DEWATERING AND DESALTING OF DIFFERENT ALGAE SPECIES USING SUBMERGED MEMBRANES (MAF-TECHNOLOGY)

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Introduction

- Micro-algae offer potential for a biobased economy.
- Harvesting = dewatering
- Harvested micro-algae can contain significant amounts of salts
- Membrane technology can be used for
  - Pre-harvesting activities – removing > 95% of the water
  - Medium recycling
  - Desalting of harvested algae

Aim of the study = Evaluating the potential of the VITO MAF-technology for different microalgae species via off-site filtration tests.

MAF-technology

- MAF = Membrane based Algae Filtration
  - Submerged membranes (UF & MF)
  - Backwashable membranes
  - Permeate recovery via under pressure → Low shear technology
- Algae densities reached: > 40 g/L OM

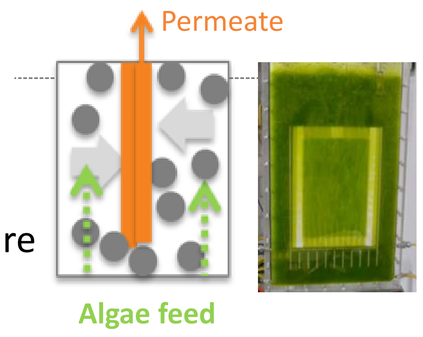


Figure 1: Submerged membrane filtration.

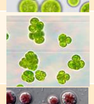
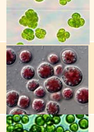
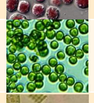
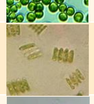
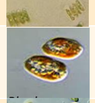
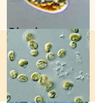
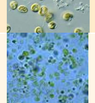
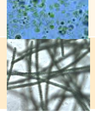
Conclusions

- The MAF technology proved to be suitable for dewatering (concentrating) a variety of microalgae species.
- *Nannochloropsis, Chloromonas typhlos*, *Chlorella sp.*, *Scenedesmus sp.* and *Pavlova* sp. were concentrated successfully with volume concentration factors up to 50 and more.
- Due to low shear forces → also fragile cells without cell wall like *Rhodomonas* sp. can be concentrated.
- Algae densities of 30 to >100 g OM/L were reached.
- Filtration fluxes were found to be impacted negatively by 1) extracellular polymeric substances (EPS) like produced by *Porphyridium sp.* and 2) impurities and cell debris.
- A transparent cell-free permeate containing >99% of the salts was generated → suitable for recirculation.
- The MAF-technology was also found very useful for desalting the preconcentrated algae biomass → for instance required when targeting feed applications.
- Longer-term continuous operations are ongoing

Overview of MAF-performance

Figure 2: MAF screening units with 0,2 – 1,1 m² membrane surface.

Table 1: Summary of MAF-performance for pre-concentrating and desalting of different micro-algae species as determined via screening test using 50-300 L algae culture.

Algae species		Pre-concentration of algae	Fluxes	Desalting after pre-concentration	Remarks
Nannochloropsis gaditana *		1 g/L → >100 g OM/L (VCF > 100)	+++	23.3 → 0.3 mS/cm	Tested extensively at lab & pilot scale
Chloromonas Typhlos *		0.92 g/L → >20.7 g OM/L (VCF = 42)	+++	Not relevant (fresh water culture)	When algae are stressed, oily layers reduce fluxes
Porphyridium purpureum *		0,7 → 1,5 g DM/L (VCF = 2-3)	-	Not applicable due to low fluxes	Negative impact of EPS on fluxes
Chlorella sp. **		1 g/L →18 - >50 g OM/L	++	Suitable when grown in brackish water	Foaming observed
Scenedesmus sp. **		< 1g/L → >31 g OM/L (VCF = 80)	+++	Not relevant (fresh water culture)	
Rhodomonas sp. ***		0,07-0,5 → >10 g OM/L (VCF > 100)	+++	42 → 1 to 2,7 mS/cm	Very fragile algae species without cell wall
Pavlova sp. ****		1 → >33 Mcells/ml (VCF 34-40)	++	50,2 → 1,1 to 0,6 mS/cm	
New Mixed Algae from open pond $		0.09 → 20 g OM/L (VCF 50 to > 200)	+++	13,4 → 3,7 mS/cm	
New *Spirulina* $$		3 → 28 g OM/l (VCF 10)	++	10,4 -→ 3,0 mS/cm	

Algae biomass cultivated (*) in Sunbuilt (Thomas More & VITO, Belgium), (**) Forschungszentrum Jülich, Germany, (***) Hogeschool Zeeland, NL, (****) University Lille, France. OM = dry organic mater
Mixed algae biomass from open pond operated with regeneration water from a demineralization unit – Yara Sluiskil ($); Spirulina grown in closed PBRs by Lgem ($$).

Concentration and desalting of microalgae without cell wall

Rhodomonas sp. are fragile algae species without a cell wall that are very sensitive to shear forces. Cell integrity of *Rhodomonas* was monitored during dewatering and desalting via the MAF-technology. Microscopic analyses and visual observation of the permeate color proved that the cells remained intact. Non-stressed cultures performed better than stressed cultures.

Figure 3: Microscopic analyses of *Rhodomonas* cells during concentration by MAF till VCF > 71 (LEFT) and before and after desalting (RIGHT).

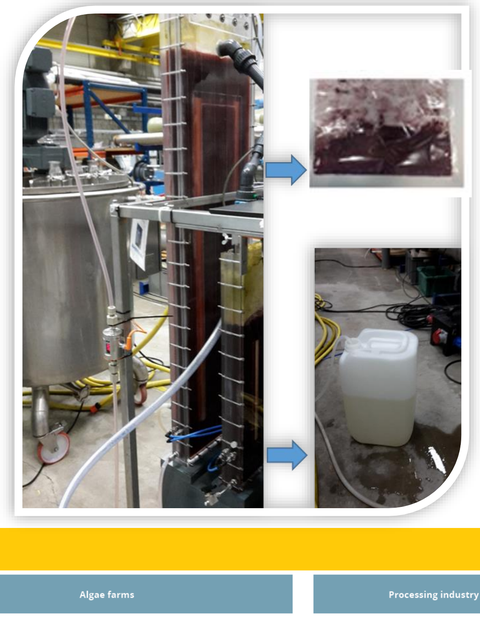


Figure 3: MAF-concentration of *Rhodomonas* sp. Generating 1) concentrated and desalted algae biomass (freeze dried) and 2) colorless permeate suitable for medium recycling.

IDEA - Implementation and development of economic viable algae-based value chains (NWE639)

Duration: 9/2017 – 10/2021, capitalisation till 12/2023

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