Developing solutions using algae to reduce waste and develop new products

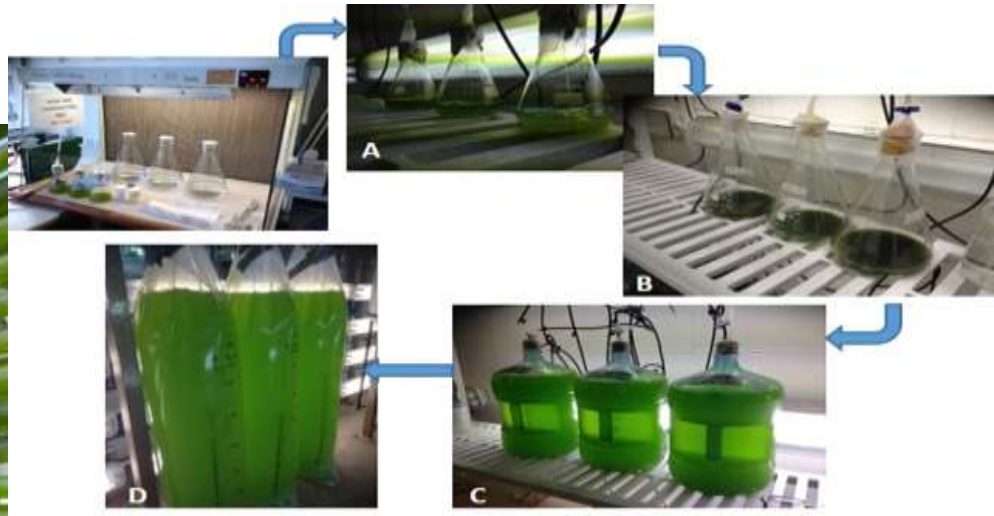
Carole Llewellyn
Professor in Applied Aquatic Bioscience
Swansea University, Wales, UK

9th October 2019

EBNet
Environmental Biotechnology

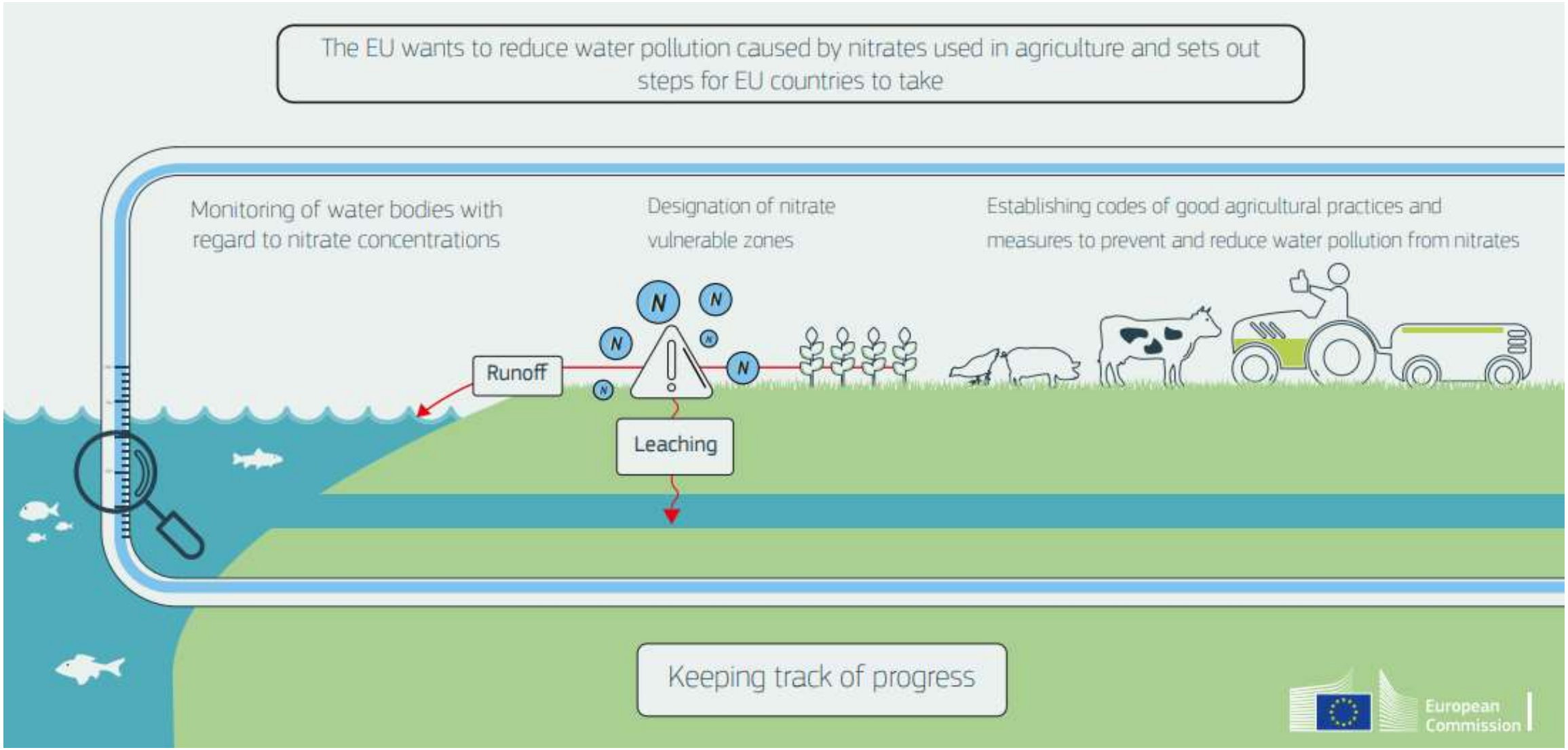
Algae-UK
Exploiting the algal treasure trove

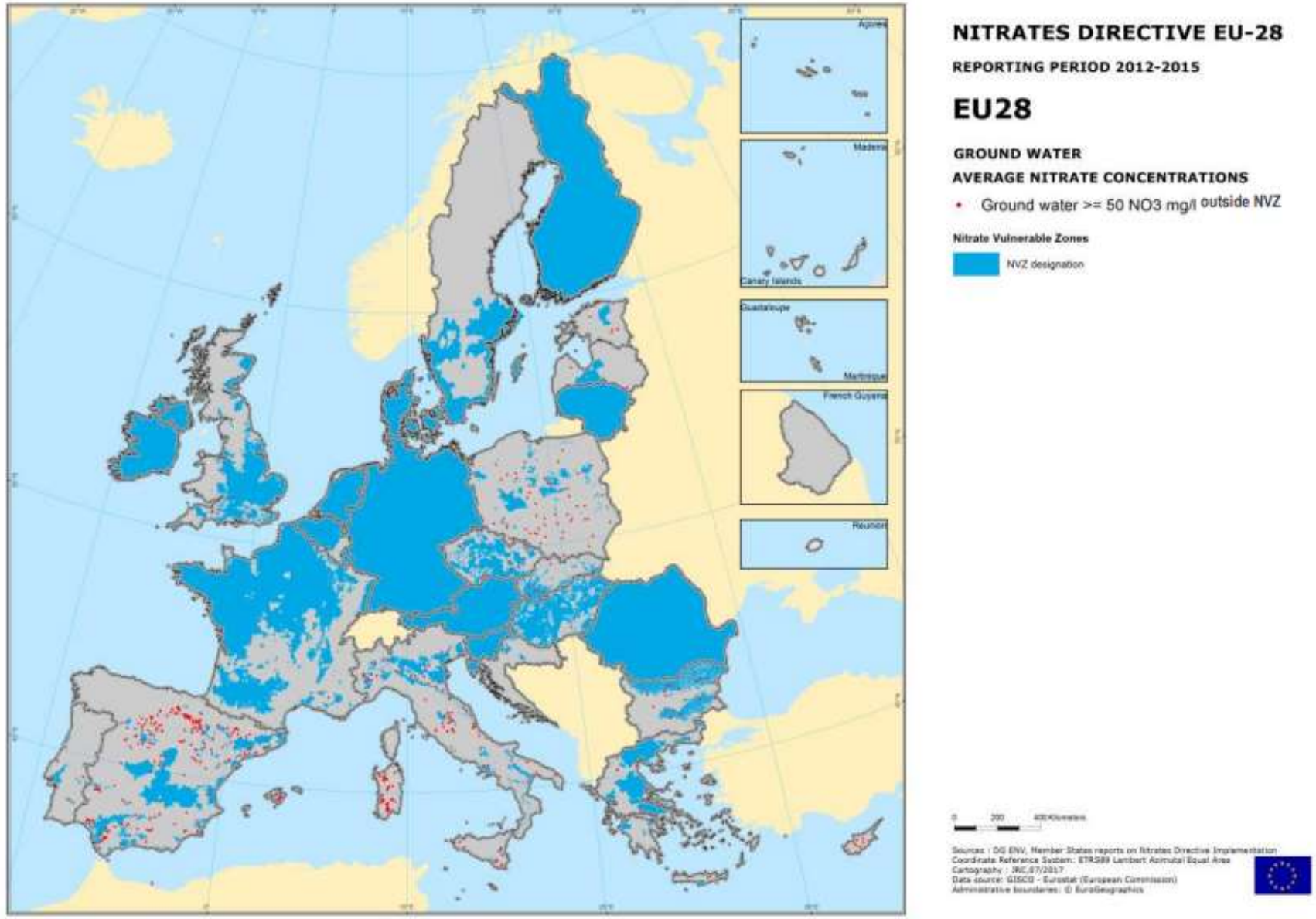
Swansea University Algal Cultivation Facilities



Controlled environment lab & greenhouse location
400L Biofence, 600L 2 x Biofences™, 2,000L 1x vertical tube PBR

Driver behind the ALG-AD project: European Nitrate Directive 91/676/EEC

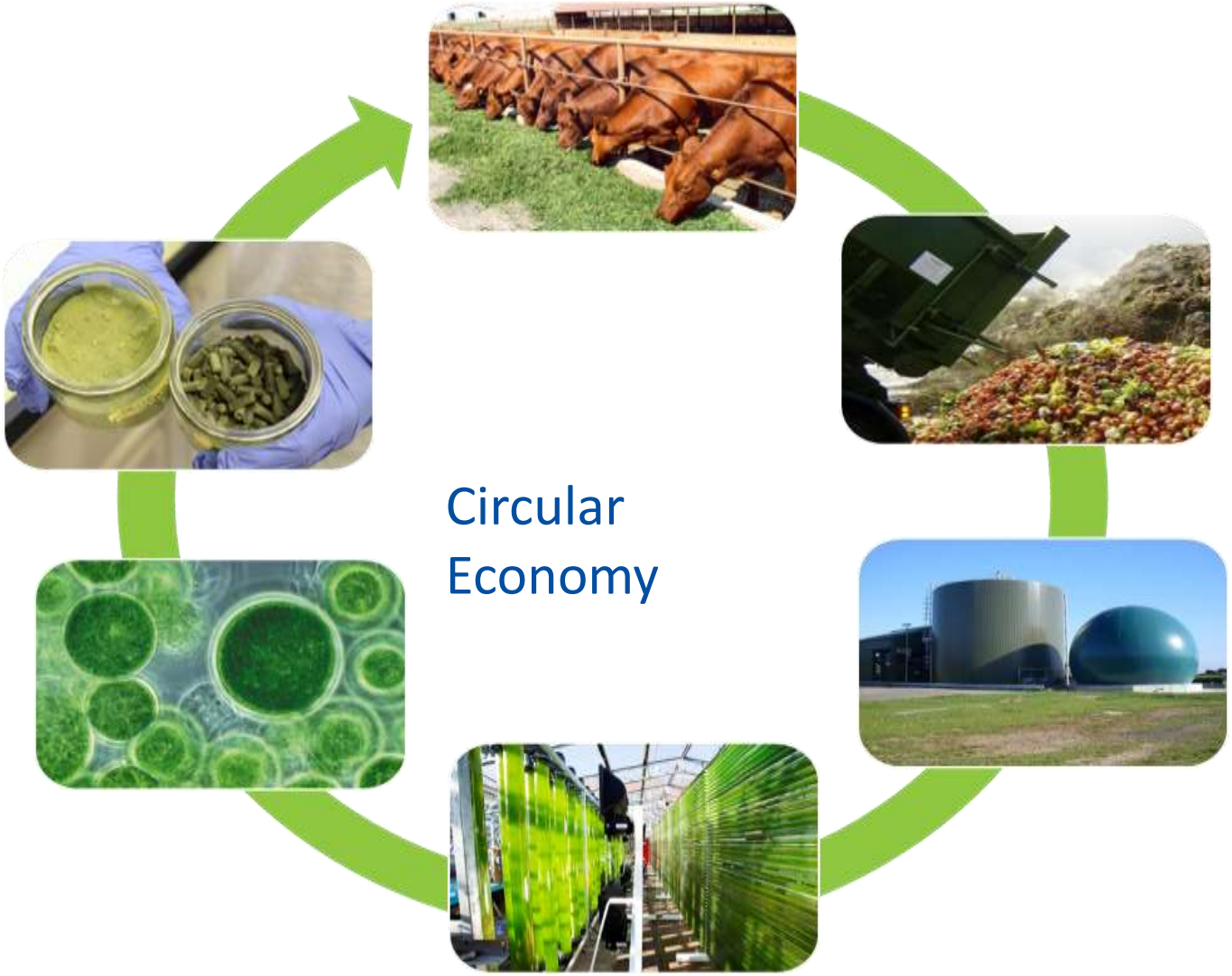




Map A. *Area designated as Nitrates Vulnerable Zone and groundwater monitoring stations with average nitrates concentrations above 50mg/L outside NVZ, period 2012-2015*[44].

ALG-AD - Creating value from waste nutrients by integrating algal and anaerobic digestion technology

Interreg North-West Europe ALG-AD



- https://youtu.be/4jzGtjlm2QU
- Three investment sites at Ghent, Brittany and Devon
- Operation of investments and recovery of waste nutrients to produce algal biomass
- Developing algal biomass into commercial products
- Scenario and Decision Tools
- Long term roll out of technology

WASTES (cattle manure/kitchen waste)

ANAEROBIC DIGESTION

Biogas production → ENERGY

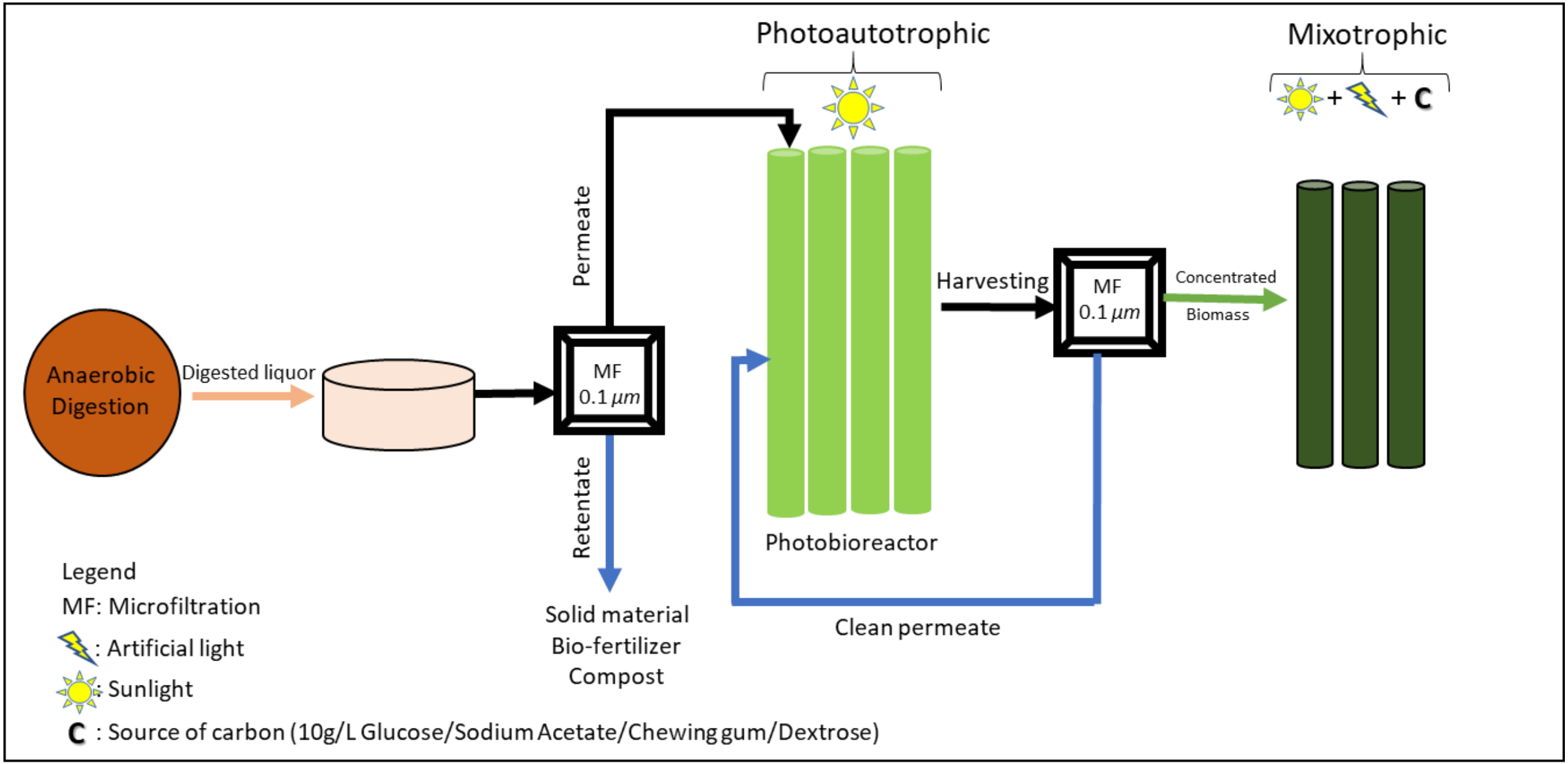
ALGAL CULTIVATION

Animal feed

Nitrogen Rich Digestate

High value compounds (lipids, proteins)

CIRCULAR ECOMOMY


Photoautotrophic
Mixotrophic
+ C
Permeate
Anaerobic Digestion
Digested liquor
MF 0.1 μm
Retentate
Harvesting
MF 0.1 μm
Concentrated Biomass
Photobioreactor
Solid material
Bio-fertilizer
Compost
Clean permeate
Legend
MF: Microfiltration
: Artificial light
: Sunlight
C : Source of carbon (10g/L Glucose/Sodium Acetate/Chewing gum/Dextrose)

Interreg North-West Europe ALG-AD

European Regional Development Fund

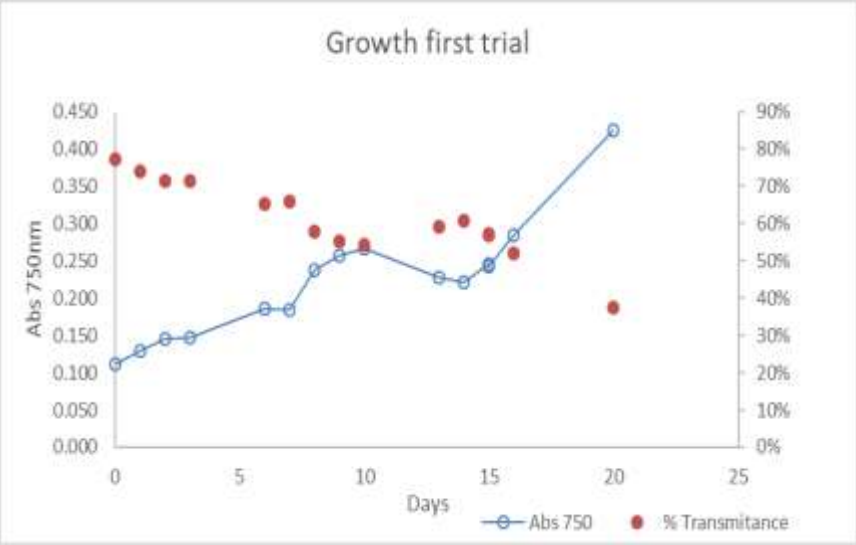
Swansea University Prifysgol Abertawe

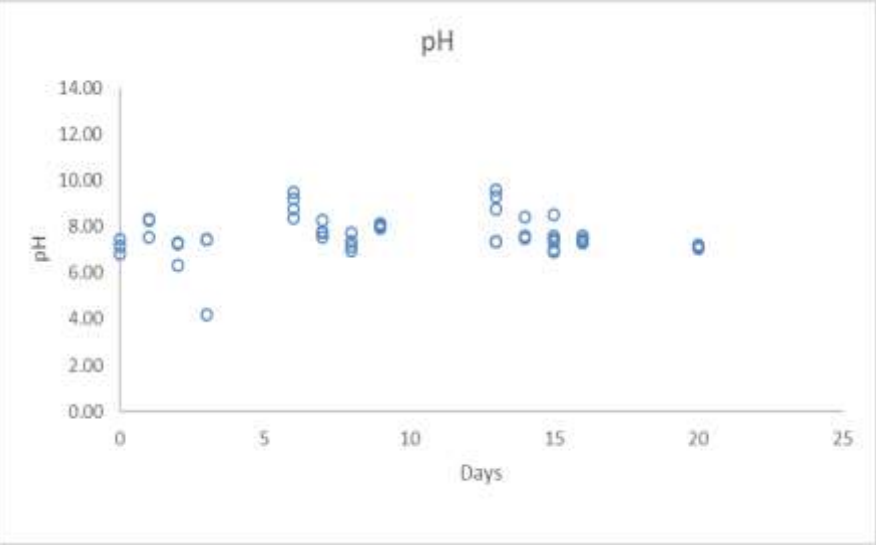
2018-2021: 5.5M Euro
Led by Swansea University:
11 partners. UK, France, Belgium, Germany

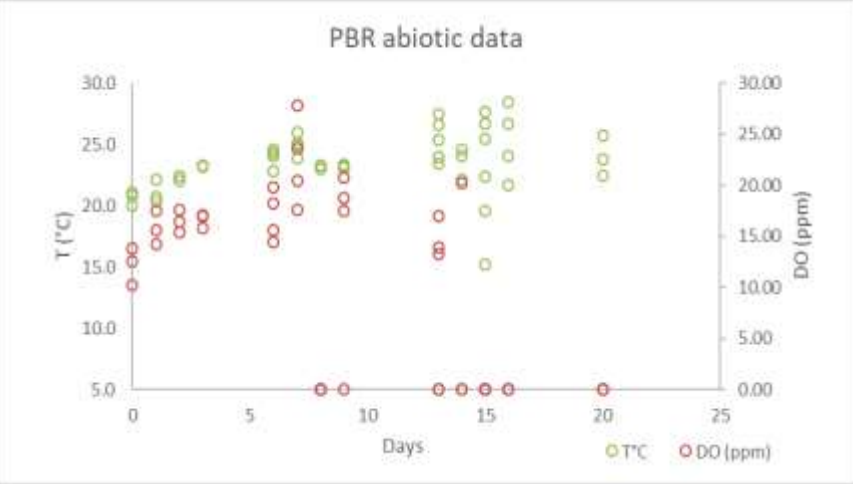
Associate Partners
Renewable Energy Association
European Biomass Industry Association (EUBIA)
Waste and Resources Action Programme (WRAP)
The National Non-Food Crops Centre
Biogas-E vzw, platform voor anaerobe vergisting
Feed Design Lab

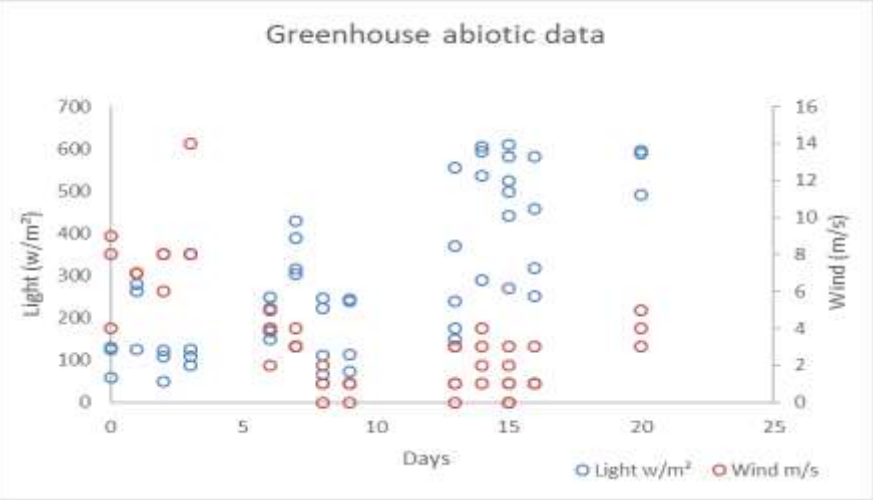
UK – Swansea University - Langage-AD Investment

Example of data being collected









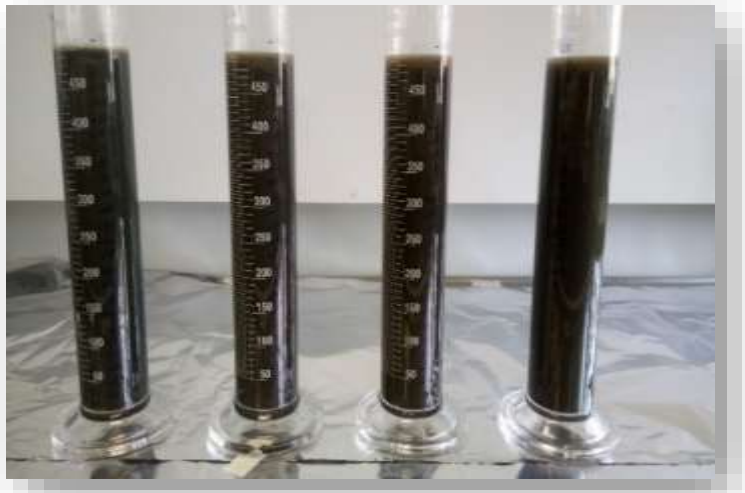
***Scenedesmus* trial 70 days of continuous culture. 50L of pure digestate injected every week**

Parameters	Average	Unit
GR (average)	0.29	div-1
DT	2.78	days
N uptake (average)	24.81	mg/l/day
P uptake	1.76	mg/l/day
Productivity (average)	21	mg/l/day
Production (average)	0.161	g/L
Max production	0.247	g/L
Total Nitrogen (average)	126.4	mg/L
Max Nitrogen	165	mg/L
Total Phosphate (average)	7.17	mg/L
Average N:P	17.6	

Downstream membrane filtration processing and metabolite characterisation of biomass

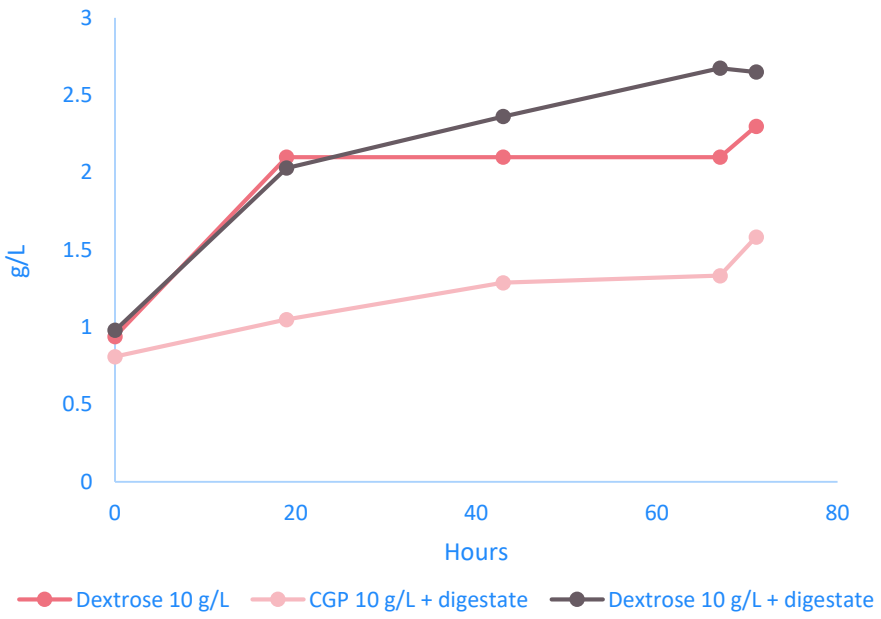
Metabolite characterisation using analytical tools: GC-MS, HPLC, LC-MS, FTIR, spectrophotometry etc

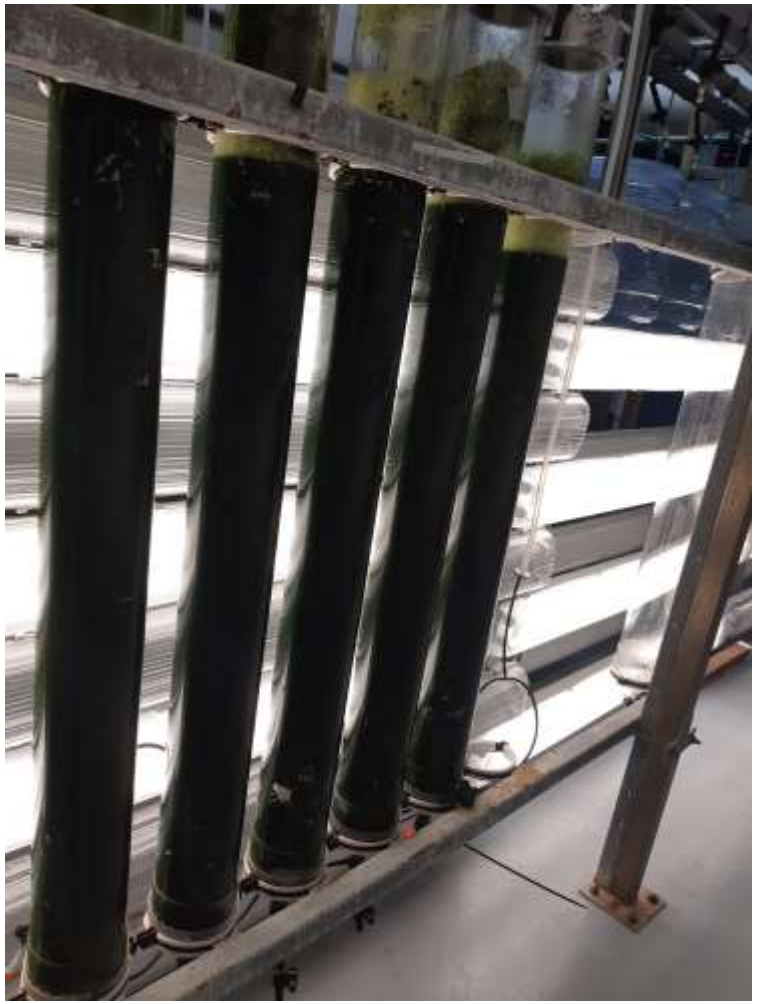
Diluting and treating the raw digestate to optimise cultivation of algae

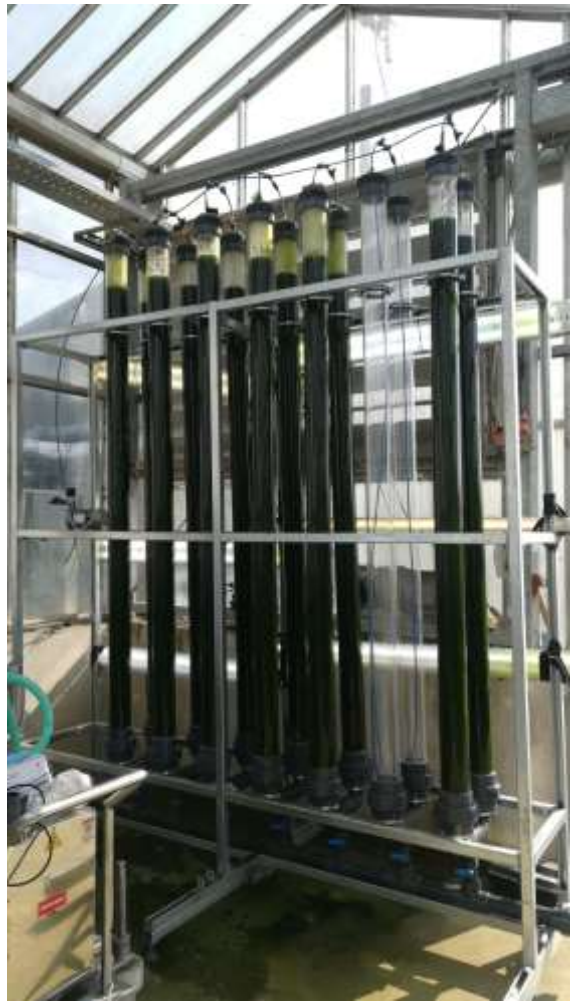


	Ammonium NH4+ (mg/L)	Total Nitrogen N (mg/L)	Phosphorus P (mg/L)
Raw Digestate	4016	5172	665
Micro-filtered	3146±224	4052±288	50.7±1.84
Ultra-filtered	1433±335	1846±432	25.76±1.19
Nano-filtered	1940±185.4	2498±238	2.66±0.21

Swansea, preliminary pilot scale mixotrophic expts







Interreg North-West Europe ALG-AD
European Regional Development Fund

Some of the challenges!

- CO_2, Solenoid and pH
- Heat exchanger
- Contamination

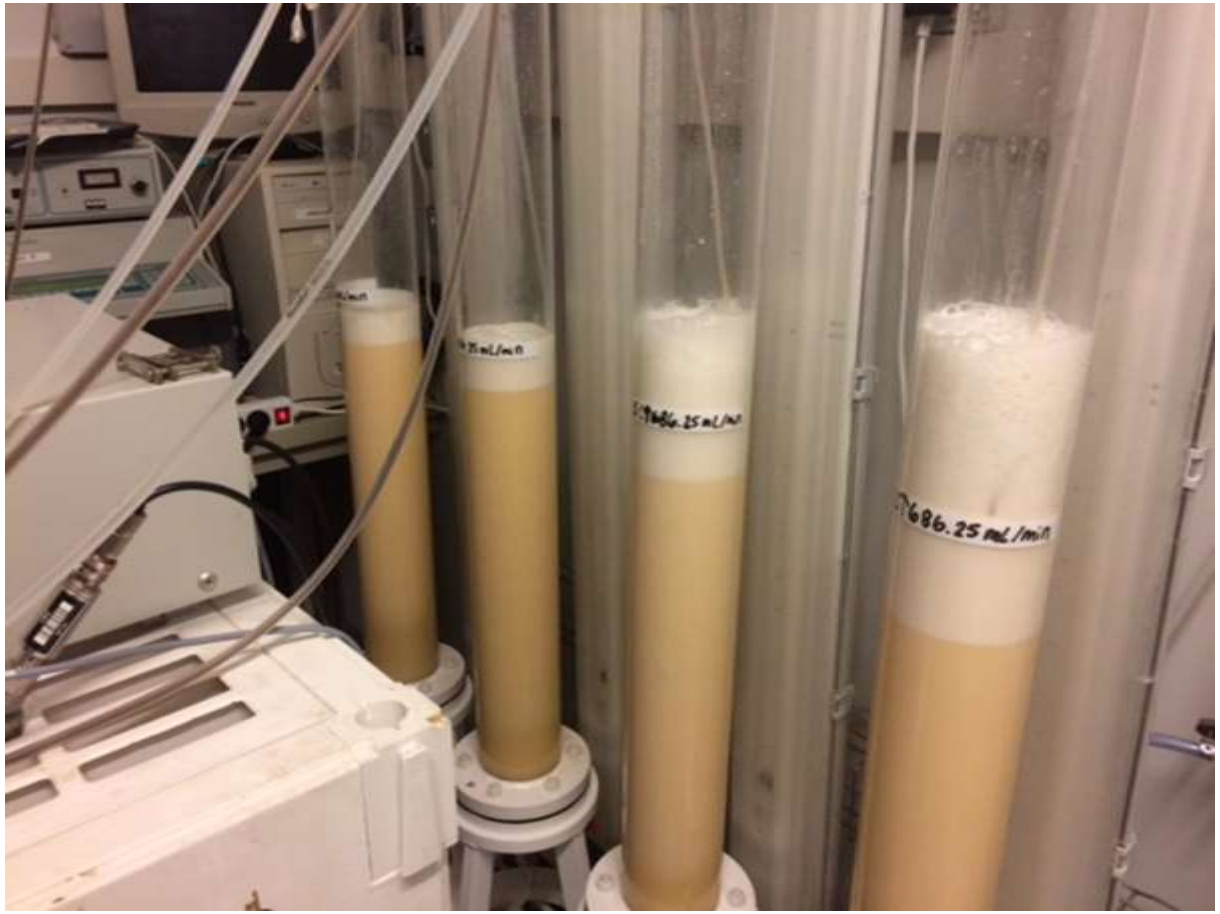
Amoeba with *Chlorella* cells inside

PBR crash after 3 days for *Amoeba* contamination

French Partners: CNRS & University of Brest

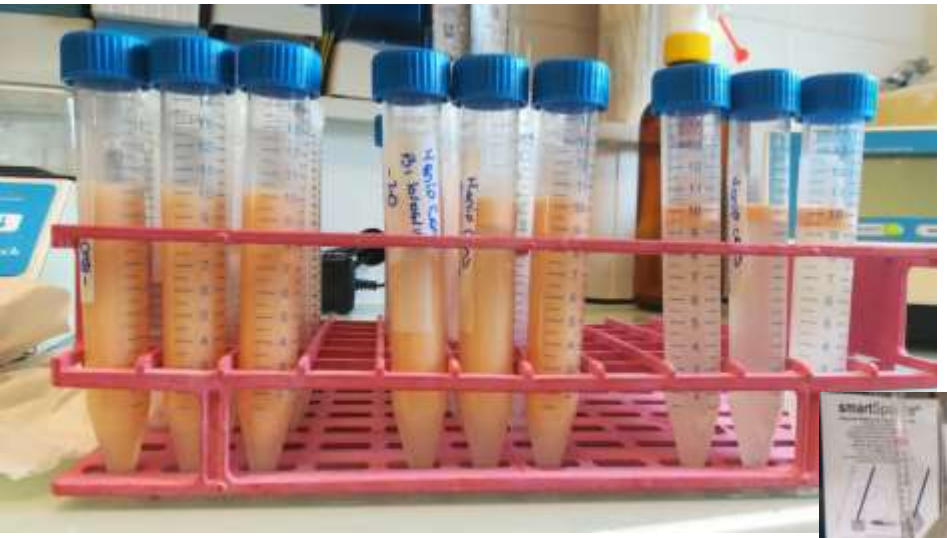
LEMAR
laboratoire des sciences de l'environnement marin
UBO | CNRS | IRD | Ifremer

12 g/L of thraustochytrid biomass: 20% TFA content of which 50% are omega oils

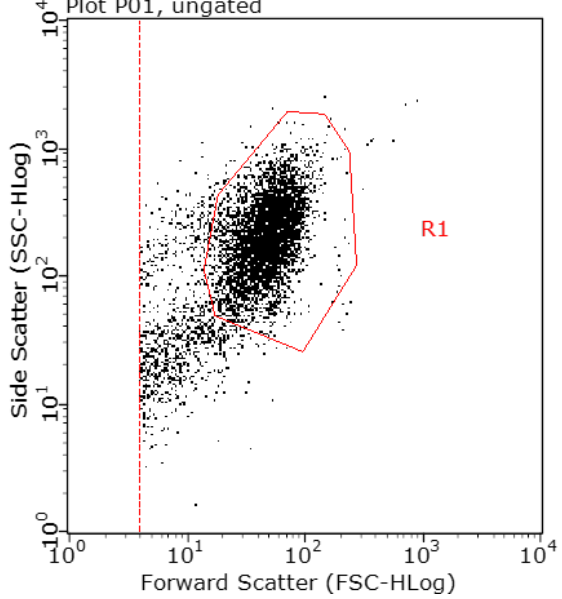


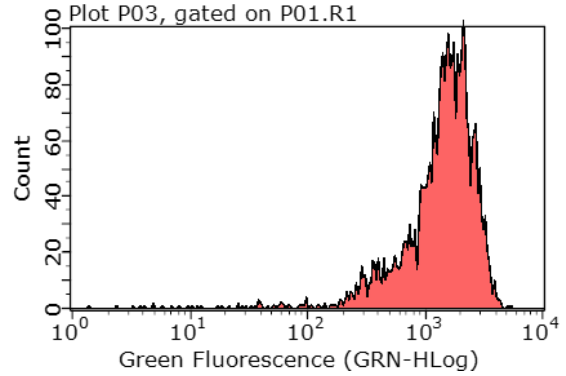
France: DSP Results

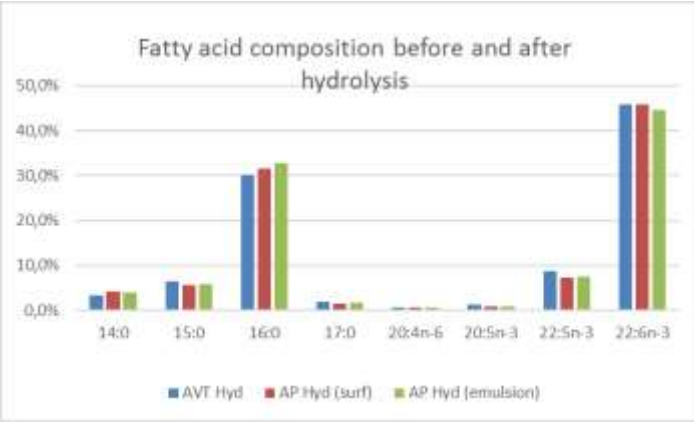
Storage of floating cells: -80°C -20°C and cold room (2 weeks)



-80°C -20°C 4°C







Interreg North-West Europe ALG-AD

PhycoPigment:

Innovate UK - CONACYT

Oct. 2016-March 2019

UK Research and Innovation

Newton Fund - PhycoPigment: Novel manufacturing methods for high value pigments products from microalgae

Lead Participant: Membranology Limited

Go back

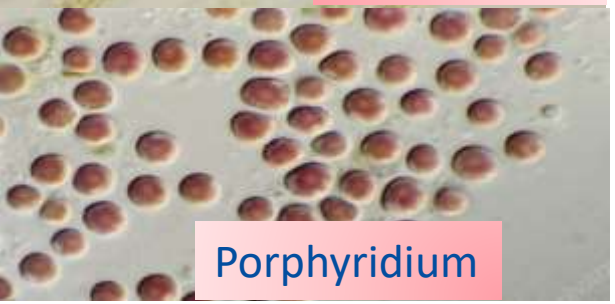
Membranology
Advanced Membrane Applications

Academics and industry
UK (Swansea University and Membranology Ltd)
Mexico (INECOL, Tecnológico de Monterrey and ALTESO)

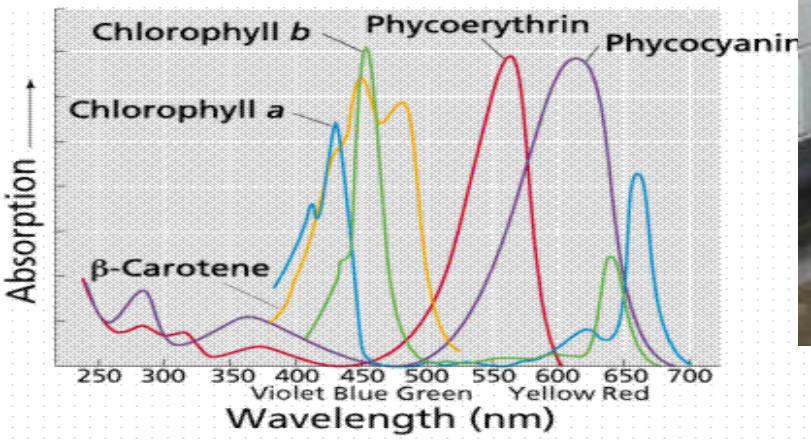
Aim: Novel production-process technologies for a range of high value protein based water soluble pigments from microalgae from laboratory up to demonstration.

PhycoPigment

Spirulina



Porphyridium



c.a.llewellyn@swansea.ac.uk

Research Council (BBSRC) Projects

Metabolite profiling of a robust cyanobacterium for Industrial Biotechnology

PhD Student: Bethan Kultschar

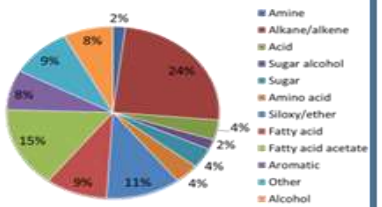
Axenic vs. Xenic

Standard vs. UV Stress conditions

- **UVA** & **UVB**: Production of **sunscreen** compounds

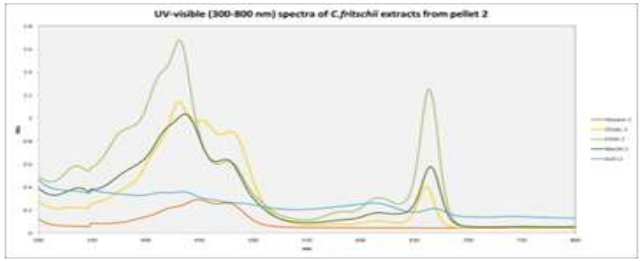
Metabolomics

- Analysis of **exo-** and **endo-** metabolomes during **growth curve**
- Untargeted metabolomics: **GC-MS**
- Bulk **carbohydrates/proteins**
- Targeted metabolomics: **MAAs (HPLC)**

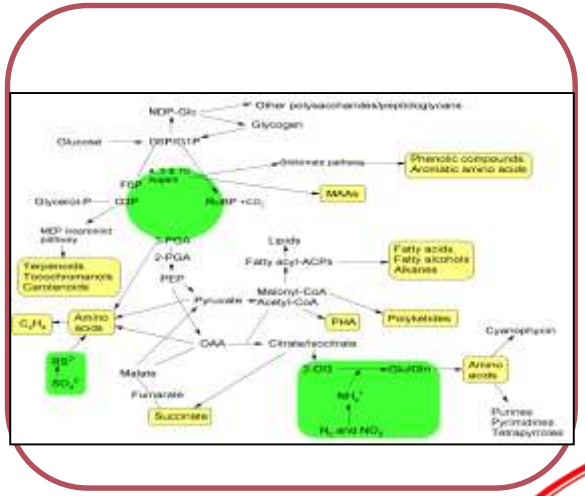


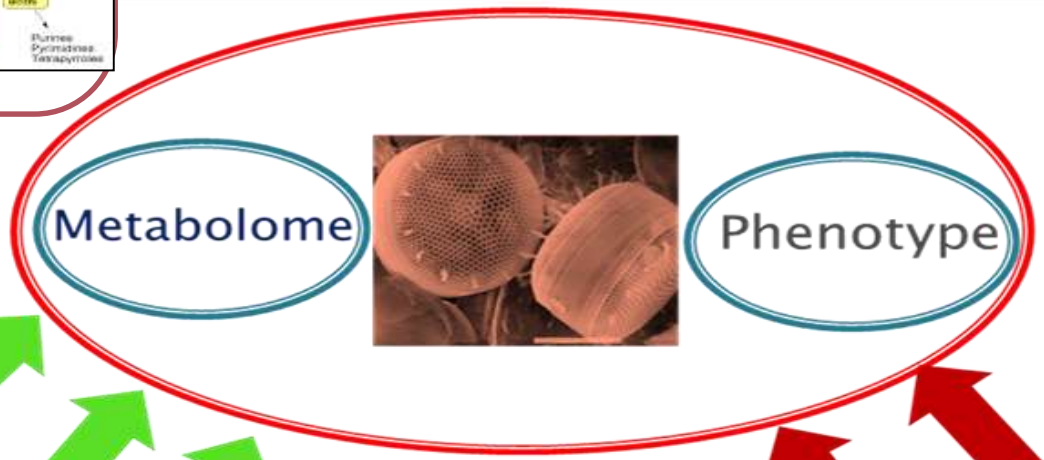
Bioactivity

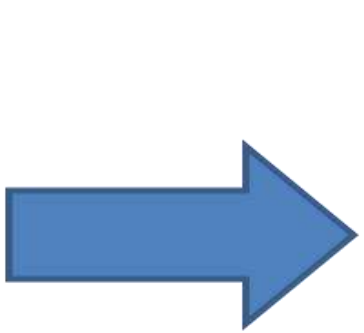
- Analysis of **bioactivity**
- **Antioxidant**
- **Antimicrobial**
- **Anti-inflammatory**



Linking environmental factors to metabolism and useful metabolites







Products

Grazers

Bacteria

Viruses

Irradiance

Nutrients

Environment

Some of the UK ALG-AD team!

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European Regional Development Fund

Developing solutions using algae to reduce waste and develop new products

www.nweurope.eu/ALGAD

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c.a.llewellyn@swansea.ac.uk