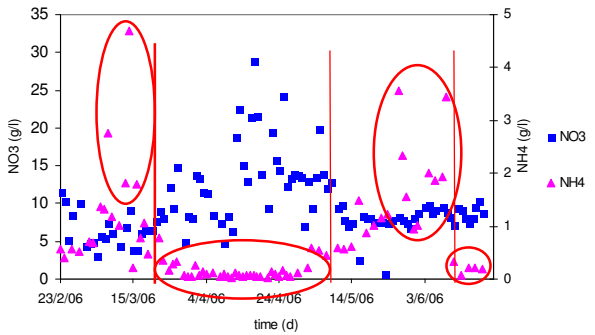
4. SMP – Fouling

2 PROBLEMS:

1) Bad nitrification: too much NH4+

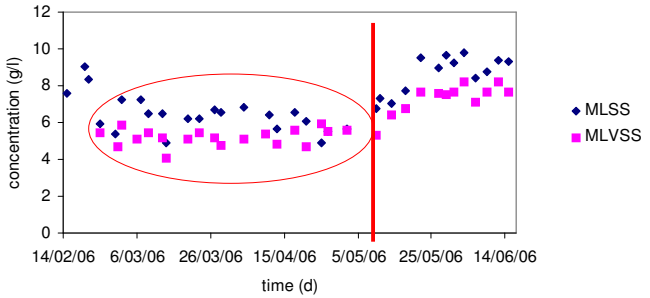
↻ Oxygen increase (1 → 2 mg/L)



4. SMP – Fouling

2) Settling particulate influent in tubes

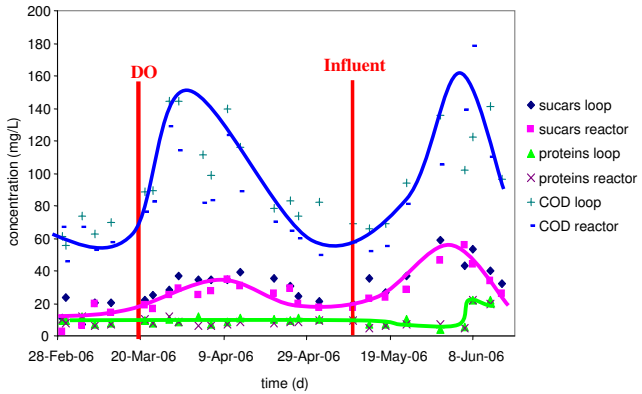
↪ increased speed (recirculation)



4. SMP – Fouling

Fixing the 2 problems

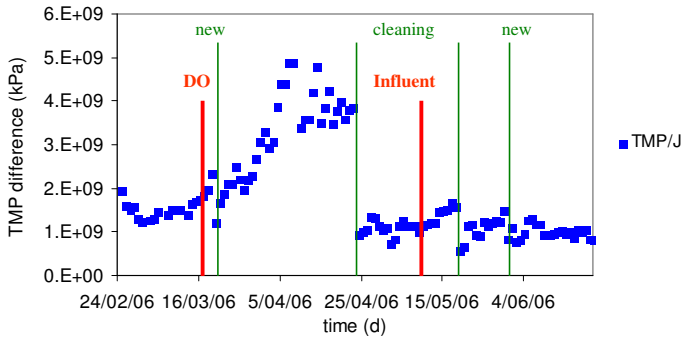
↪ Influenced SMP concentration



4. SMP – Fouling

Influence SMP on fouling

↪ not straightforward



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5. Conclusions

- Labscale reactor: stable
  - collect data for model calibration
- PSD
  - instruments not optimal
  - small changes at different places
- SMP – Fouling relationship
  - not straightforward

Disscusion points

Particle size distrubution
- which technics to use?

SMP- fouling
- what can cause the different fouling behavior?