Membrane Performance Study for Concentrating Digested and Dewatered Biogas Plant Effluent

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Introduction

Co-Digestion of renewable raw materials with other waste product streams from agriculture (e.g. liquid manure) is a process introduced in commercial practice over the last few years. The digested product, the digester effluent, is used as a fertilizer in agriculture. A storage tank on the biogas plant site is often needed, because the digested effluent can only be deployed onto the fields before the vegetation period starts. Its storage capacity has to be calculated for a minimum period of 180 days. In many cases the availability of storage capacity is limited. In such cases it is reasonable to reduce the amount of digested effluent with appropriate processes.

Aim of research

To reduce the amount of digester effluent

1. a mechanical dewatering process in combination with
2. a membrane filtration system was used.

Next to the reduction of the amount of digested effluent a concentration of the nutrients is desired. Here first experimental results are presented for the concentration of nutrients in the process water after mechanical dewatering and the membrane permeate.

Methods and results

Materials and methods

- Characterization of nutrients in feed and permeate
- Filtrate flux versus time for Dead-End and Cross-Flow filtration unit

1. Dead-End filtration unit with flat membranes
2. Cross-Flow filtration unit with flat and tubular membranes

Digester effluent for all experiments was taken from an established biogas plant near Dresden.

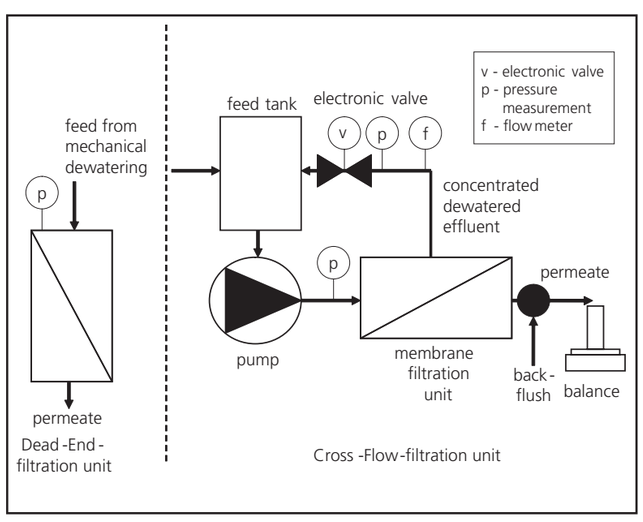

Figure 1: Schematics of lab-scale micro filtration membrane units (left: Dead-End-filtration unit; right: Cross-Flow filtration unit)

Concentration of Nutrients in different operational steps

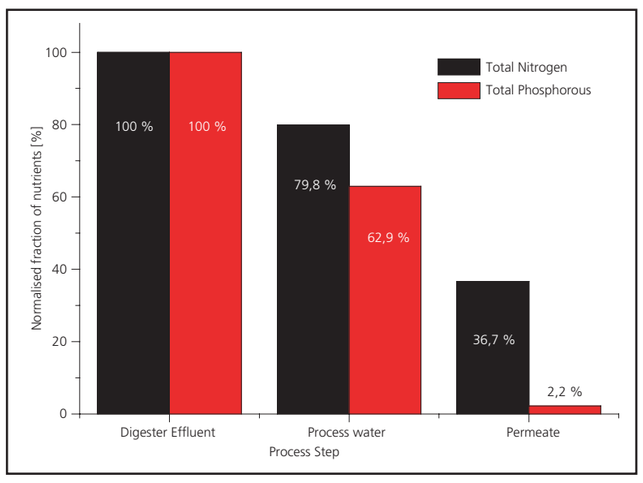

Figure 2: Concentration of nutrients after dewatering and Cross-Flow filtration with HITK e.V. 200 nm, tubular membrane (α-Al_2O_3 ceramic)

- 37 percent of total nitrogen of digester effluent is still found in permeate; this is due to ammonia in total nitrogen content
- Only 2 percent of total phosphorous of digester effluent is found in permeate
- Retention of total nitrogen for membrane micro filtration step is approx. 50 percent in average over all tested membrane types (flat and tubular with different pore sizes)
- Retention of total phosphorous for membrane micro filtration step is approx. 95 percent over all membrane types

Retention of membranes for nutrients

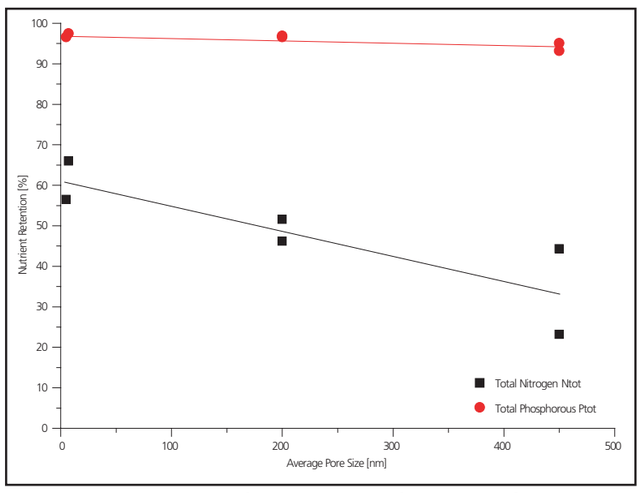

Figure 3: Retention of Nutrients as function of pore size of different membrane types

- Retention of total nitrogen decreases with increasing pore size
- Only slight decrease in retention of phosphorous with increasing pore size

Membrane flux performance of flat type membrane

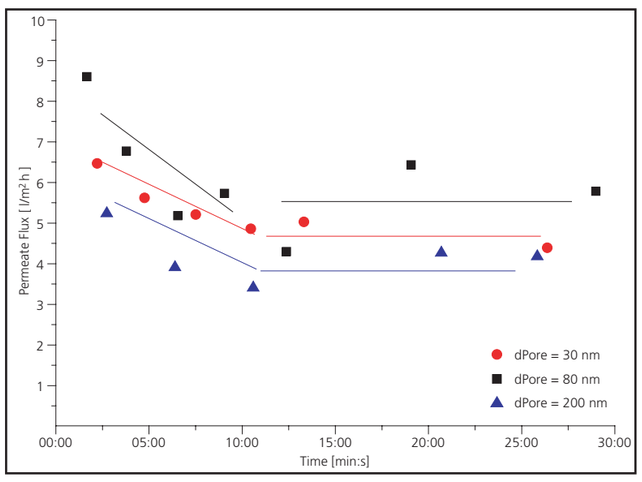

Figure 4: Permeate flux as function of process time for different flat Cross-flow membranes (Microdyn Nadir membranes; pore sizes: 30, 80, 200 nm; materials: PES, PVDF, PVDF)

- Permeate flux decreases to steady state after 10 minutes
- Permeate flux is for all tested membranes approx. $J = 5$ l/(m²h)
- Pressure difference $\Delta p = 0{,}9$ bar
- Volume flow V = 12,4 l/min

Conclusions

- Nutrients can be concentrated by all type of membranes
- Retention is decreasing with increasing pore size
- Phosphorous can be nearly eliminated whereas more than one third of nitrogen can still be found in permeate
- Flux for flat membrane Cross-Flow module is low

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