ENHANCE MICROALGAE

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Extraction and purification of metabolites from microalgae: some insights in choice and ecodesign of processes

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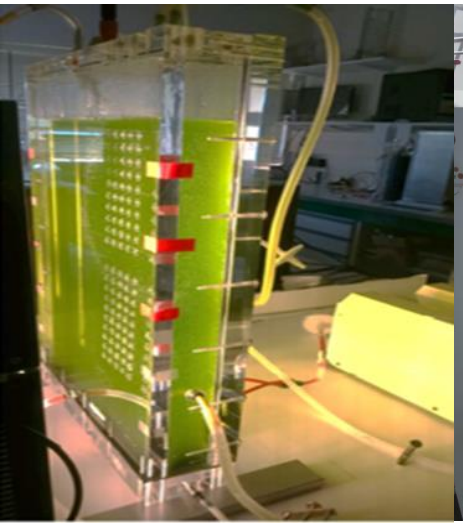
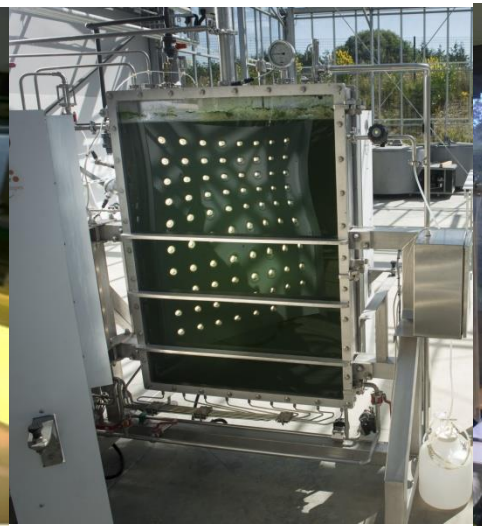
Scientific ref of CPC Engineering Business Unit of Capacités SAS
Biorefinery team of GEPEA Lab

01 Bioprocess Applied to Microalgae team

Up-stream – Mid-stream – Down-stream

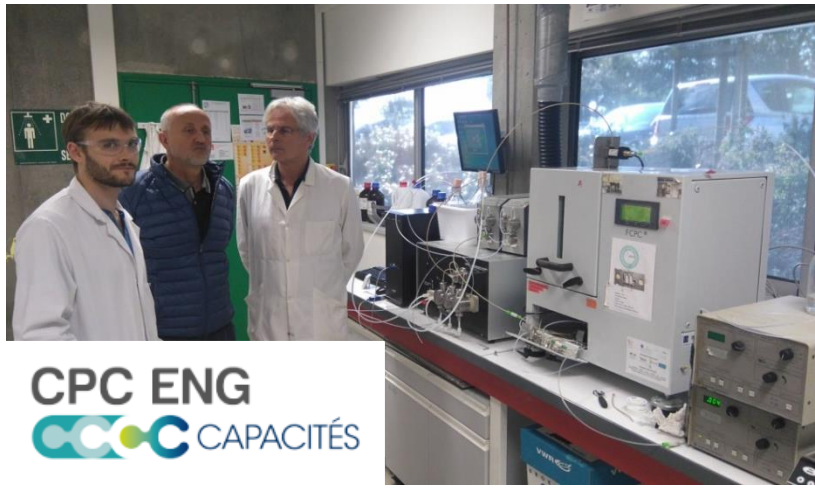

Nantes Université

Graduate school of engineering of the university of Nantes

GEPEA Environnement • Énergie Agro-alimentaire • Mer

ALGOSOLIS MICROALGAE R&D FACILITY

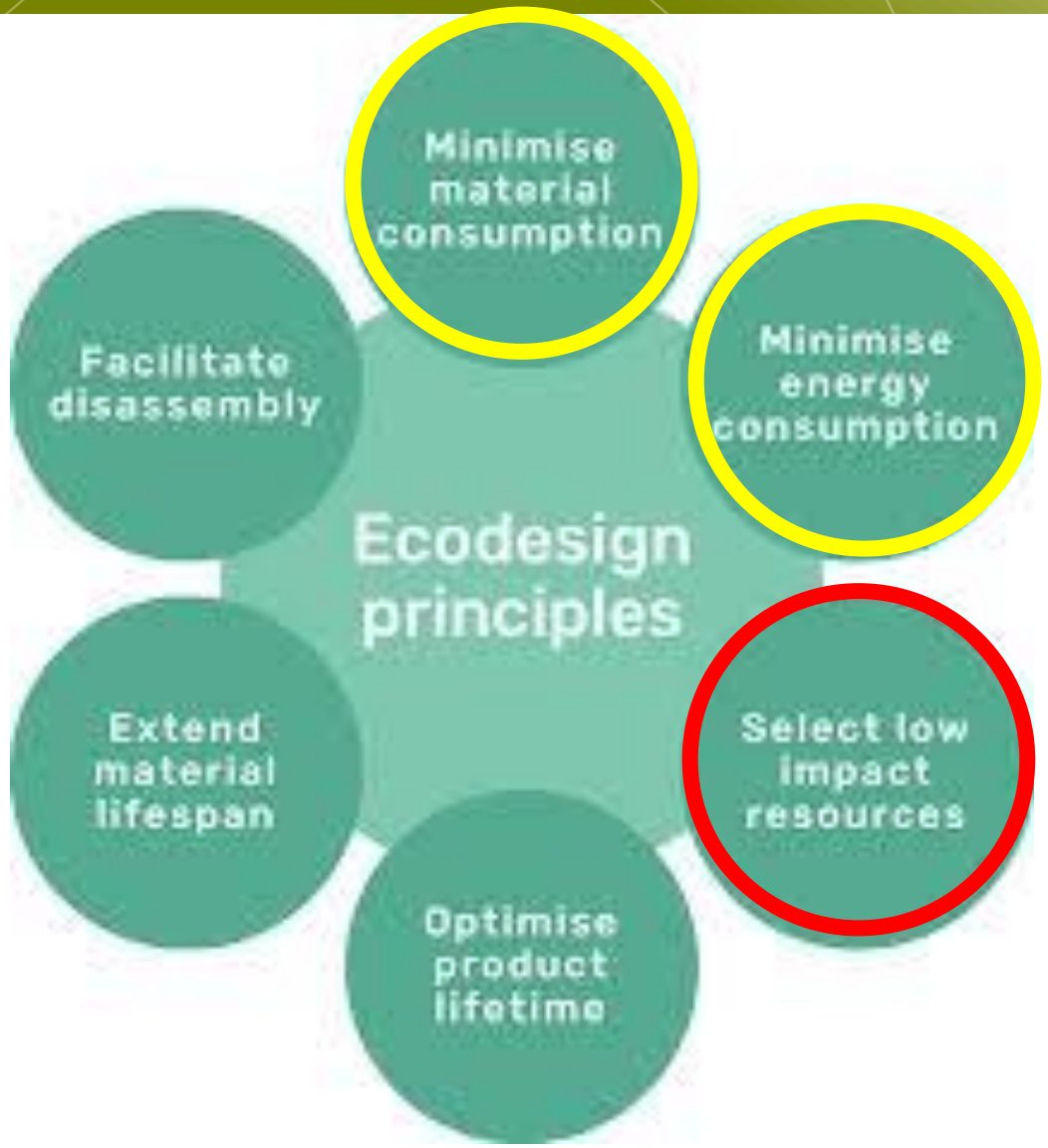

- ➔ Photobioreactor engineering
- ➔ Process integration (biorefinery)
- ➔ Wet biomass fractionation
  - Mechanical cell disruption
  - Membrane separation
  - Liquid-liquid extraction
  - Centrifugal Partition Chromatography
  - Scale-up



CPC ENG

CAPACITÉS

02 Extraction and purification of metabolites from microalgae



➔ microalgae are identified as low impact renewable resources

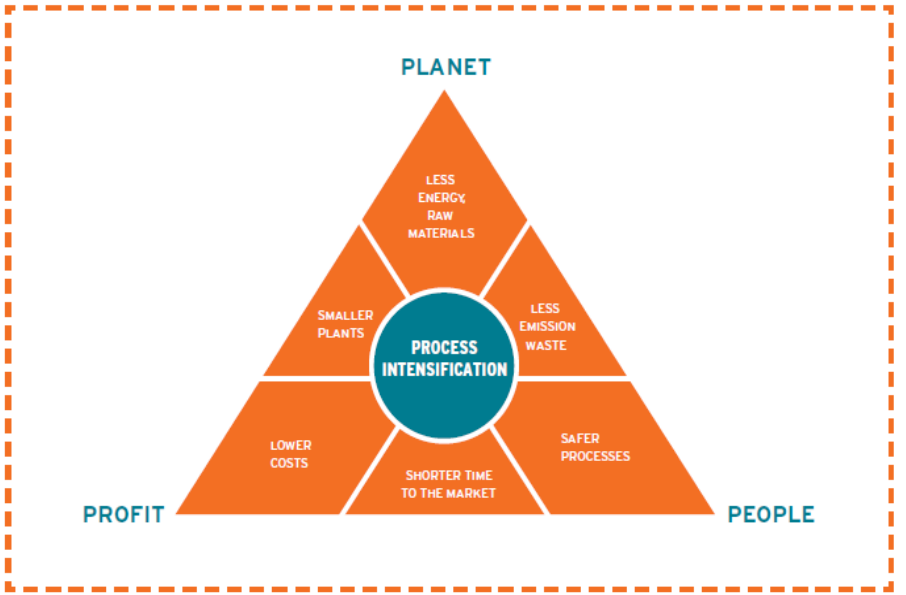
➔ take care of other resources (process facilities)

➔ huge impact on BIOPROCESSES (*1 of the 10 bottlenecks*)

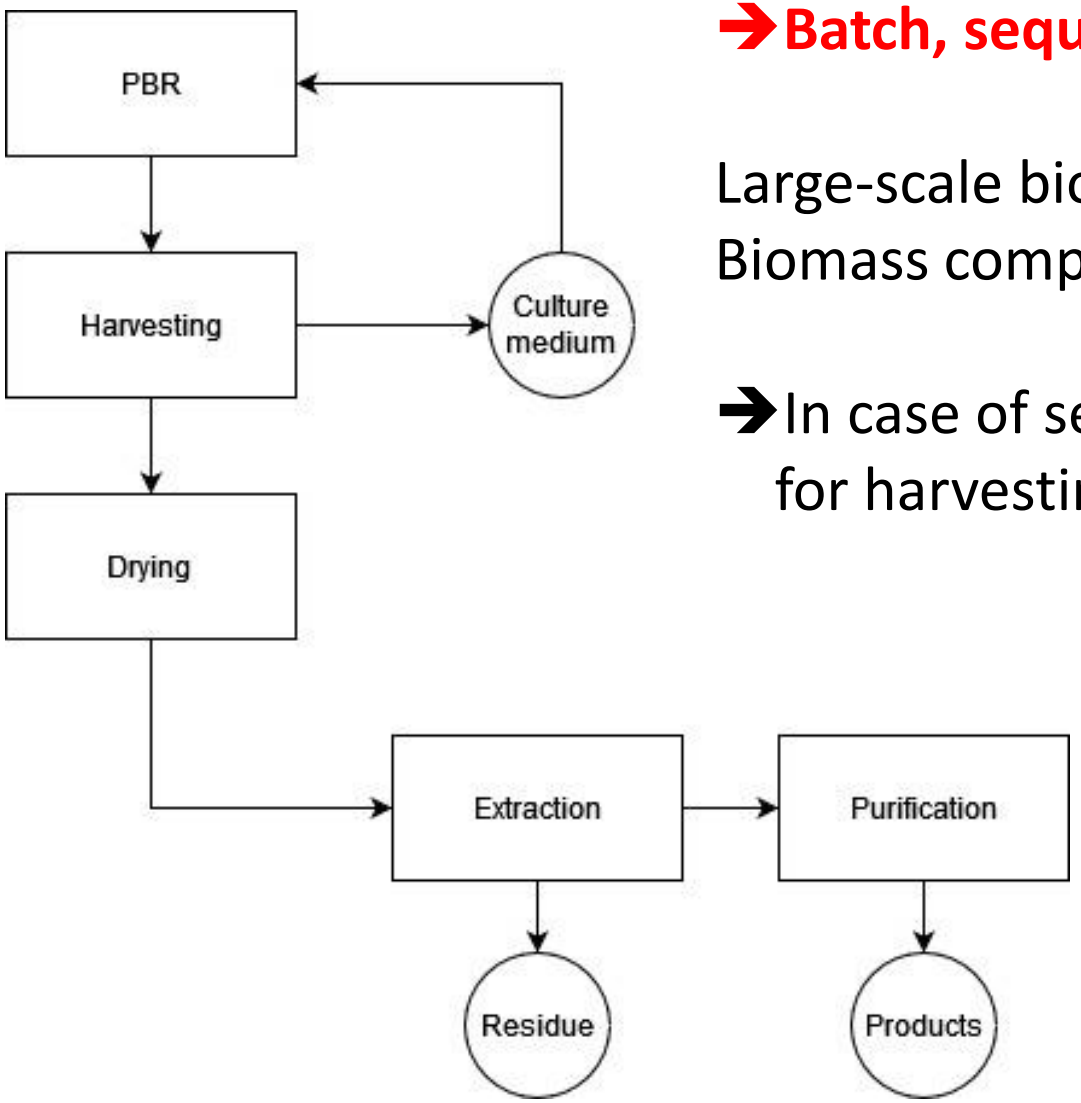
- choice (*technologies*)
- design (*innovation, intensification, hybridation, integration, recycling*)
- development (*mass and energy consumption*)

3 approaches for microalgae DSP eco-design :

- Following the biological rythm
  batch, continuous or sequential ?
- Manage the water
  dry or wet processing ?
- Extraction/Purification without solvent
  alternatives, green solvents



03 Extraction and purification of metabolites from microalgae

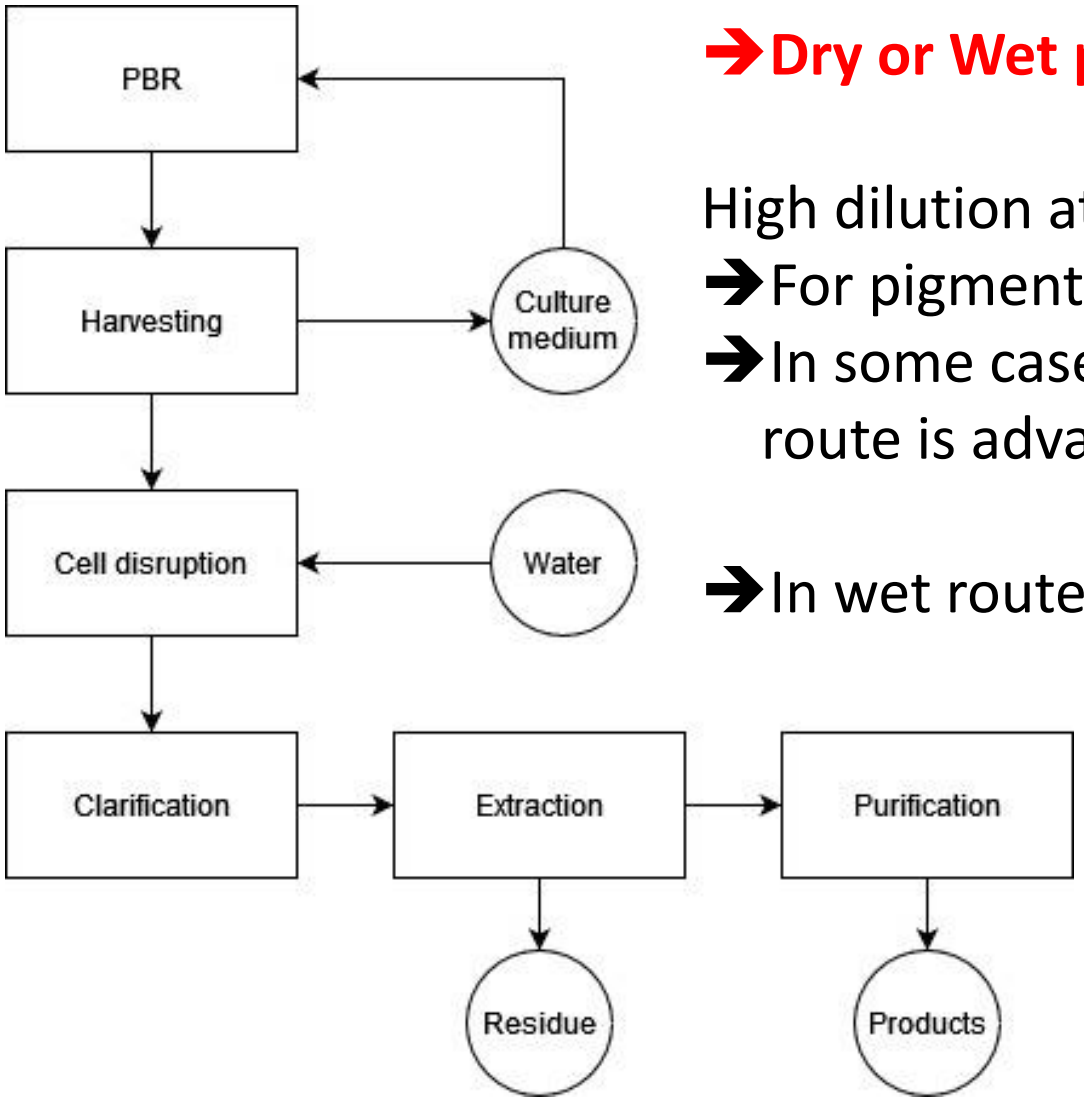


➔**Batch, sequential or continuous process ?**

Large-scale biomass production in solar conditions
Biomass composition, density… depend on the night/day time

➔In case of sequential mode, is there a right period for harvesting and processing ?

04 Extraction and purification of metabolites from microalgae



➔**Dry or Wet processing ?**

High dilution at PBR outlet (<1% dw)

➔For pigments extraction a dry route is convenient (*higher value*)

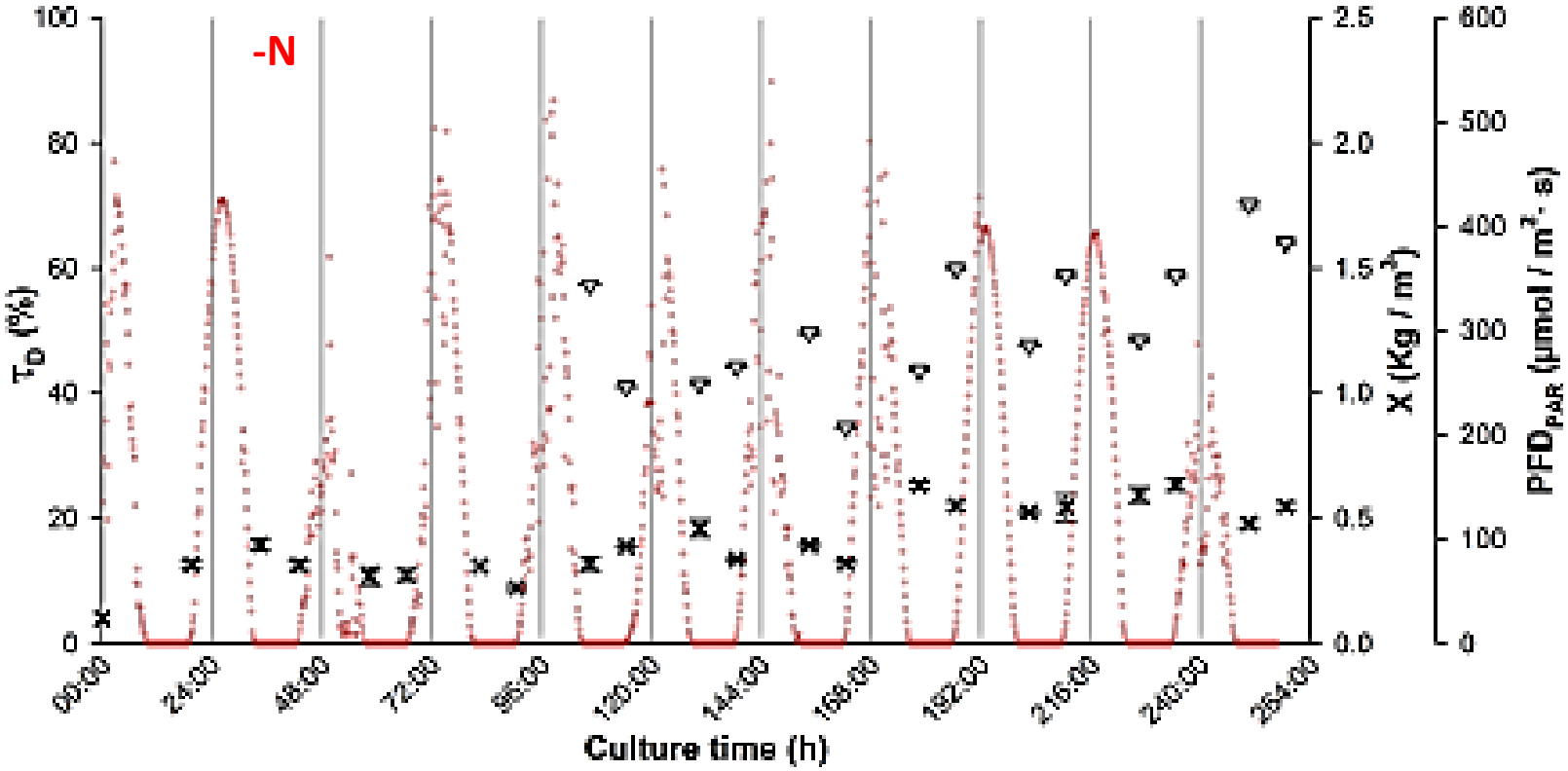
➔In some cases (soluble protein fractions, EPS, biodiesel) wet route is advantageous

➔In wet route, **cell disruption** is the controlling step

SEQUENTIAL PROCESS, INTEGRATION and ENERGY MINIMUM

Vladimir Heredia (2020)

Nannochloropsis oceanica



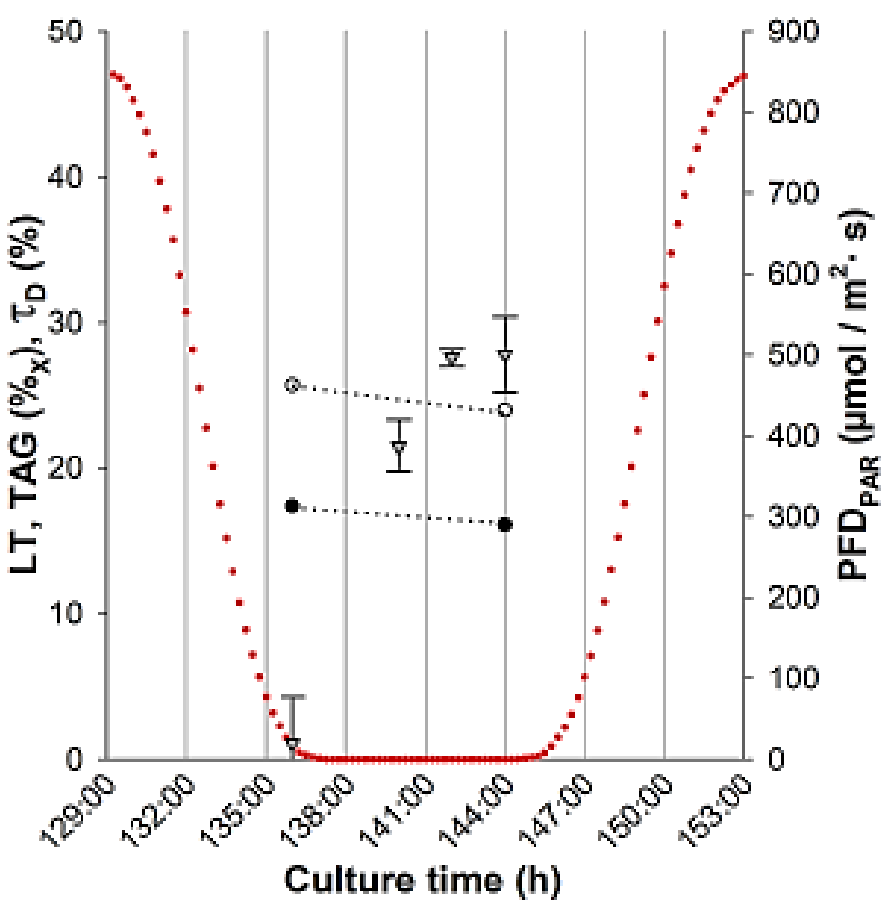
(c) Depleted culture

SEQUENTIAL PROCESS, INTEGRATION and ENERGY MINIMUM

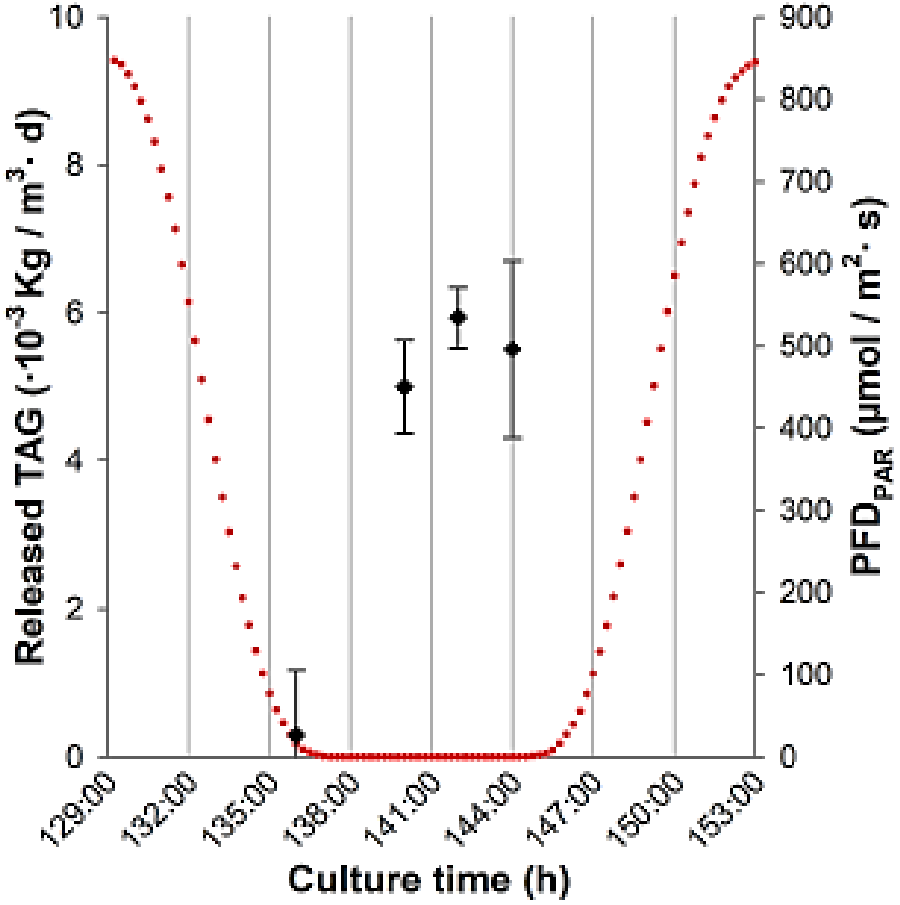
Vladimir Heredia

Nannochloropsis oceanica

Best harvesting period 5h after the end of de day



(a) τ_D , TFA, TAG



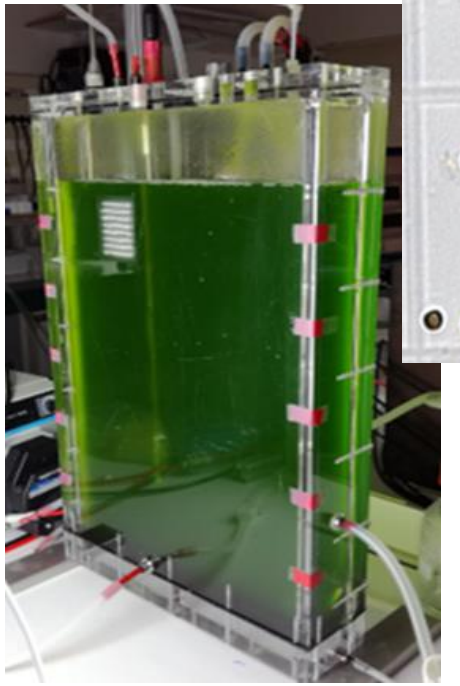
(b) Released TAG

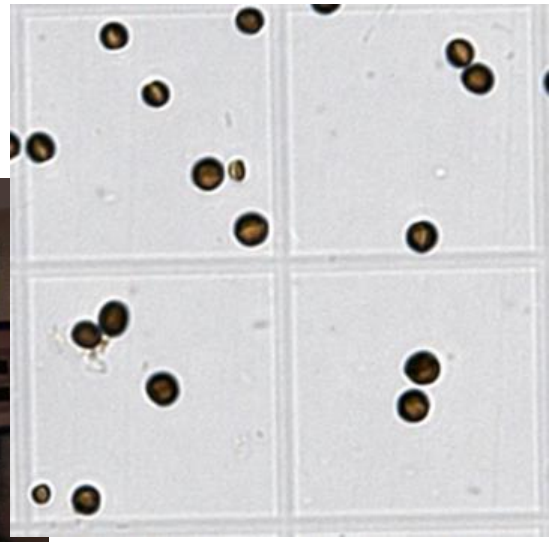
SEQUENTIAL PROCESS, INTEGRATION and ENERGY MINIMUM

Rosine Zinkoné (2018)

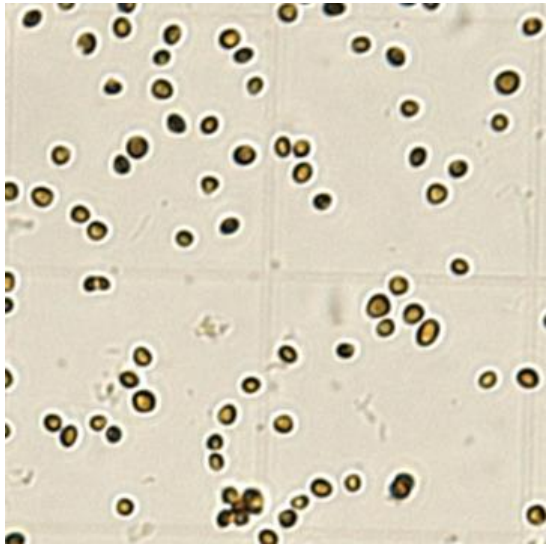
Synchronization of *N. oleoabundans:*

- Cycles de 16h day/ 8h night
- Synchronization **after 4 cycles**





Mother Cells 16h



Daughter Cells 24h

Average of 4 daughter cells / mother cell

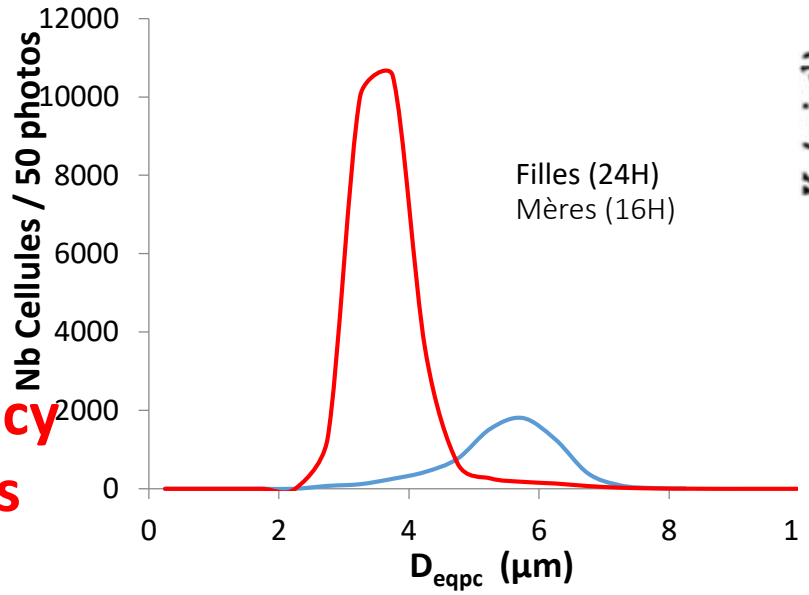
SEQUENTIAL PROCESS, INTEGRATION and ENERGY MINIMUM

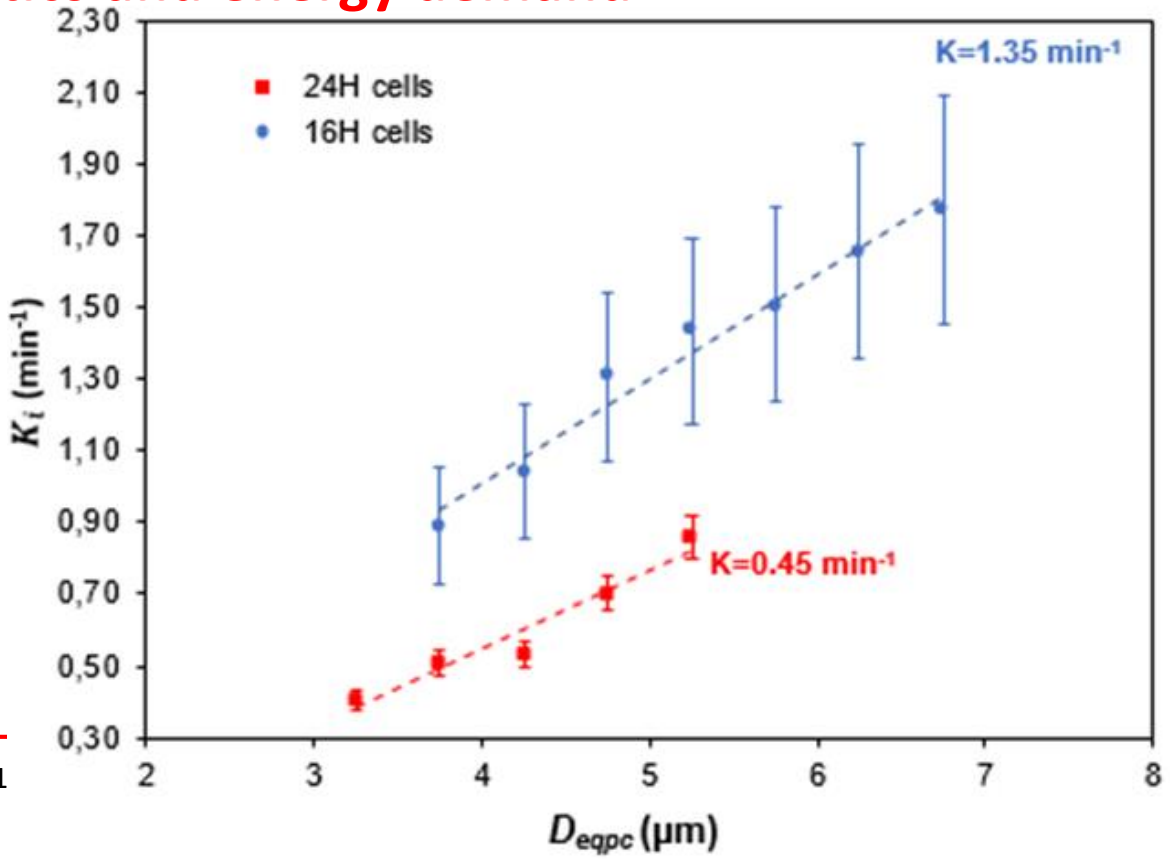
Rosine Zinkoné (2018)

Bead milling kinetics and energy demand

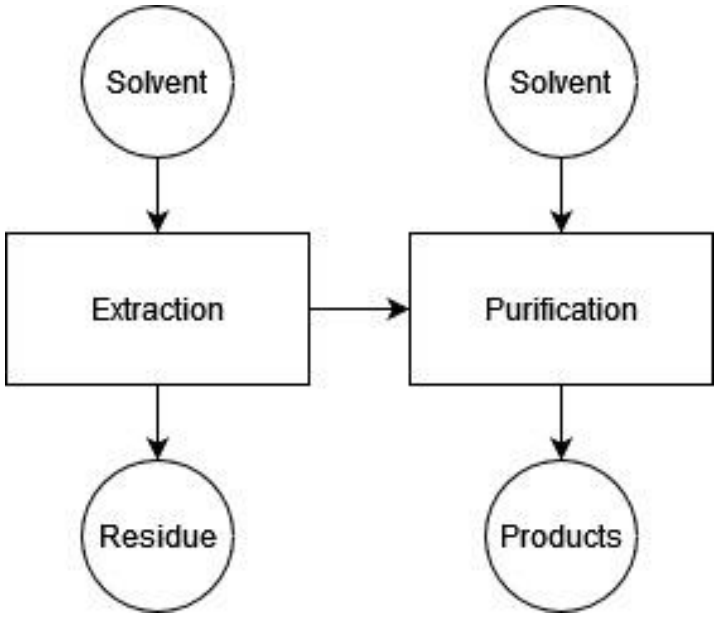
Mother cells are weaker than daughter ones

➔ Cell division moment for disruption efficiency and energy savings





09 Extraction and purification of metabolites from microalgae



➔**Extraction and purification with or without solvents ?**

➔Solutions for water soluble molécules : **membrane** concentration, fractionation

➔For other metabolites : **what solvents** are in accordance with bioressource valorization ? In accordance with the application field ?

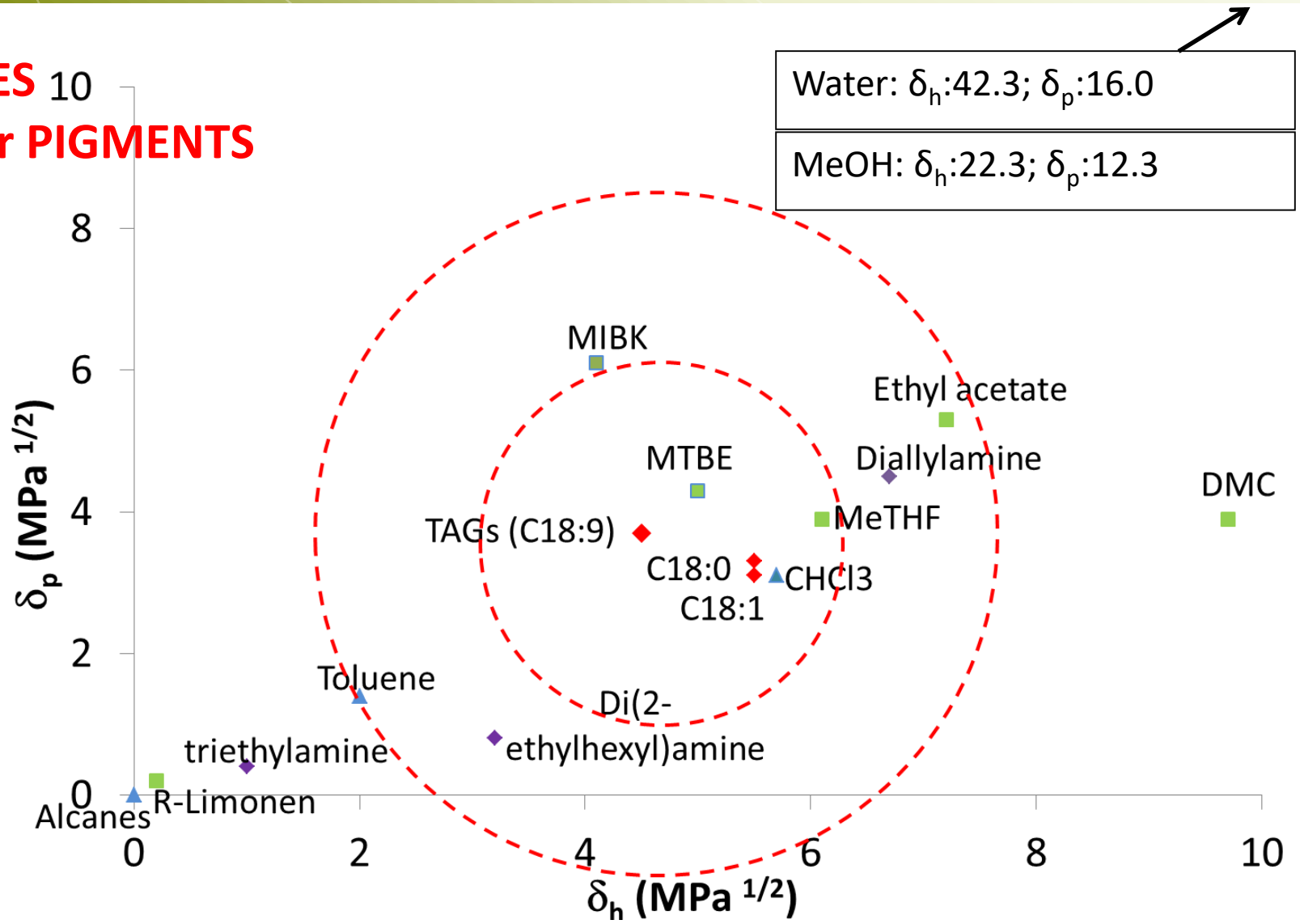
CO_2, green (organic) solvents, NaDES
Low volatility phases = des-extraction step ? Carrier solvent ?

➔**Green solvent = green process ?**

SOLVENTS AND TECHNOLOGIES FOR EXTRACTION OF LIPIDS or PIGMENTS

Emilie Angles (2014)

Hansen solubility param.

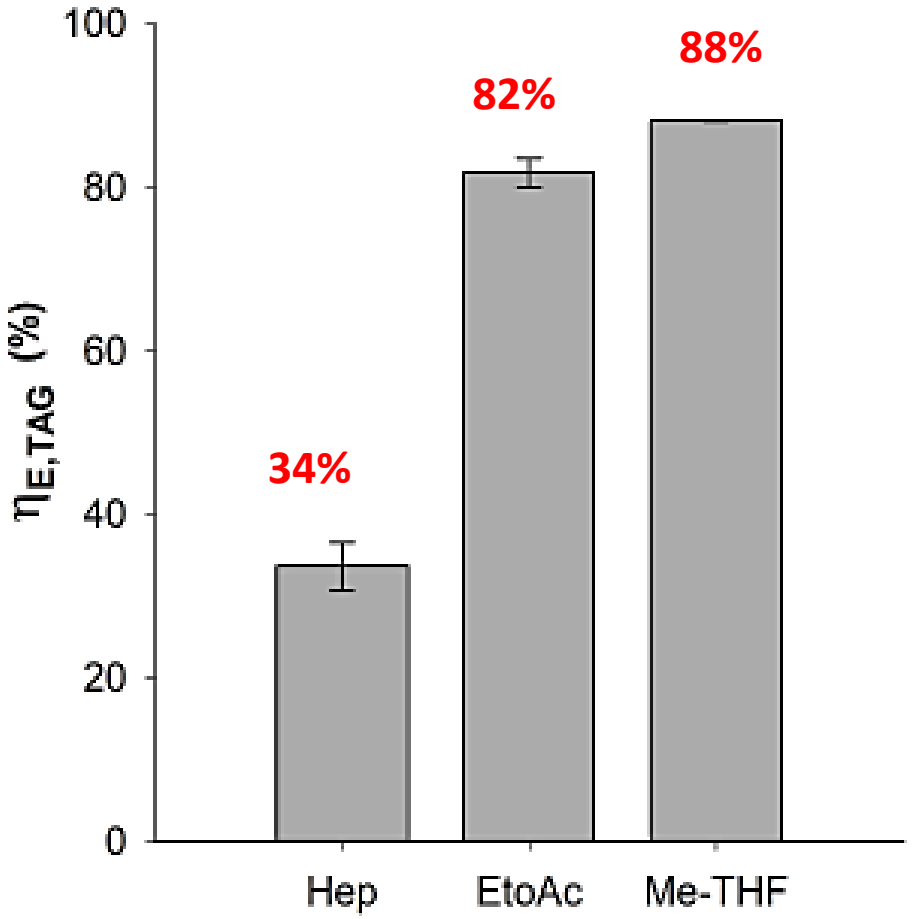


SOLVENTS AND TECHNOLOGIES FOR EXTRACTION OF LIPIDS or PIGMENTS

Vladimir Heredia (2020)

Nice performances of lipids extraction in wet route

➔ Solubility with water that make solvent recovery more difficult



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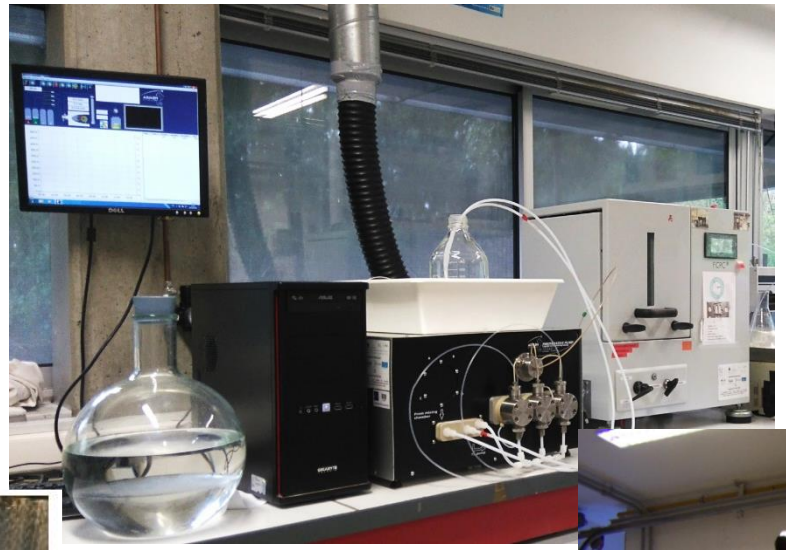
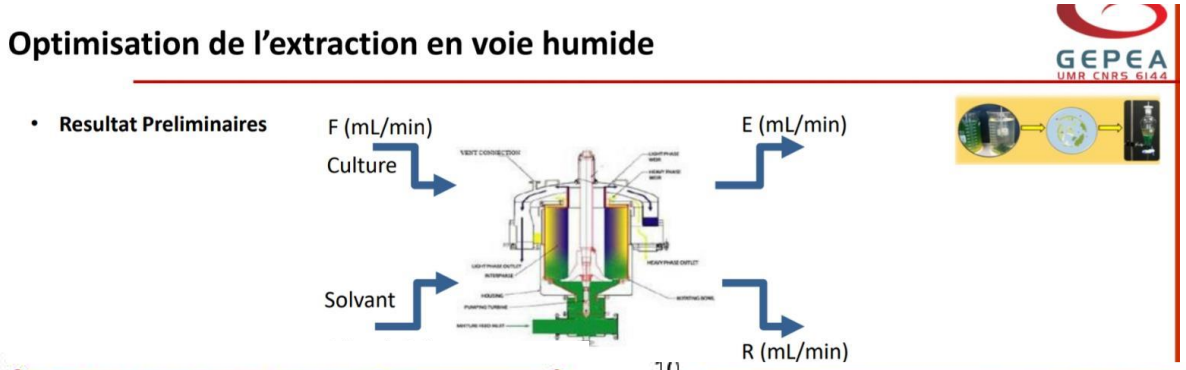
SOLVENT CONSUMPTION REDUCTION (PROCESS INTENSIFICATION by CENTRIFUGATION)

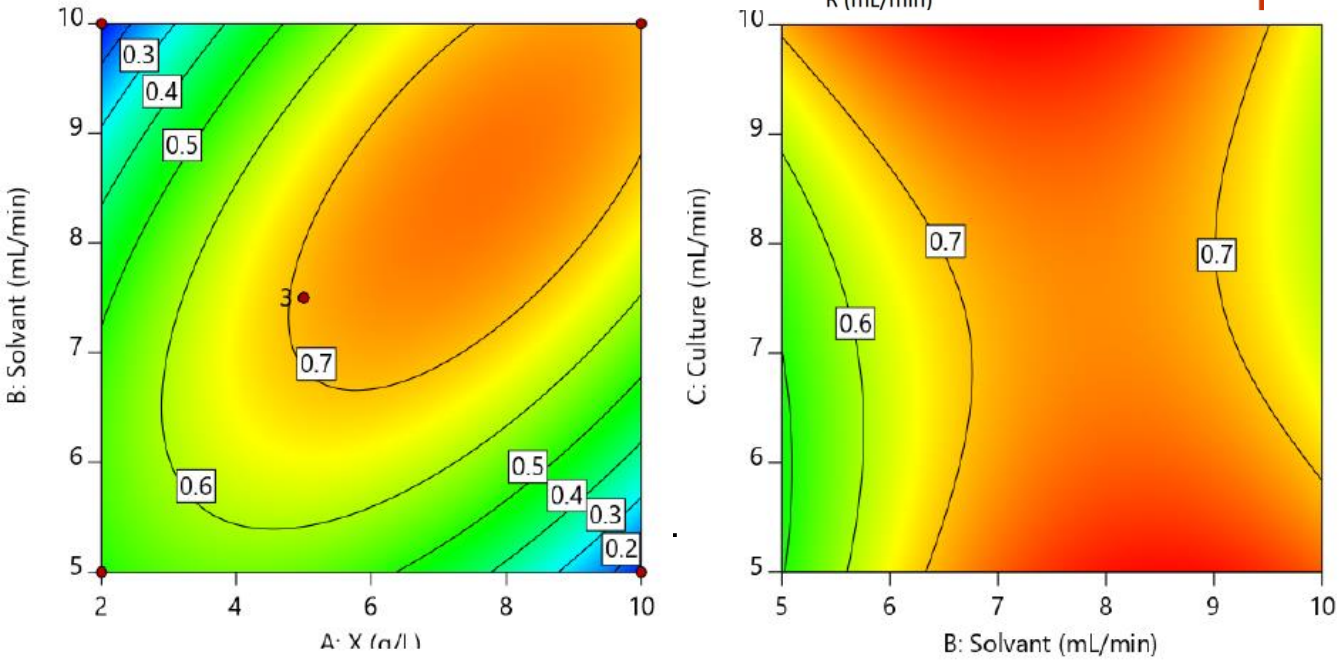


CPC

BXP

BXP : one stage, continuous



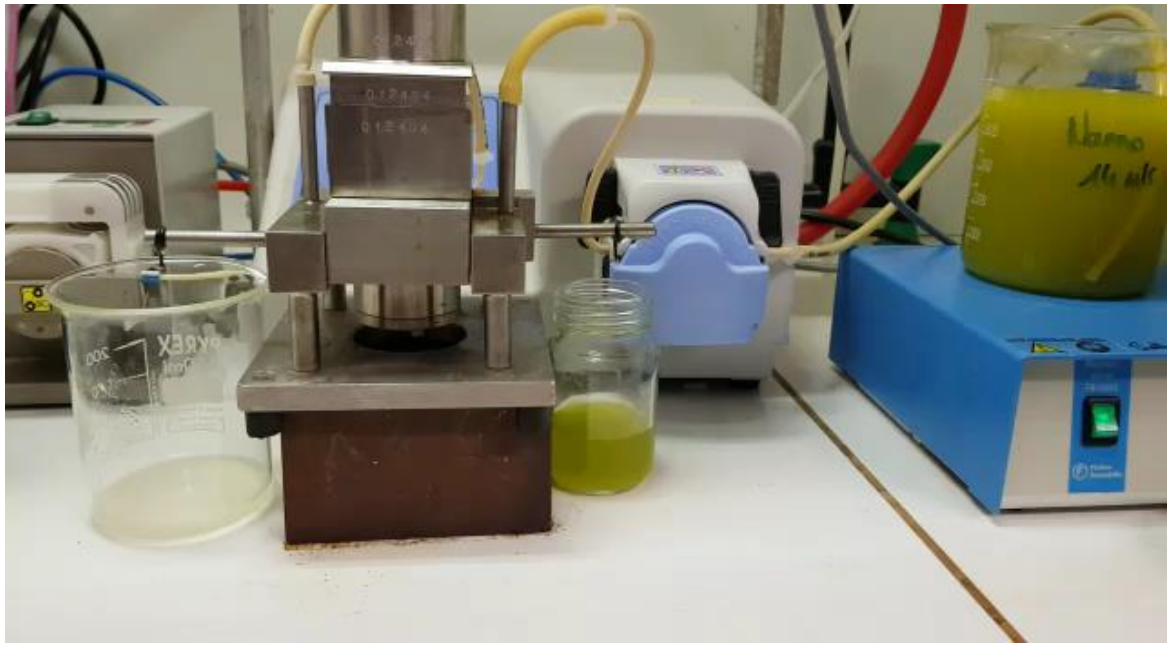


Extraction yields: 75-80%

Limitations:

Low dw concentrations at process inlet (5-6 g/l) Optimal Solvent Ratio : **1**

Specific solvent need 172 g/g_{ms}



14 Extraction and purification of metabolites from microalgae

CPC : one stage, discontinuous

Green solvents can be implemented

8x Solvent reduction by technology

➔ Still some limitations

Extraction yields: >80%

Limitations:

Low dw concentrations at process inlet (5-6 g/l) Optimal Solvent Ratio : **0.07**

Specific solvent need 23 g/g_{ms}

	Heptane	m-THF
Density	**0,68**	**0,86**
Bp (°C)	**98,4**	**79,0**
Solubility in water	**3,4 mg/l**	**130 g/l** (décroit avec la T)
lipids recovery	**80 %**	**150 %**
TAG recovery	**35 %**	**83 %**

Extraction and purification of metabolites from microalgae

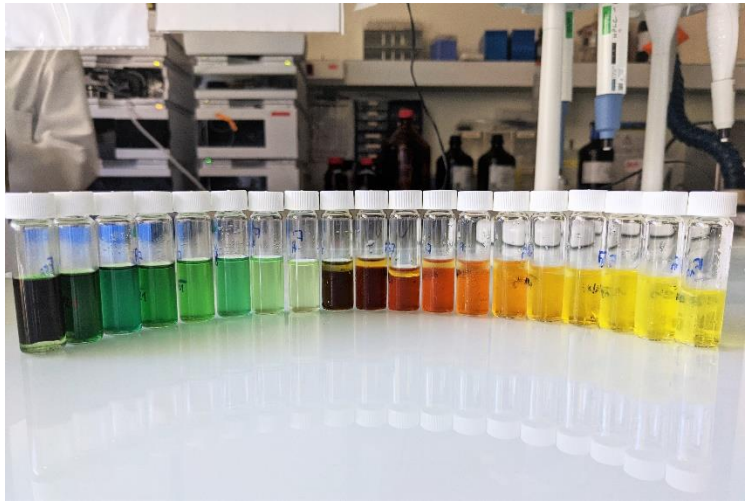
CONCLUSIONS :

- Microalgae can have a growing production cycle controlled by solar day/night cycle
- This has a direct effect on microalgae composition, size and mechanical robustness

- Some strategy for optimal metabolite release and disruption energy minimization can be proposed for <u>sequential production</u>

- Membrane concentration, fractionation is efficient for biopolymers, hydrolysates

- For lipids, <u>alternative (green) solvents</u> can be proposed for extraction or purification



- For <u>low volatility</u> solvents (glyOH, oils, NaDES): solvent recycling issues

THANK YOU FOR YOUR ATTENTION
SEE YOU SOON in SAINT NAZAIRE !

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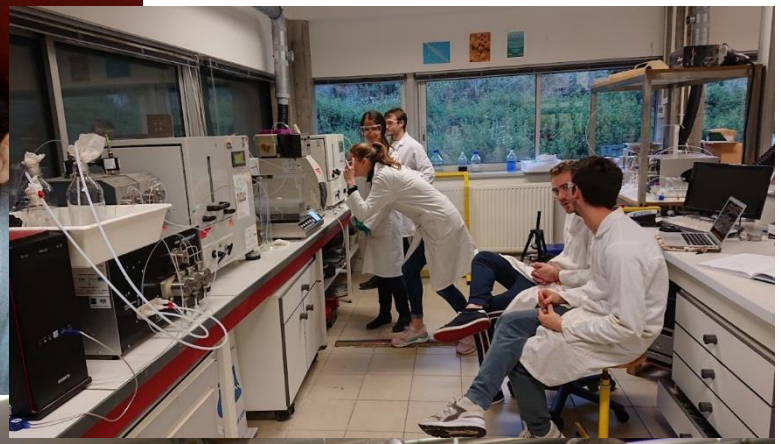

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