The effect of HRT on the treatment of domestic wastewater by MBR

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Introduction

Water = source of life

Increasing population & industrialization = clean water resources ↓↓

Pollutants removal from wastewater = environmental issue of utmost importance

- Variety of macro- & micro-pollutants (e.g. detergents, pesticides, endocrine disruptor compounds & heavy metals)

- Organic matter & nutrients (nitrogen & phosphorus) also require removal from wastewater
  - Oxygen consumption
  - Eutrophication

CAS systems widely used
Introduction

CAS systems: highly sensitive in organic/volumetric load fluctuations; settleability issues when MLSS↑↑

Recent rapid development in membrane technology & production costs ↓

Membrane Bioreactors (MBRs) now cost-effective, widely applied in wastewater treatment

MBR advantages:
- MLSS concentrations & SRTs ↑
- sludge amount ↓
- enhanced activity of bacterial populations when SRTs↑
- operation under increased organic/hydraulic loadings
- resistance to shock loads
Objective

**MBRs**: fouling still remains the greatest challenge to overcome; essential to optimize the operating conditions.

**HRT**: low (contact time between wastewater & biomass ↓; limited bacterial growth; increased fouling) ≠ high (possible system oversizing).

Examine the **effectiveness** of a lab-scale **MBR** for the removal of **COD & nutrients** from domestic wastewater from Erzurum (Turkey).

 Vaughn different HRTs (9.6, 7.7 & 6.2 h) ↔ flux values (16, 20 & 24 L m⁻² h⁻¹) applied
Materials & Methods

Lab-scale submerged flat-type ultrafiltration MBR system

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1: feed pump</td>
<td>P3: vacuum pump</td>
</tr>
<tr>
<td>M: mechanical stirrer</td>
<td>S1: flow meter</td>
</tr>
<tr>
<td>P2: return pump</td>
<td>T1: pressure gauge</td>
</tr>
<tr>
<td>G1: influent</td>
<td>G2: effluent</td>
</tr>
</tbody>
</table>

Used to pump into anoxic section

Aeration for aerobic & MBR sections

Return from the MBR to the anoxic section

Transmembrane pressure control

Reactor divided in 3 sections (anoxic, aerobic, MBR)
Materials & Methods

The lab-scale submerged flat-type ultrafiltration MBR treatment system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>[mg L⁻¹]</td>
<td>198-245</td>
</tr>
<tr>
<td>BOD</td>
<td>[mg L⁻¹]</td>
<td>95-175</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>[mg L⁻¹]</td>
<td>22.2-28.1</td>
</tr>
<tr>
<td>PO₄-P</td>
<td>[mg L⁻¹]</td>
<td>5.7-8.5</td>
</tr>
<tr>
<td>NO₃-N</td>
<td>[mg L⁻¹]</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>MLSS</td>
<td>[g L⁻¹]</td>
<td>11-11.5</td>
</tr>
<tr>
<td>SRT</td>
<td>[d]</td>
<td>∞</td>
</tr>
<tr>
<td>HRT</td>
<td>[h]</td>
<td>9.6 (period 1), 7.7 (period 2), 6.2 (period 3)</td>
</tr>
<tr>
<td>flux</td>
<td>[L m⁻² h⁻¹]</td>
<td>16 (period 1), 20 (period 2), 24 (period 3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Anoxic section</th>
<th>Aerobic section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td>[mg L⁻¹]</td>
<td>0.10-0.21</td>
<td>4.10-5.20</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>7.61</td>
<td>7.53</td>
</tr>
<tr>
<td>ORP</td>
<td>[mV]</td>
<td>-1.1, -1.6</td>
<td>247</td>
</tr>
<tr>
<td>Temperature</td>
<td>[°C]</td>
<td>16</td>
<td>17</td>
</tr>
</tbody>
</table>

- Samples (COD, NH₄-N & PO₄-P) taken 3 times per week from inlet, anoxic, aerobic, membrane & effluent sections
- Probes for DO, ORP & pH in all sections
Results

A. COD removal in the three different operating periods (period 1: HRT=9.6 h, period 2: HRT=7.7 h & period 3: HRT=6.2 h).

- Membrane flux from 16 to 20 L m\(^{-2}\) h\(^{-1}\) → HRT decrease from 9.9 to 7.7 h (period 1 to period 2):
  - COD removal ↓ from 99.5 to 96.4%
  - COD concentrations in the effluent ↑ from 1.2 to 8.4 mg L\(^{-1}\)
- Further membrane flux increase to 24 L m\(^{-2}\) h\(^{-1}\) (i.e. period 3: HRT=6.2 h):
  - COD removal ↓ at 93.4%
- Longer contact time between the biomass & the substrate at the highest HRTs → enhanced substrate degradation
Results

B. NH$_4$-N removal in the three different operating periods (period 1: HRT=9.6 h, period 2: HRT=7.7 h & period 3: HRT=6.2 h).

- Membrane flux from 16 to 20 L m$^{-2}$ h$^{-1}$ → HRT decrease from 9.9 to 7.7 h (period 1 to period 2):
  - NH$_4$-N removal ↓ from 99.6 to 67.2%
  - NH$_4$-N concentrations in the effluent ↑ from 0.1 to 7.5 mg L$^{-1}$
- Further membrane flux increase to 24 L m$^{-2}$ h$^{-1}$ (i.e. period 3: HRT=6.2 h):
  - NH$_4$-N removal ↓ at 46.3%
  - NH$_4$-N concentrations in the effluent ↑ from 7.5 to 13.4 mg L$^{-1}$
- Longer time for the nitrifying bacteria growth at the highest HRTs → enhanced nitrification
Results

C. PO₄-P removal in the three different operating periods (period 1: HRT=9.6 h, period 2: HRT=7.7 h & period 3: HRT=6.2 h).

- Membrane flux from 16 to 20 L m⁻² h⁻¹ → HRT decrease from 9.9 to 7.7 h (period 1 to period 2):
  - PO₄-P removal ↓ from 80.5 to 30.3%
  - PO₄-P concentrations in the effluent ↑ from 1.2 to 4.8 mg L⁻¹
- Further membrane flux increase to 24 L m⁻² h⁻¹ (i.e. period 3: HRT=6.2 h):
  - PO₄-P removal ↓ at 17%
  - PO₄-P concentrations in the effluent ↑ from 4.8 to 5.3 mg L⁻¹
- Longer time for the effective PO₄-P removal at the highest HRTs
Conclusions

- Different fluxes (16, 20 & 24 L m⁻² h⁻¹) ↔ hydraulic retention times (HRTs: 9.6 h, 7.7 h & 6.2 h) as variable parameters

- **flux ↑ ↔ HRT↓ → worse MBR performance**
  - ↓↓ organic matter removal
  - ↓↓ nutrient removal (disturbed nitrification etc.)

Meeting the Turkish limits for discharge:
- COD removal during all the examined periods
- NH₄-N removal only in periods 1 & 2
- PO₄-P removal only in period 1

Addition of low-cost post-treatment (i.e. chemical precipitation):
  - enhance PO₄-P removal & allow keeping the HRT=7.7 h
THANK YOU FOR YOUR ATTENTION