THE EFFECT OF HYDRAULIC RETENTION TIME ON SLUDGE PROPERTIES AND MEMBRANE FOULING OF A THERMOPHILIC AEROBIC SUBMERGED MEMBRANE BIOREACTOR

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Outline

- Introduction
- Research Objectives
- Experimental
- Results and Discussion
- Summary
Pulp and Paper Wastewaters

- Pulp and paper mills effluent
  - High in biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), temperature, toxicity and color.

- Thermomechanical pulping pressate
  - Heat and mechanical refining movement
  - High COD
  - High temperature
  - High dissolved and suspended solids concentration
Trends in Industrial Wastewater Treatment

- Higher removal efficiency
- Lower cost
- Environmentally compatible
- System closure (water re-use)

Membrane Bioreactor (MBR) Technology

- Combines suspended biomass with immersed microfiltration or ultrafiltration membranes that replace gravity sedimentation and clarify the wastewater effluent.

Advantages of MBR

- High-quality effluent
- Smaller footprint
- Handling high organic loading rate
- Reduced sludge production
- Easy integration into the industrial processes
- Toward system closure

Forest Industries produce high strength and/or high temperature wastewater.

No need of pre-cooling and post-heating systems in closed cycle operation.

Benefit from the thermophilic aerobic process:
- High biodegradation rate
- Low sludge production
- High organic loading rate

References:
TSAMBR Challenges

- Removal Efficiency
- Membrane Fouling


Membrane Fouling

- Undesirable deposition and accumulation of microorganisms, colloids, solutes, and cell debris within/on membranes.
- Reduce permeation flux.
- Increase trans-membrane pressure (TMP).

MBR Parameters and Membrane Fouling

- **Biomass Characteristics**
  - Extracellular polymeric substances (EPS)
  - Flocs size and structure
  - Sludge viscosity and hydrophobicity

- **Operation Conditions**
  - Hydraulic retention time (HRT)
  - Sludge retention time (SRT)
  - Flux
  - Aeration

Research Objectives

- Investigate the HRT effect on the sludge properties of TSAMBR for pulp and paper mill effluent treatment.

- Investigate the HRT effect on the membrane fouling in the TSAMBR.
TSAMBR Set-up

- Pressure gauge
- Peristaltic pump
- Feed pump
- Level sensor
- Aeration
- Water Jacket
- Flat Sheet Membrane
- Stirrer
- Air sparge
- Feed Tank
- Fridge
- Water bath
- Effluent Tank
- Water Jacket
Experiment Conditions

- **Wastewater**
  - Thermomechanical pulping pressate (pulp and paper mill)
    - High strength (rich in organics)
    - High temperature (~50°C)

- **Operation Temperature and Period**
  - $51 \pm 1^\circ C$ for 156 days

- **Hydraulic Retention Times (HRTs)**
  - $1.7 \pm 0.2d$
  - $1.1 \pm 0.1d$
  - $0.9 \pm 0.1d$
## MLSS and COD Removal in the TSAMBR

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>MLSS</td>
<td>10.0 – 12.0 g/L</td>
</tr>
<tr>
<td>Feed COD</td>
<td>~3300 – ~4200 mg/L</td>
</tr>
<tr>
<td>Permeate COD</td>
<td>~300 – 440 mg/L</td>
</tr>
<tr>
<td>Removal Efficiency</td>
<td>89 – 92%</td>
</tr>
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TMP Profiles at Different HRTs

- Flux=11LMH, HRT=0.9±0.1d
- Flux=9.5LMH, HRT=1.1±0.1d
- Flux=6.5 LMH, HRT=1.7±0.2d

Normalized operation time (d)

TMP (Kpa)
Particle Size Distribution

- Bulk Sludge
Particle Size Distribution

- Cake sludge

![Graph showing particle size distribution with various HRT values]
EPS Contents of Bulk Sludge

![Graph showing the concentration of EPS contents in bulk sludge for different HRT values. The x-axis represents the components: Protein, Carbohydrate, EPS, PN/CH. The y-axis represents the concentration in mg/mLSS. Different bars represent different HRT values: HRT=1.7±0.2d, HRT=1.1±0.1d, HRT=0.9±0.1d.](image-url)
Cake Layer Structures

Homogeneous

Heterogeneous

HRT = 1.1 ± 0.1d

HRT = 0.9 ± 0.1d
Temporal Evolution of Cake Layer
A two-stage TMP evolution was observed for the shorter HRTs of 1.1 ± 0.1 and 0.9 ± 0.1d.

The properties of bulk sludge vary with HRT.

HRT has significant influences on the cake sludge properties.

The thickness and the structure of the cake layer vary with operation time.

The cake layer structure is considered as a more important factor for membrane fouling in TSAMBR.
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Question?

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