Microfiltration and ultrafiltration as a post-treatment to biogas plant digestates for producing concentrated fertilizers

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INTRODUCTION

Centralized biogas production is of growing interest as a green energy technology in areas with industrialized livestock production. The effluent from the biogas plant contains high amounts of nutrients in the form of nitrogen, phosphorus, and potassium (N, P, and K). It is advantageous to separate the effluent in a solid fraction rich in P and liquid fraction (LF) rich in N and K [1]. This reduces transportation costs when redistributing the effluent as fertilizer. The digestate LF though is still dilute in N and K and further concentration is necessary. Further the low P content in the LF (about 30%) might be increased by concentration of the particulate dry matter (DM) in the digestate LF, as P is known to adhere to the particles size fraction of 0.45-2mm [2].

Microfiltration (MF) and ultrafiltration (UF) can be used as methods for concentration of DM from the digestate LF [1]. It is of interest to determine the separation and rejection of P by means of MF and UF.

MATERIALS AND METHODS

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<tr>
<th>MF experiments</th>
<th>UF experiments</th>
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<tr>
<td>Digestate was ultrafiltered</td>
<td>Raw feed was screw pressed</td>
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<td>Digestate was ultrafiltered at continuous flow</td>
<td>Digestate was ultrafiltered</td>
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<td>Batch tests for concentration experiments at different operation conditions (Table 2), determination of volume reduction factor (VRF)</td>
<td>Ultrafiltration performed at continuous flow</td>
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RESULTS AND DISCUSSION

Microfiltration tests

- PVDF and PS membranes were used for microfiltration tests of Fangel Biogas digestate liquid fraction (Figure 4).
- The initial clean water flux at 1bar and 1.44 m/s was 208 m²/h for new PVDF and 230 m²/h for new PS.
- During the microfiltration test:
  - PVDF (0.5µm) showed a more stable and uniform permeate flux at all operation conditions, between 7.15 L/m²h and 9.12 L/m²h.
  - PVDF (0.5µm) achieved a higher stable permeate flux compared to the tested PVDF membranes, around 6.9-8.9 L/m²h.
- MF experiments using Fangel Biogas digestate (Table 1)
  - Digestate was centrifuged and separated in a solid and a liquid fraction.
  - Liquid fraction was pre-treated at 300-1200µm and it was microfiltered.
  - Recirculation tests performed for different membrane pore sizes and materials, at different operation conditions (Table 2).
  - Concentration tests performed, determination of volume reduction factor (VRF).

Ultrafiltration tests

- PES membrane was used for ultrafiltration tests of Bioscan A/S digestate.
- The clean water flux showed a linear relationship between the applied pressure and the obtained permeate flux. At 2.5bar of applied pressure and 2mm/s, 34L/m²h of permeate were obtained (Figure 5).
- During MF concentration tests, the permeate flux decay was less acute when using PVDF membranes than PVDF membranes. At a VRF 0.5, PVDF membrane (MF5) achieved 6.9L/m²h/Bar while the PS membrane (M5) achieved 5.2L/m²h/Bar. Although the permeability was lower for PS membranes, the more stable flux could be due to a weaker attachment of the fouling layer (Figure 6). However, this was different when using PVDF membranes. The permeability for PS at VRF 0.5 was about 15% lower and it dropped dramatically while increasing the VRF (Figure 7).
- This might indicate that the influence of the foulant material is more predominant on the PS membrane size (5).

Phosphorus rejection

- PES membrane was used for ultrafiltration tests of Bioscan A/S digestate.
- The clean water flux showed a linear relationship between the applied pressure and the obtained permeate flux. At 2.5bar of applied pressure and 2mm/s, 34L/m²h of permeate were obtained (Figure 5).
- During MF concentration tests, the permeate flux decay was less acute when using PVDF membranes than PVDF membranes. At a VRF 0.5, PVDF membrane (MF5) achieved 6.9L/m²h/Bar while the PS membrane (M5) achieved 5.2L/m²h/Bar. Although the permeability was lower for PS membranes, the more stable flux could be due to a weaker attachment of the fouling layer (Figure 6). However, this was different when using PVDF membranes. The permeability for PS at VRF 0.5 was about 15% lower and it dropped dramatically while increasing the VRF (Figure 7).
- This might indicate that the influence of the foulant material is more predominant on the PS membrane size (5).

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<th>OBJECTIVE</th>
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<td>The aim is to study the influence of membrane material, pore size, operation conditions and cleaning procedures on the permeate flux and flux recovery during MF.</td>
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<td>Further, phosphorus rejection at optimal operating conditions is investigated and compared to an alternative treatment with UF.</td>
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CONCLUSIONS

- Flux decay occurs during concentration tests. PS membranes achieved the most stable permeate flux, followed by PVDF and PES membranes. Subsequently, membrane material is a decisive factor while designing treatment processes for biogas plant digestates.
- Membrane cleaning during MF tests, was more effective for PS membranes regardless the operation conditions and membrane pore size. PVDF cleaning performance was poor, just MPs (0.5µm) was slightly cleaned. This might be due to a higher hydrophobicity of PVDF membranes which attracts organic fouling, that could not be removed with the applied cleaning strategy.
- A more effective P rejection was achieved when using PS membranes, followed by PES and PVDF. Therefore, membrane pore size was not a determining factor for P rejection and the membrane material might have an important contribution in this case.

By observing the results, it can be concluded that further investigations are needed to determine the influence of membrane material on nutrient rejection from biogas plant digestates.

REFERENCES:

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