Removal of Heavy Metals with Membrane Bioreactor combined with Activated Carbon

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Introduction

Water Scarcity  Sustainable wastewater resources management  Circular economy concept → Water reuse

- Stringent water quality standards in recent years
- Heavy metals in surface + underground waters:
  - lead (Pb)
  - nickel (Ni)
  - arsenic (As)
  - zinc (Zn)

Pollutants with significant direct/indirect effects

- Discharged by various industrial sectors; e.g. metallurgy, mining, electroplating plants, leather, nuclear & electronic industries, etc.
Introduction

Living beings: certain heavy metals concentration NEEDED for survival & essential vital activities

Even low heavy metal concentration: hardly biodegradable; only converted to less toxic forms

Discharge to environment: food chain, ecosystem affected

Before discharge: pre-treatment required for such effluents

- ion exchange
- adsorption
- coagulation/flocculation
- flotation
- electrochemical precipitation
- membrane bioreactors (MBRs)
Objective

**MBRs:** small carbon footprint, superior effluent quality, high biomass retention & organic matter removal at high organic loading rates

**Biosorption:** heavy metals bound by living cells, dead biomass & extracellular polymeric substances

Examine the **effectiveness** of lab-scale **MBR (pre-treatment)** combined with **granular activated carbon (GAC) (post-treatment)** for the removal of **selected** heavy metals (Ni, Pb, As & Zn) from synthetic wastewater

✓ **3 different flux values** (16, 20 and 24 L m$^{-2}$ h$^{-1}$) applied
Materials & Methods

1st part of experimental set-up: MBR (pre-treatment)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1: feed pump</td>
<td>G1: influent</td>
</tr>
<tr>
<td>P2: vacuum pump</td>
<td>G2: effluent</td>
</tr>
<tr>
<td>P3: membrane blower</td>
<td>M1: fleet sheet membrane</td>
</tr>
<tr>
<td>P4: air pump</td>
<td>K1: conductor</td>
</tr>
</tbody>
</table>

1st section aeration

Fouling prevention in 2nd section

Used to apply 3 different fluxes (i.e. 16, 20 & 24 L m⁻² h⁻¹)

Flat-sheet membrane

MBR tank divided in 2 sections to enable water flow from bottom
Materials & Methods

2nd part of experimental set-up: GAC (post-treatment)

Whole experimental set-up: MBR + GAC

Synthetic wastewater:
- COD: 475.4-680.7 mg L\(^{-1}\)
- Stock solution containing the selected heavy metals (Ni, Pb, As & Zn) added

- Influent & effluent heavy metal concentration continuously measured
- Heavy metal analysis by inductively coupled plasma mass spectrometry (ICP-MS)
Results

Ni removal

Zn removal

Pb removal

As removal

MBR effluent (after pre-treatment)
Results

COD removal

MBR effluent (after pre-treatment)

NH4-N removal

PO4-P removal

After GAC adsorption: all heavy metals under limit of detection!!!
Conclusions

- Different fluxes (16, 20 & 24 L m\(^{-2}\) h\(^{-1}\)) ↔ hydraulic retention times (HRTs: 12.8 h, 10.4 h & 9.2 h) as variable parameters

- MBR effluent: **flux ↑↔ HRT↓ → worse MBR performance**
  - ↓↓ heavy metal removal
  - ↑↑ heavy metal toxicity within reactor
  - ↓↓ nutrient removal (disturbed nitrification etc.)

GAC post-treatment step: **almost total heavy metal removal!**
THANK YOU FOR YOUR ATTENTION