Comparison of digestate liquid treatment technologies: mass and nitrogen balances

E. Tampio[1,2], S. Marttinen[1] and J. Rintala[2]

[1] Bio-based Business and Industry, Natural Resources Institute Finland (Luke), Tietotie 2 C, FI-31600 Jokioinen, Finland (E-mail: elina.tampio@luke.fi; sanna.marttinen@luke.fi)

[2] Department of Chemistry and Bioengineering, Tampere University of Technology, PL 541, FI-33101, Tampere, Finland (E-mail: jukka.rintala@tut.fi)

Introduction

- The use of separated liquid digestate in agriculture is limited due to its high volumes, transportation costs and uneven nutrient ratios.
- With advanced digestate liquid treatment technologies, nutrients, especially nitrogen, can be concentrated into fractions with low mass and to produce fertilizer products with optimal composition to match the crop nutrient requirements.
- The aim of this study was to compare the mass and nitrogen flows of four digestate treatment systems, which were based on a theoretical full-scale anaerobic digestion (AD) plant. The studied technologies for the digestate liquid treatment were ammonia stripping with acid scrubbing, evaporation and reverse osmosis (RO) as well as combinations of these technologies (Figure 1).

Materials & Methods

- Background: studied case was a theoretical mesophilic AD plant digesting pig slurry (60 kt/a), municipal biowaste (20 kt/a) and sewage sludge (20 kt/a).
  - Feedstock mixture characteristics: TS 24%, VS 11%, Ntot 5.8 g/kgFM, NH_4-N 2.2 g/kgFM.
  - Digestate separation with a centrifuge into solid and liquid fractions.
- Comparison of four digestate liquid treatment systems (Figures 1 and 2).
- The following assumptions were based on literature values:
  - Stripping and evaporation recovered 80% of Ntot and NH_4-N in ammonium sulfate/concentrate.
  - Evaporation recovered 20% of mass in concentrate.
  - RO treatment recovered 15% of mass and 90% of Ntot and NH_4-N in retentate.

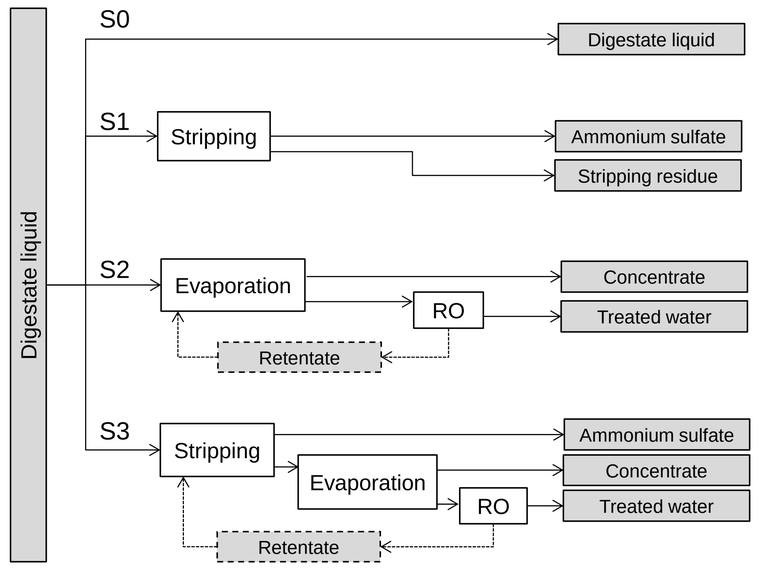

Figure 1. Studied digestate liquid treatment systems. White boxes: studied unit operations; grey boxes: process inputs/outputs.

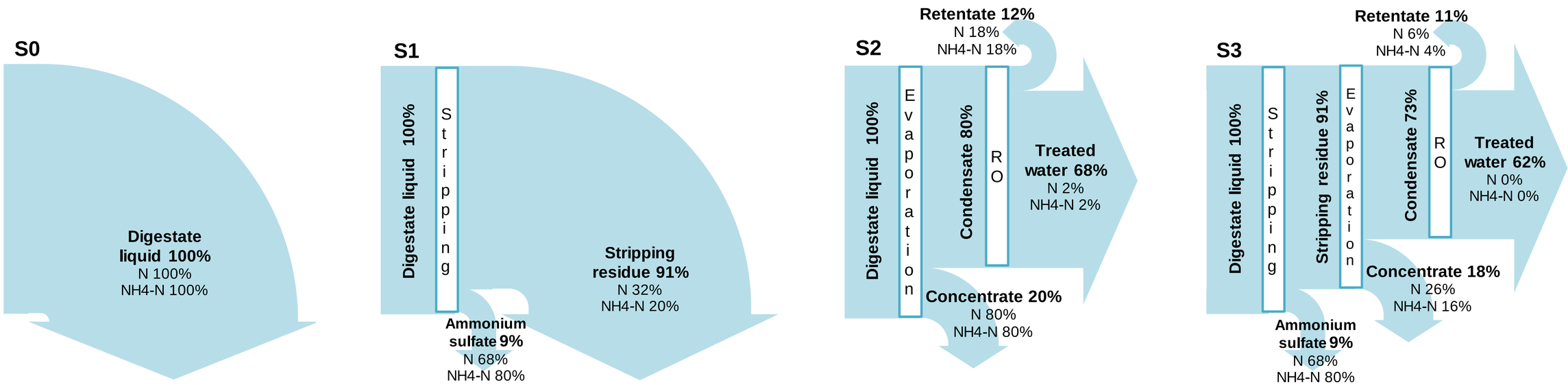

Figure 2. Digestate liquid mass, Ntot and NH_4-N flows in the studied digestate liquid treatment systems (S0-S3). The width of the arrows represents mass.

Conclusions

- Evaporation + RO (S2) and Evaporation + stripping + RO (S3) produced the most concentrated nitrogen product flows: concentrate and ammonium sulfate (Table 1).
- The RO treatment with systems S2 and S3 enabled the discharge of excess water and concentration of nutrients into products with decreased volume, which facilitates the utilization and transportation of the products in agriculture.
  - Stripping combined with evaporation and RO (S3) produced concentrated nitrogen flows, but multiple process steps most likely increase processing costs.
- Stripping alone (S1) produced a high volume of stripping residue (67 kt/a). The residue was not a feasible nutrient product due to the large volume and low nitrogen content (1.9 g/kg), which increases transportation need and spreading amounts per hectare.

Table 1. Characteristics of the products from digestate liquid treatment systems.

System	Product	TS (%)	VS (%)	Ntot (g/kgFM)	NH_4-N (g/kgFM)	Volume (kt/a)
	Digestate	6.2	3.5	6.3	4.6	92
S0	Liquid fraction	0.8	0.4	5.5	4.7	74
S1	Ammonium sulfate	0	0	40	40	13
	Residue	0.9	0.5	1.9	1	67
S2	Concentrate	3.7	2.1	21	17.8	15
S3	Ammonium sulfate	0	0	40	40	13
	Concentrate	4.1	2.3	7.4	3.9	14

- When further evaluating the total efficiency of the digestate liquid treatment and the usability of products, also the flows of P, K and energy should be considered.

Acknowledgements

This project was funded by the Ministry of Agriculture and Forestry and the Fortum Foundation (grant number 201400302).