MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

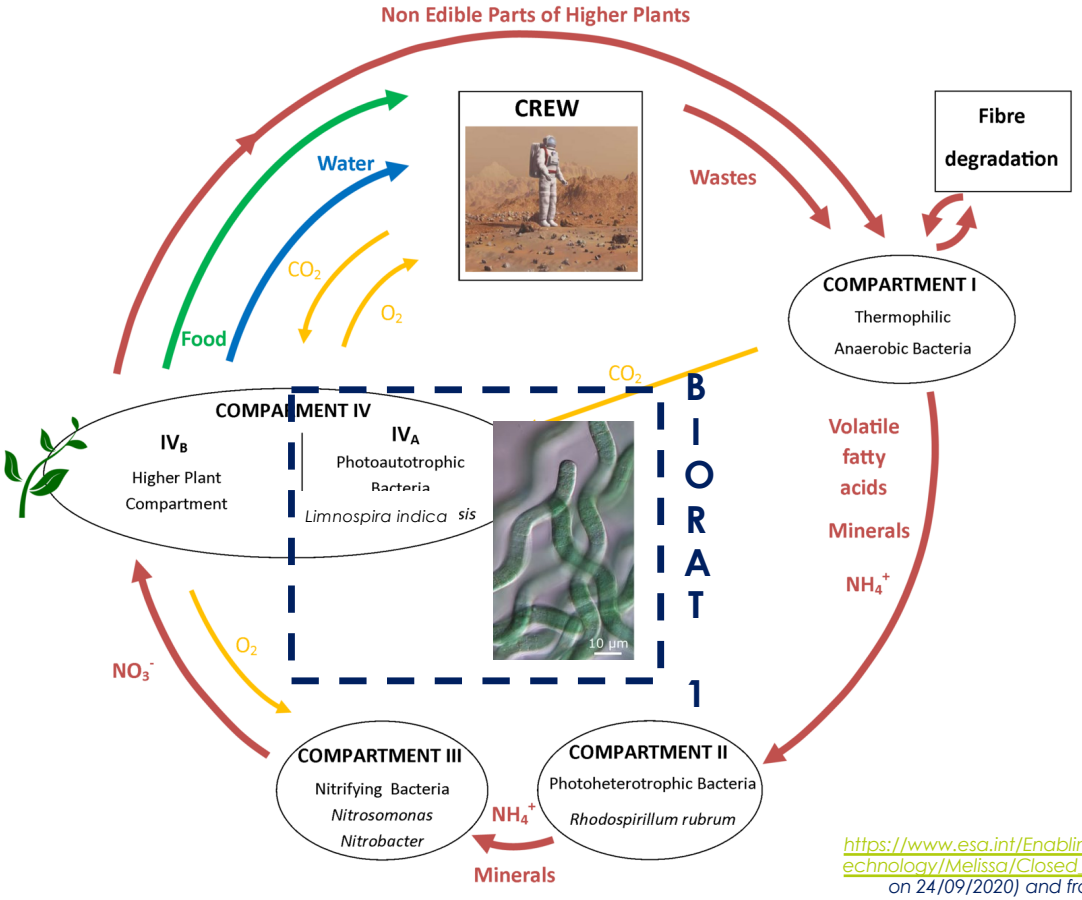
CREATING A CIRCULAR FUTURE

Solid-Liquid Separation Technology for Biomass Harvesting in Bioreactors

Marie Vandermies, Dries Demey, Filip Dewitte

QINETIQ

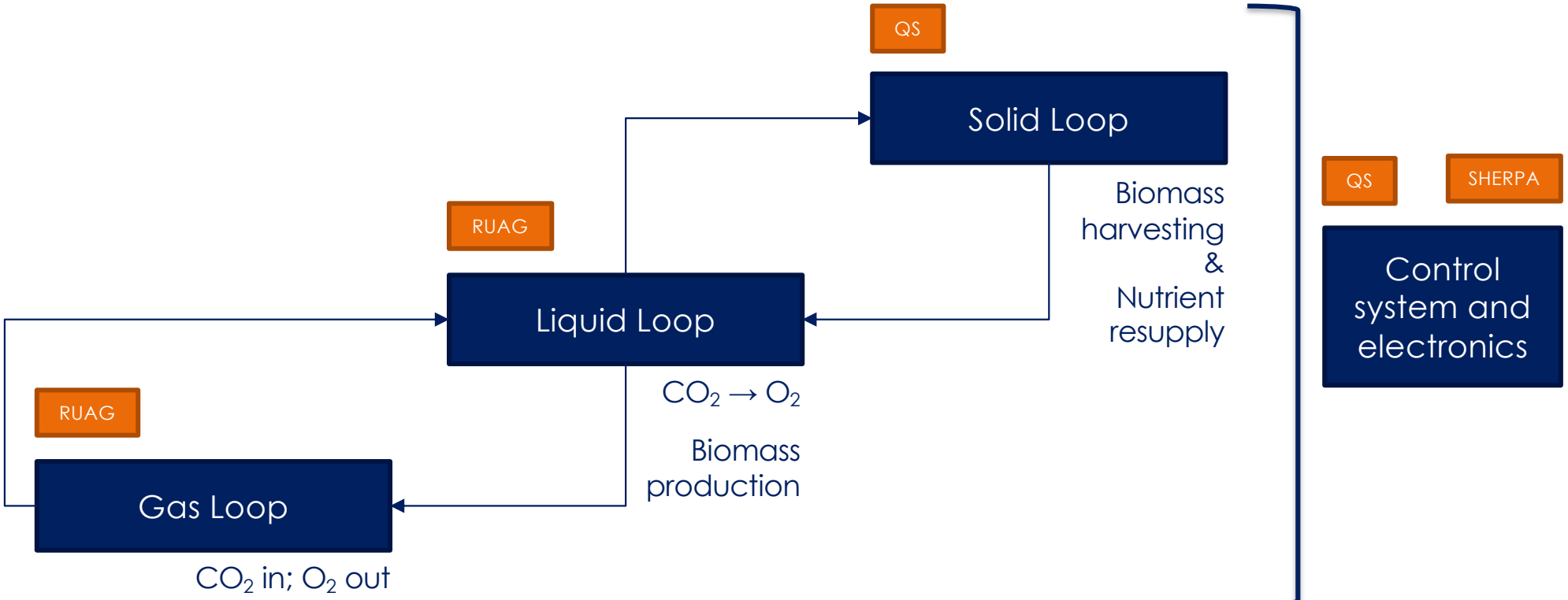
1. CONTEXT



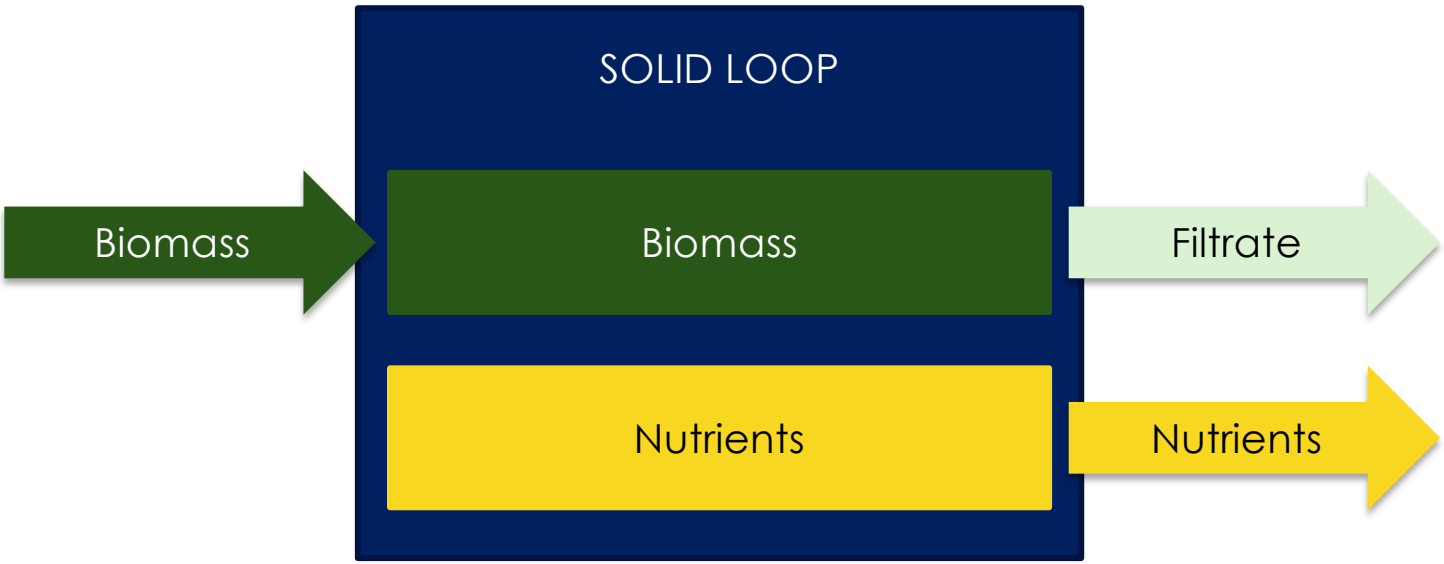
Adapted from https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Melissa/Closed_Loop_Compartments (accessed on 24/09/2020) and from Nowicka-Krawczyk et al. 2019

2. PROCESS OVERVIEW

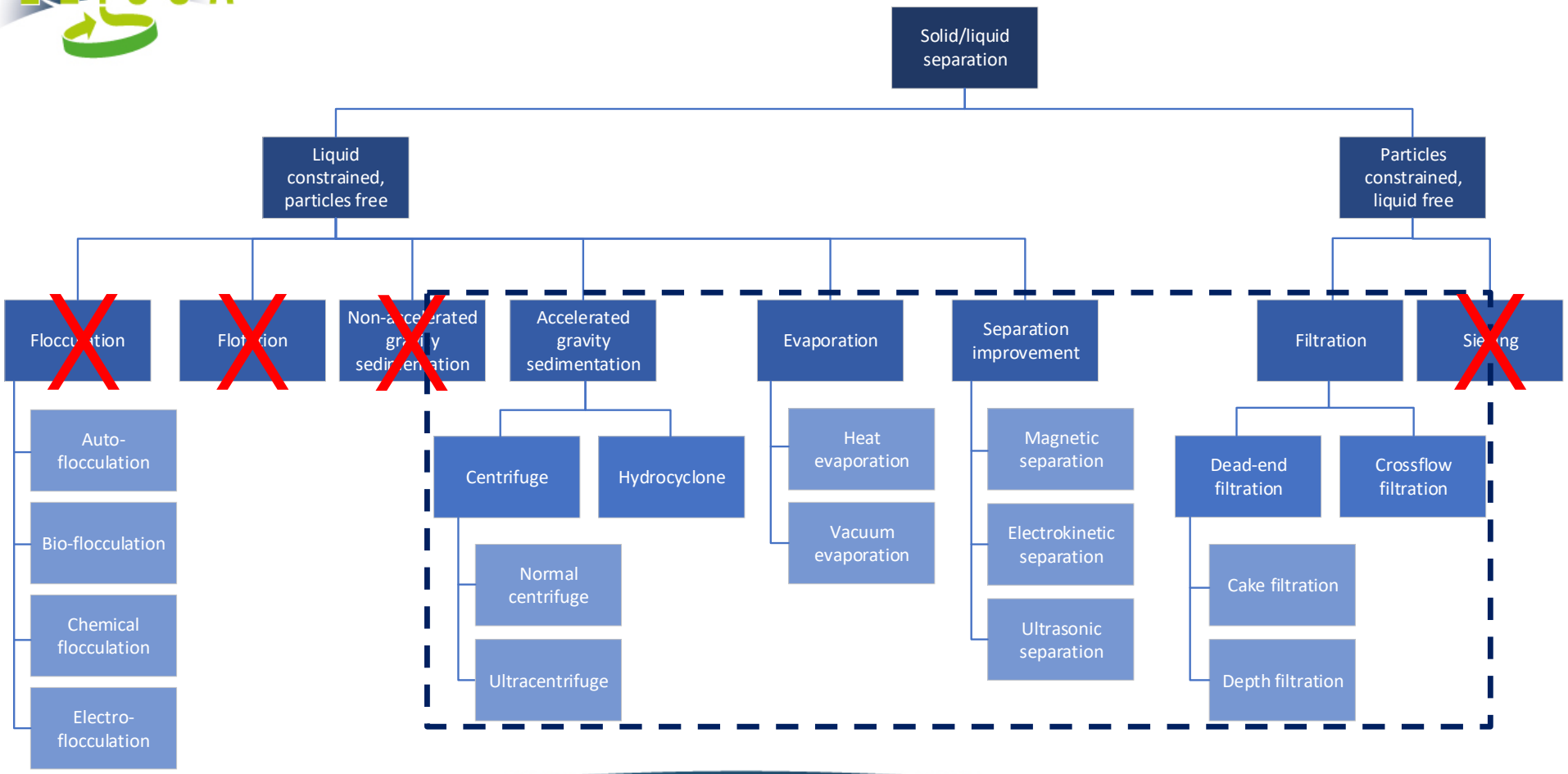
BIORAT 1

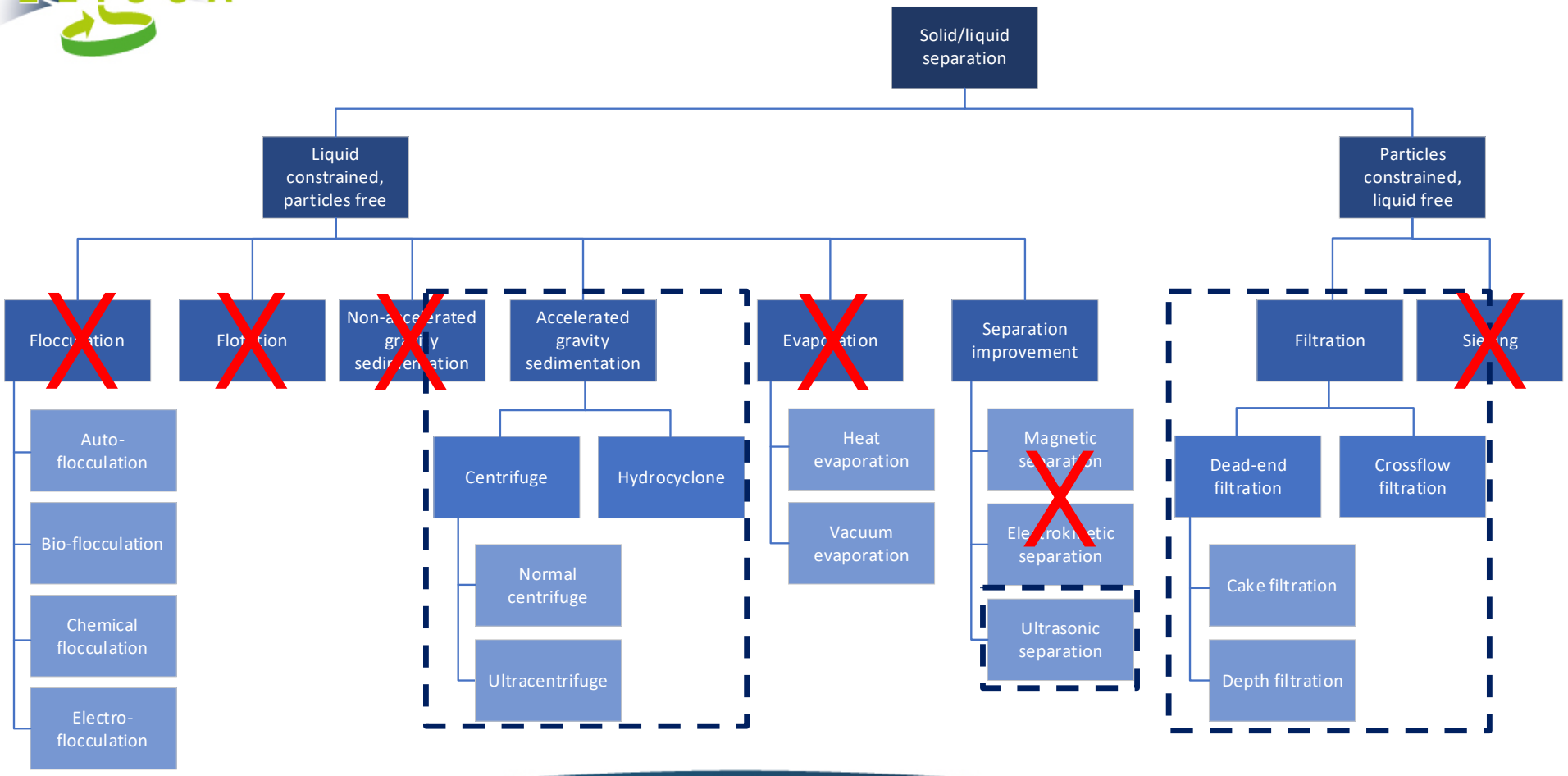

QS
Solid Loop
Biomass harvesting & Nutrient resupply
RUAG
Liquid Loop
$CO_2 \rightarrow O_2$
Biomass production
RUAG
Gas Loop
CO_2 in; O_2 out
QS
SHERPA
Control system and electronics

BIORAT 1: Solid loop



3. SOLID/LIQUID SEPARATION


Solid/liquid separation
Liquid constrained, particles free
Particles constrained, liquid free
Flocculation
Flotation
Non-accelerated gravity sedimentation
Accelerated gravity sedimentation
Evaporation
Separation improvement
Filtration
Sieving
Auto-flocculation
Bio-flocculation
Chemical flocculation
Electro-flocculation
Centrifuge
Hydrocyclone
Normal centrifuge
Ultracentrifuge
Heat evaporation
Vacuum evaporation
Magnetic separation
Electrokinetic separation
Ultrasonic separation
Dead-end filtration
Crossflow filtration
Cake filtration
Depth filtration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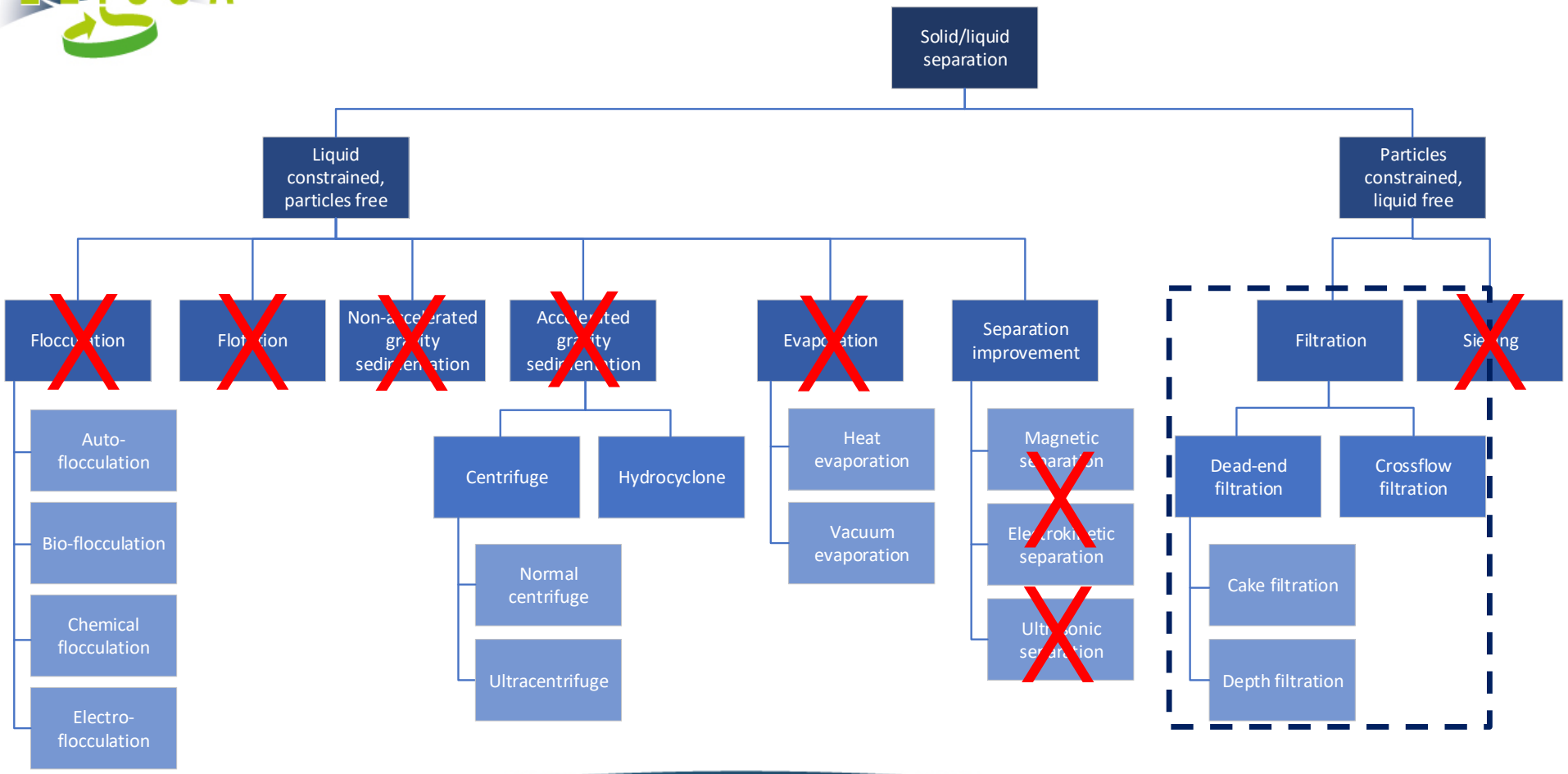
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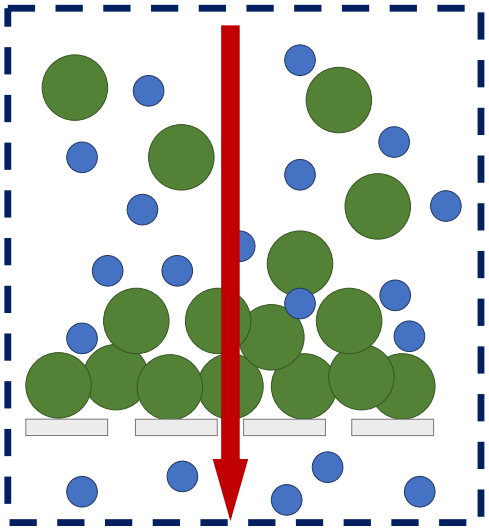
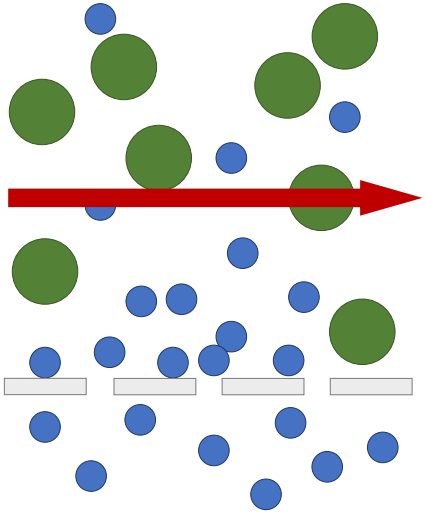
Heat evaporation
Vacuum evaporation
Separation improvement
Filtration
Dead-end filtration
Crossflow filtration
Cake filtration
Depth filtration

Dead-end vs crossflow

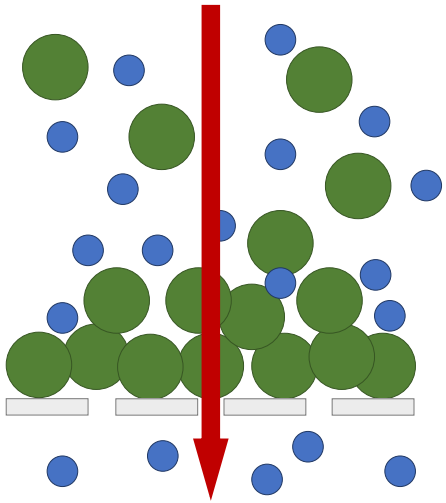


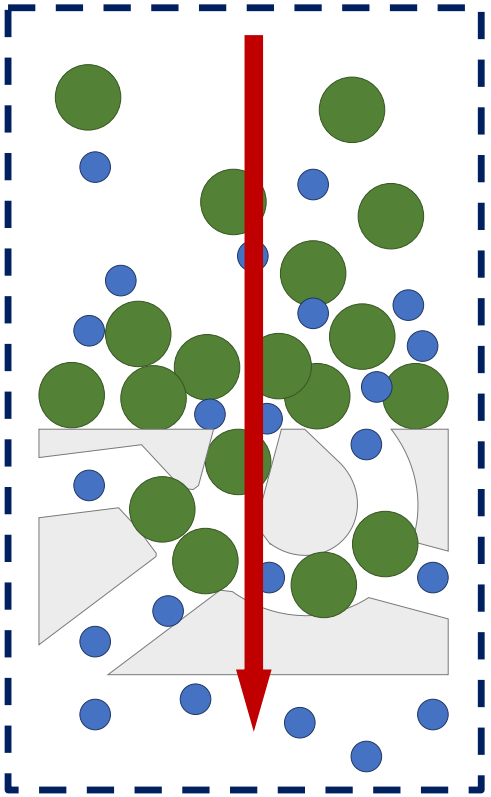


Algae cell

Solvent molecule

Cake vs deep bed

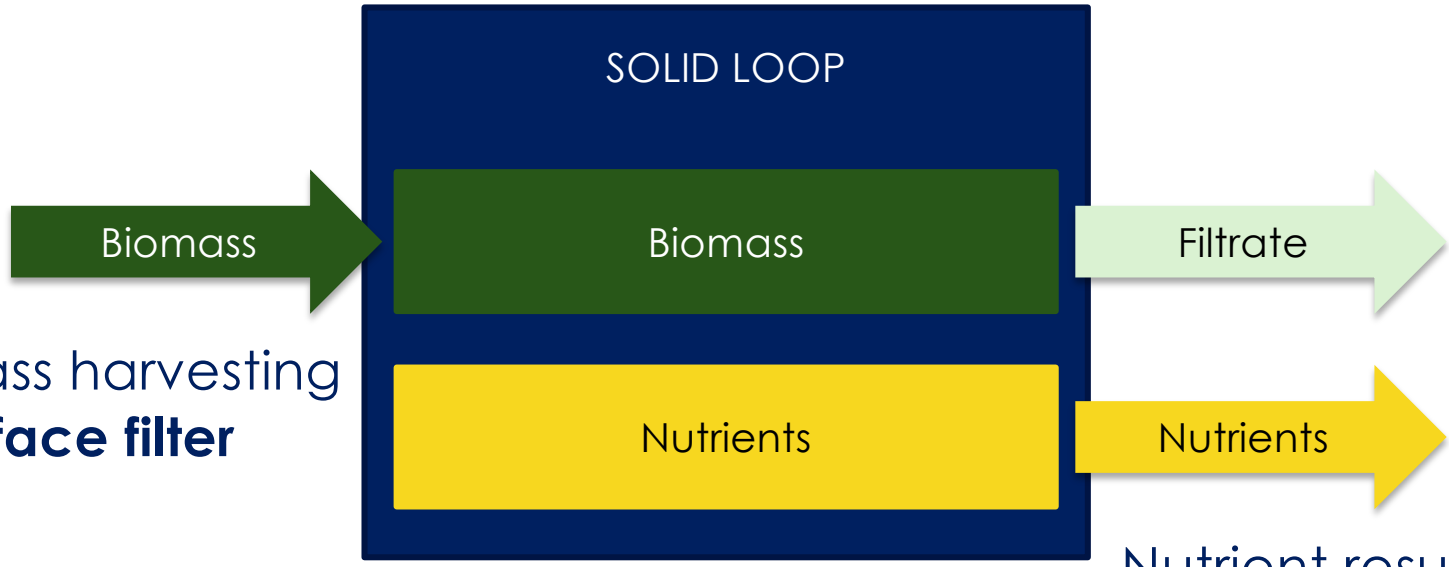




Algae cell

Solvent molecule

4. DESIGN CRITERIA



Biomass harvesting
→ **surface filter**
= ?

Nutrient resupply
→ **volume solid loop**
= 3.2 L

Filter trade-off

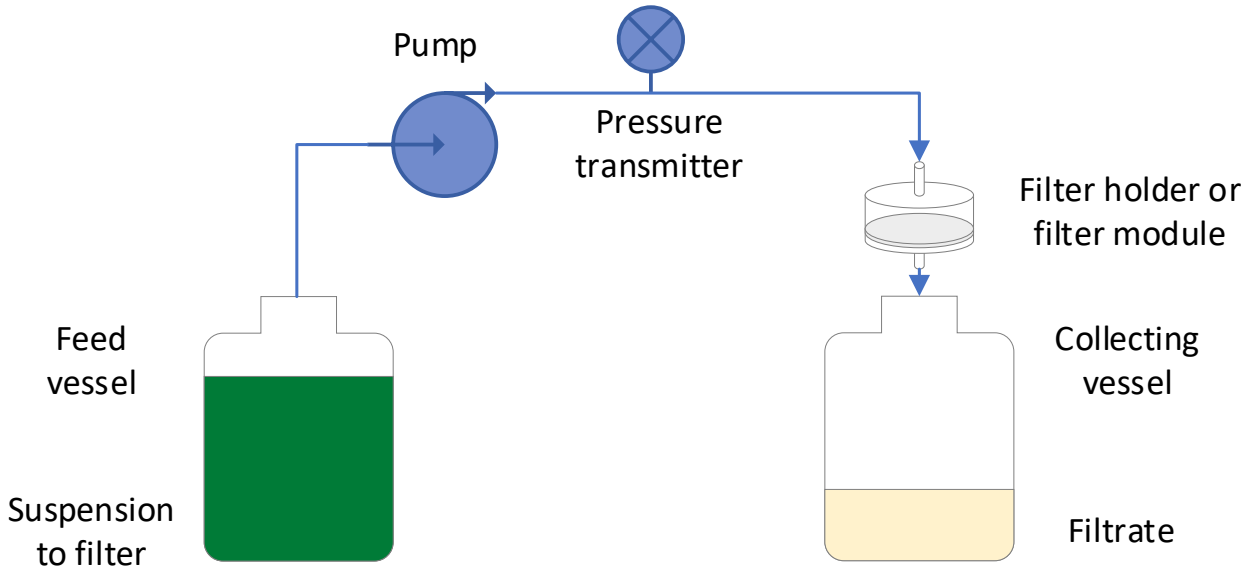
FILTER TYPE (FILTROX PURAFIX)

Reference	Retention rate [µm]
CH 9P	30 - 10
CH 41HP	9 - 4

FILTER CONFIGURATION

https://www.filtrox.com/ *(accessed on 28/09/2020)*

Test setup



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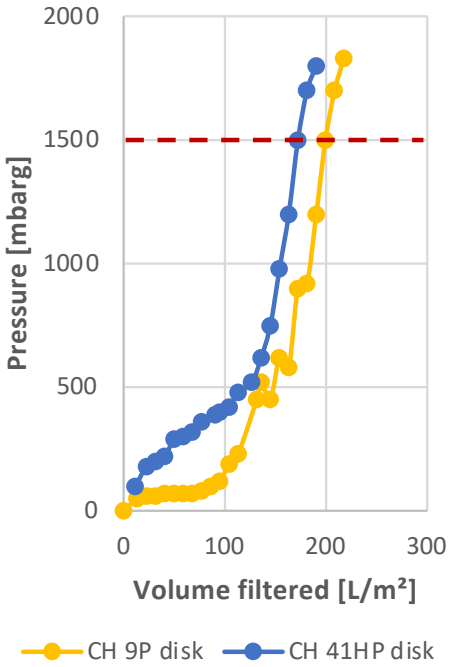
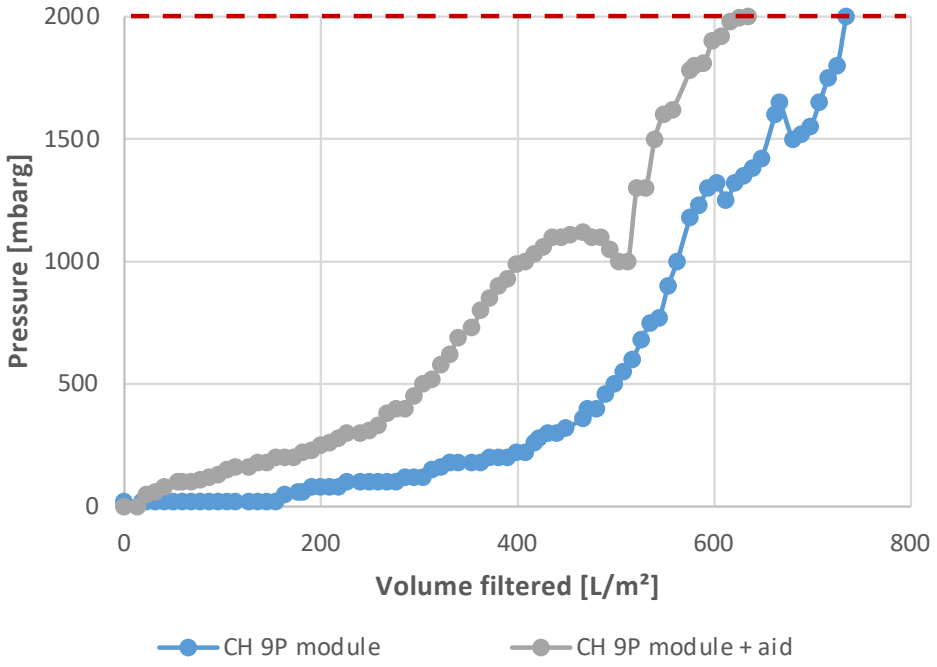
Filter disks



Filter modules (CH 9P)



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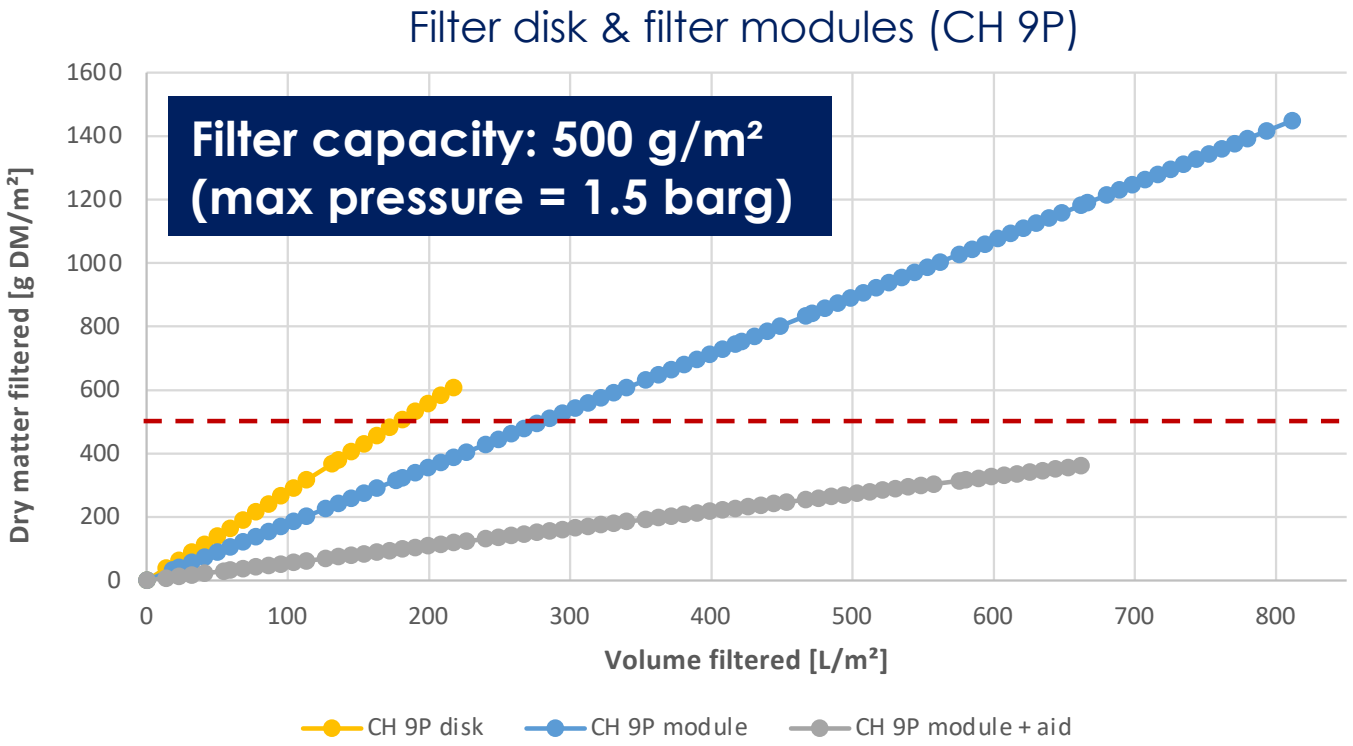
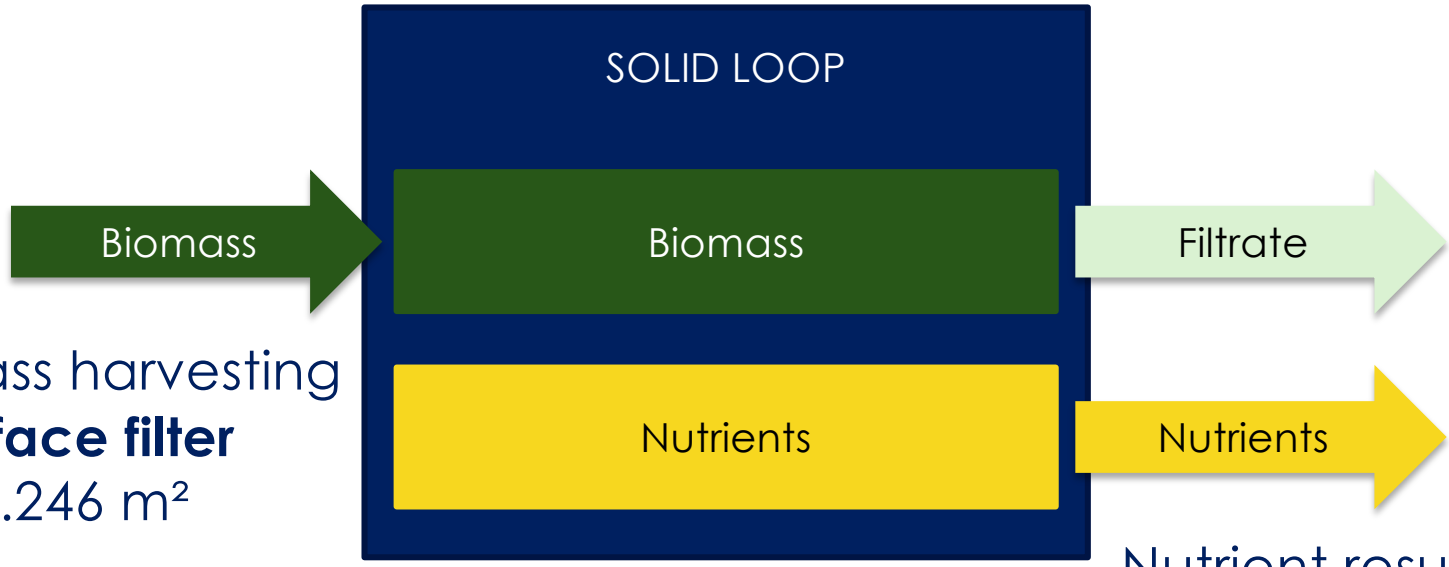
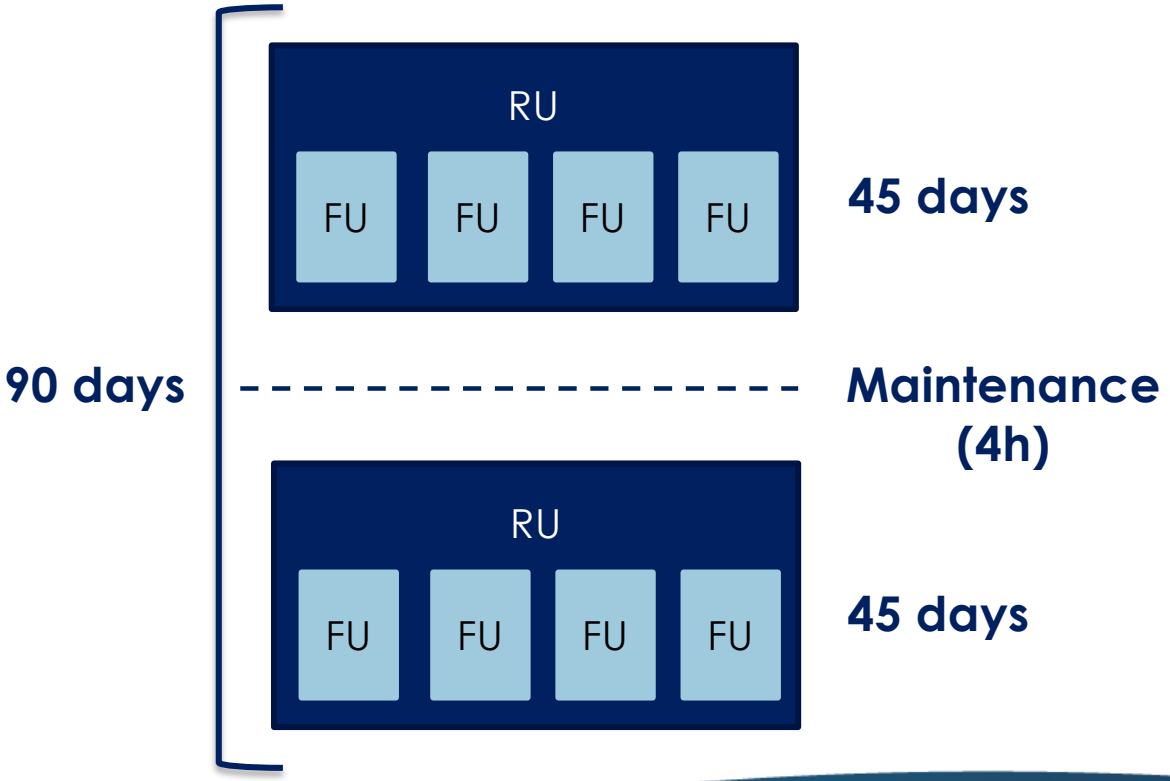


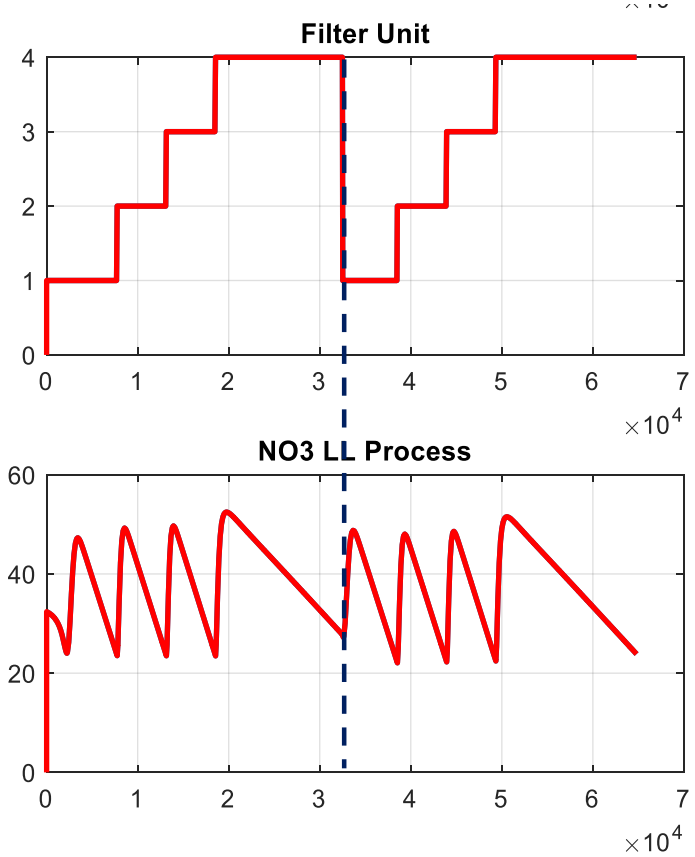


Biomass harvesting
→ **surface filter**
= 0.246 m²

Nutrient resupply
→ **volume solid loop**
= 3.2 L

Operation





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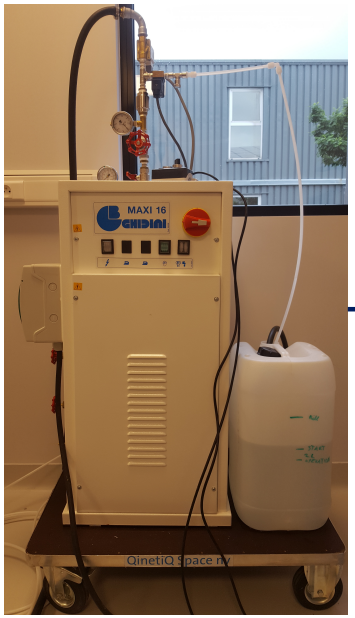
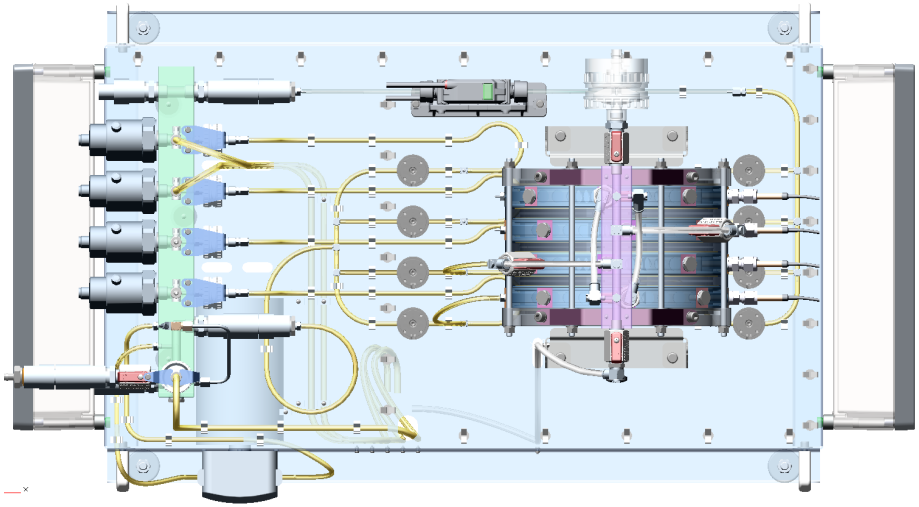
5. BREADBOARD MODEL

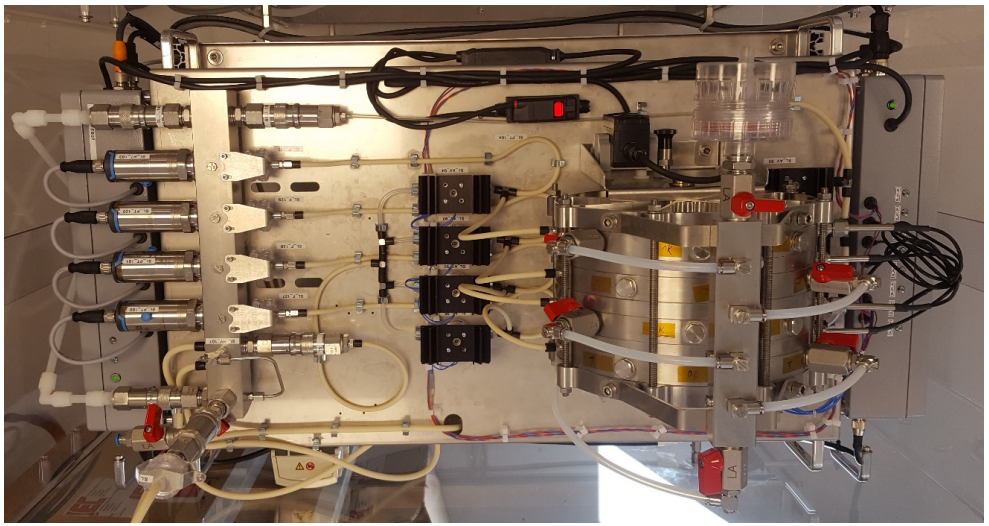


Solid Loop

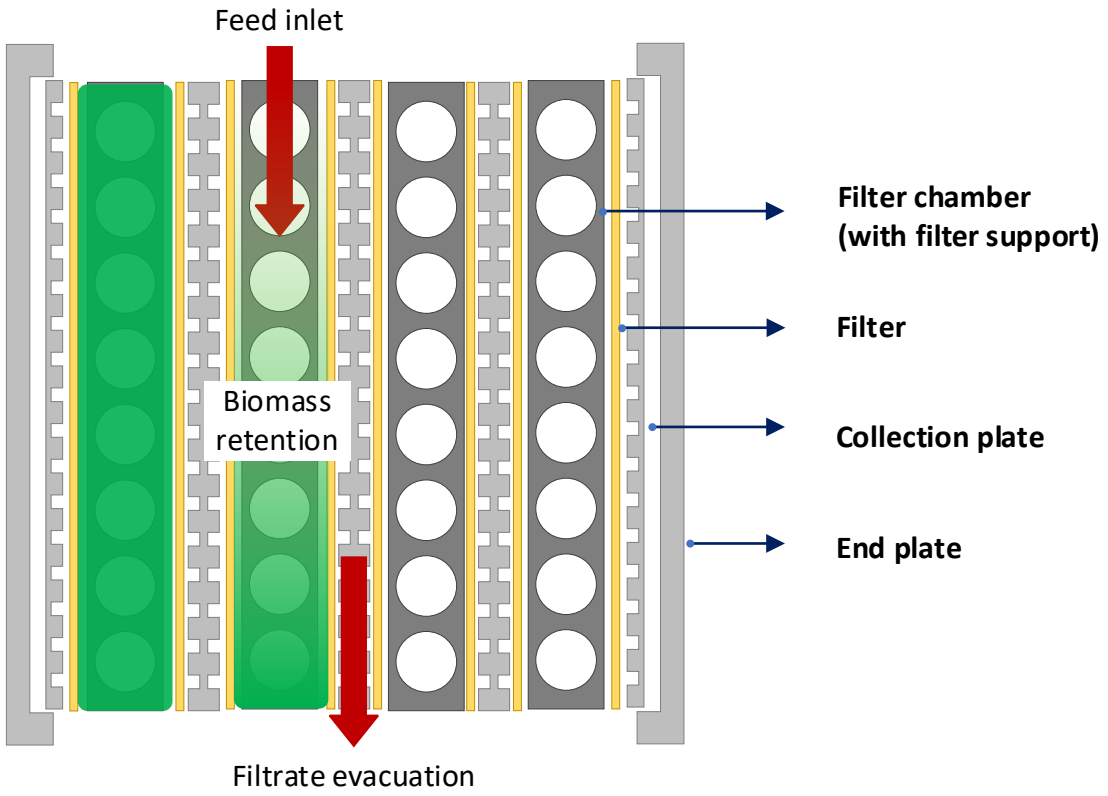
Ground Support Equipment

Top view

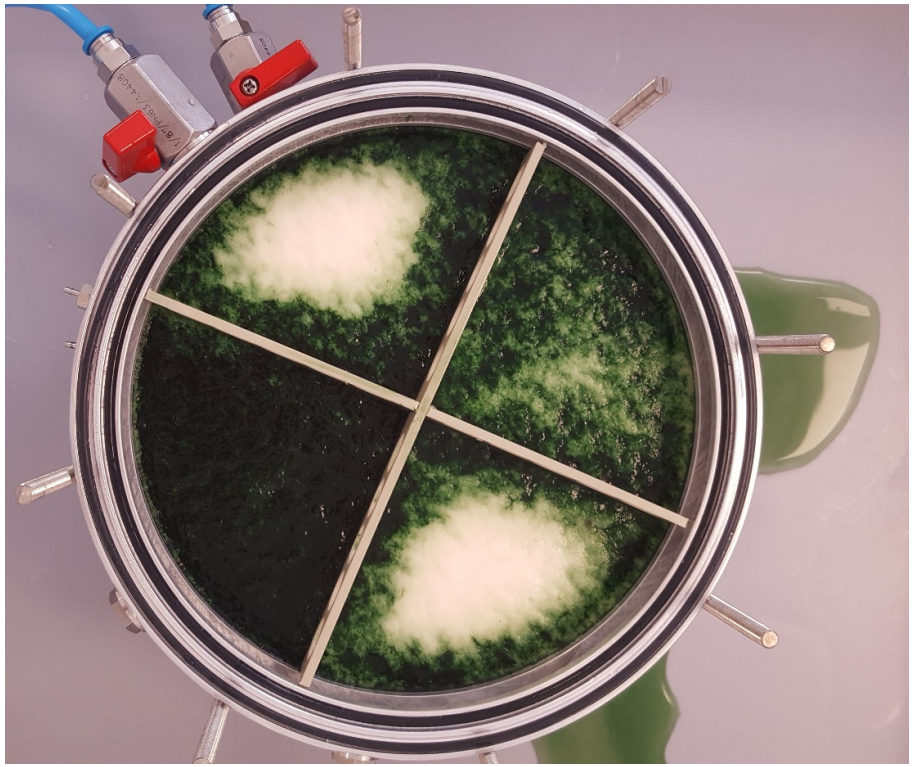




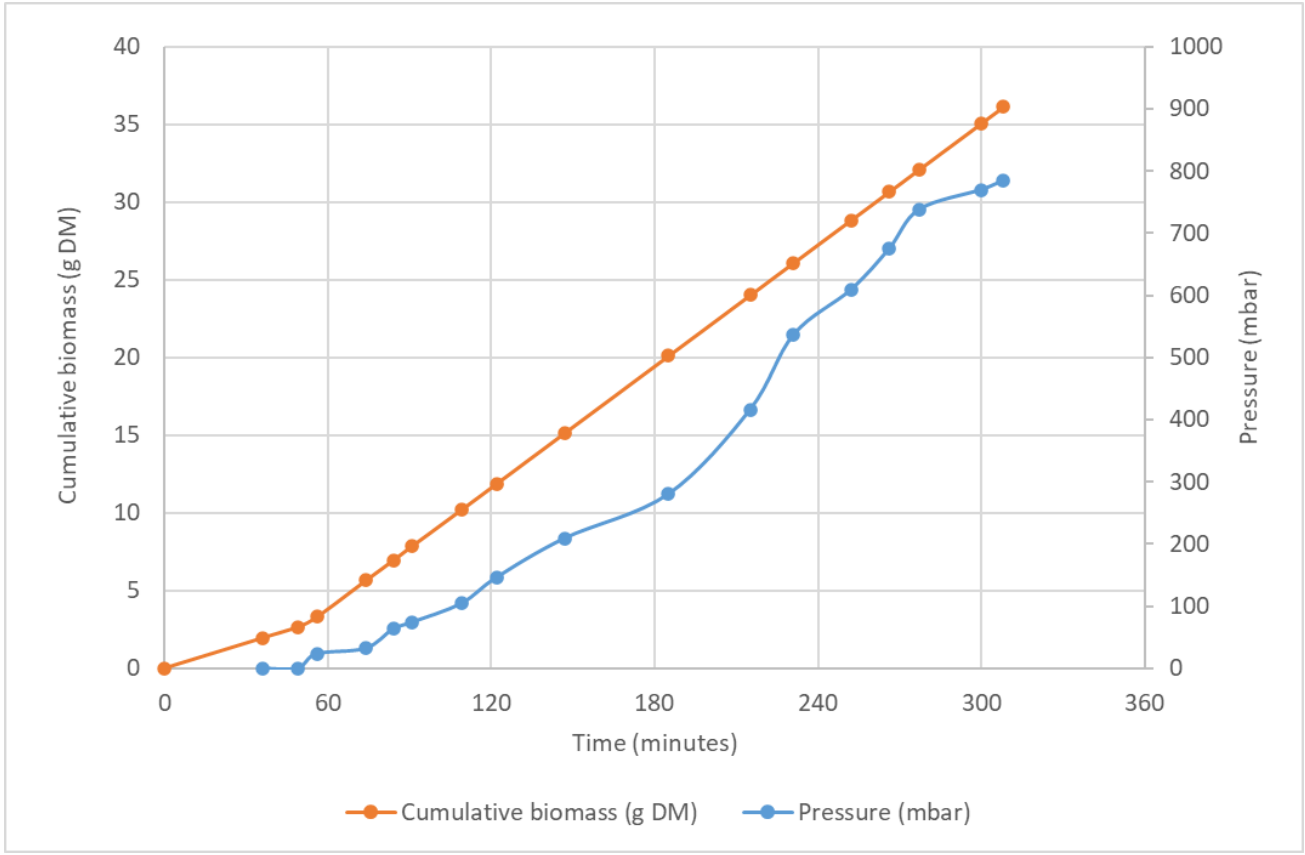
Replaceable unit



6. RESULTS



- Flow rate (min): 30 mL/h
- Flow rate (max): 4 L/h
- Pressure gradient: 30 – 80 mbarg
- Filtrate quality: < 0.01 g biomass/L
- Biomass captured: 36 g/filter unit


Cumulative biomass (g DM)
Pressure (mbar)
Time (minutes)
0
5
10
15
20
25
30
35
40
0
100
200
300
400
500
600
700
800
900
1000
0
60
120
180
240
300
360
Cumulative biomass (g DM)
Pressure (mbar)

7. PERSPECTIVES

BIORAT 1
(phase B)

BioHarvest
Deepening of solid/liquid separation

BIORAT 1
(phases C-D)

GreenLung
Earth application

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THANK YOU.

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