a4f
algae for future

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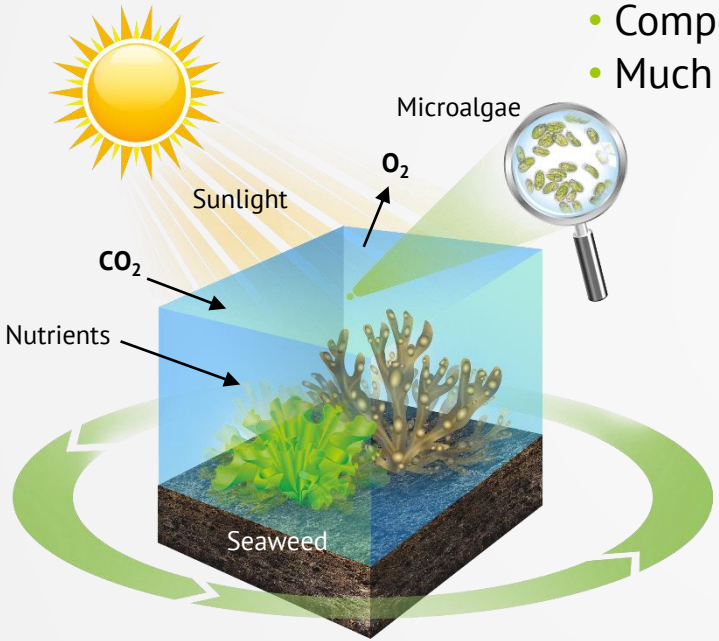
Biomeet Sessions

Inovação Biotecnológica ao serviço da Agricultura

7 June 2023

A4F is specialized in the process of design–build–operate–transfer (DBOT) of commercial scale algae production facilities.

Similar to agriculture



Photosynthesis

No need…

- Arable land;
- Compete with food crops;
- Much water (>90% recycled)

But need…

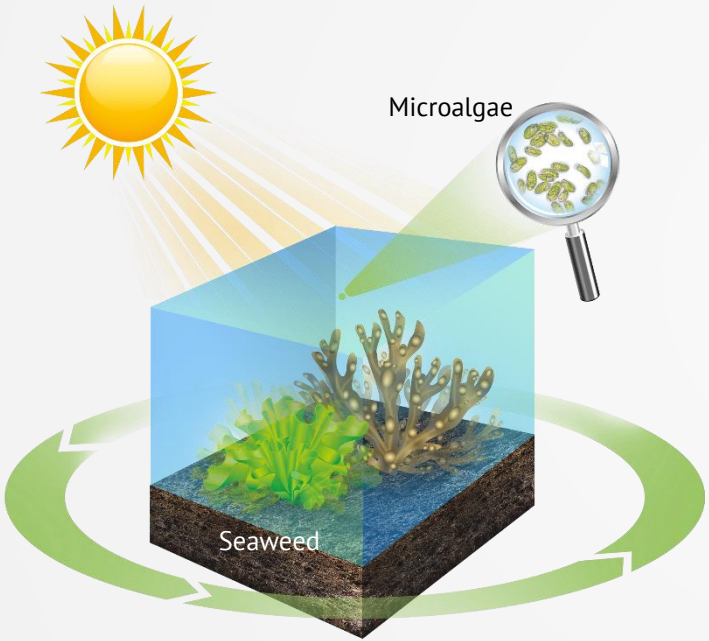
- CO_2 (Lots…!!!)
- Daily harvest, ≈ 330 Days!
- Water (fresh or seawater)
- Technology (several…)

30-100 ton/ha/year
(autotrophic/mixotrophic)
more efficient than any other crop

Microalgae on industrial scale: 5.0 g/m^2/day of protein
Seaweed on industrial scale: 4.10 g/m^2/day of protein
Soya on industrial scale: 0.11 g/m^2/day of protein

ALGAE COMPOSITION

Microalgae & Seaweed



Photosynthesis

Protein
Essential amino acids (profile similar to food)

Polysaccharides
Starch, glucose, alginates, agar, carragenan

Pigments
Chlorophyll, carotenoids, astaxanthin, phycobilins

Lipids
PUFAs (ARA, EPA, DHA), TAGs, Polar Lipids

Essential vitamins
A, B1, B2, B6, B12, C, E, nicotinate, biotin, folic acid and pantothenic acid

APPLICATIONS & FRAMEWORKS

Current applications

Food
- Food ingredients
- Healthy foods

Feed
- Premix feeds
- Specialty feeds

Health
- Nutraceuticals
- Pharmaceuticals

Cosmetics
- Cosmeceuticals
- Thalassotherapy

Fertilizers
- Biofertilizer
- Soil remediation

Emerging applications

Fuels
- Biofuels
- CO_2 mitigation

Wastewater
- N&P removal
- Bioremediation

Chemicals
- Biofibers
- Bioplastics

A4F IN NUMBERS

Founded in 2008

People

- **50+** highly educated
  > 50 % PhD & MSc
- Highly trained people: **20 years of accumulated experience** in microalgae industrial production

Co-financed Projects

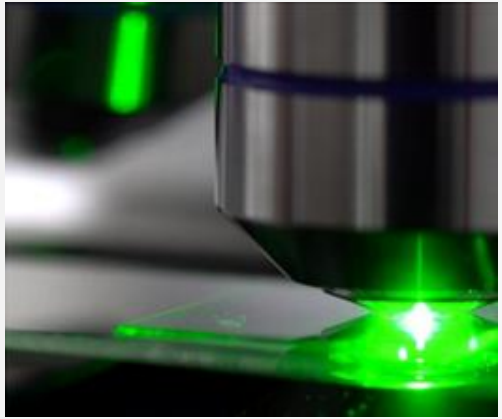
- **29+** R&D projects with **>250 M€** funding
- Involved in **11** projects: **biorefining** for added value products and energy

Units Operated

- **5 units**, from R&D to Commercial Scale
- **Currently** building **4 units** in Europe and Africa
- Currently involved in other projects abroad: South America, Africa, Europe and Middle East

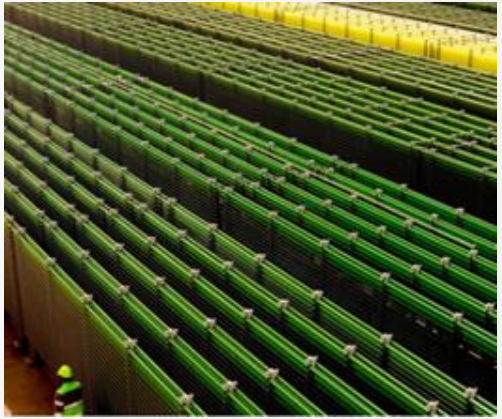
WHAT WE DO

APPLIED R&D



CONTRACT R&D
TECHNOLOGY SUPPLY

INDUSTRIAL PRODUCTION



APPLIED R&D

Applied R&D in Biotechnology

Jan 2011
GIAVAP (FP7)
36 months | 7M€

Apr 2011
BIOFAT (FP7)
60 months | 10M€

Oct 2012
PHOTO.COMM (FP7)
48 months | 3,9 M€

Dec 2012
DEMA (FP7)
54 months | 6,4M€

Nov 2013
PUFACHAIN (FP7)
48 months | 7M€

Dec 2013
D-FACTORY (FP7)
48 months | 10M€

Dec 2014
ALFF (H2020)
48 months | 3,8M€

Jul 2015
PHOTOFUEL (H2020)
48 months | 6M€

Dec 2020
Move2lowC (P2020)
36 months | 11,2M€

May 2020
MULTI-STR3AM (EU-BBI-JU)
48 months | 9,1M€

Apr 2020
ALGAREF (P2020)
24 months | 2,8M€

May 2019
EXTRATOTECA (P2020)
36 months | 1,4M€

Nov 2017
ARA.FARM (P2020)
48 months | 4,7M€

Nov 2017
EnhanceMicroalgae
(Interreg Atlantic Area)
71 months | 2,45M€

Mar 2017
ABACUS (H2020)
48 months | 5,1M€

May 2021
REDWine (EU-BBI-JU)
48 months | 5,7 M€

Oct 2022
CIRCALGAE (HorizonEU)
48 months | 10M€

Oct 2022
ALIGNED (HorizonEU)
36 months | 3,4M€

Oct 2022
Pacto Bioeconomia Azul (PRR)
38 months | 133M€

Jan 2023
ASTEASIER (EIC Transition)
24 months | 2M€

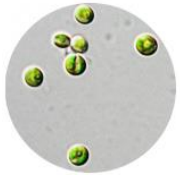
Jun 2023
INNOAQUA (HorizonEU)
48 months | 7,3M€

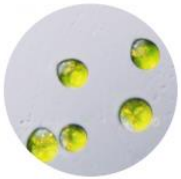
Jun 2023
InnoProtein (CBE-JU)
48 months | 5M€

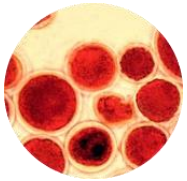
Microalgae production expertise at pilot and industrial scale

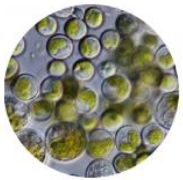

Arthrospira sp. (Spirulina)


Chlamydomonas sp.


Chlorella sp.


Dunaliella salina

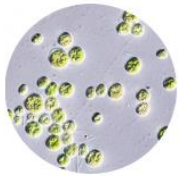

Haematococcus pluvialis

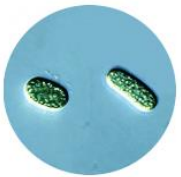

Lobosphaera incisa

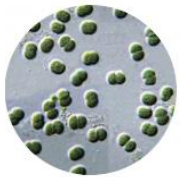

Nannochloropsis sp.

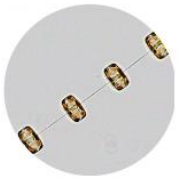

Phaeodactylum tricornutum

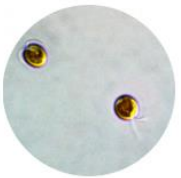

Raphidonema sp.

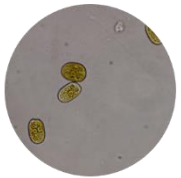

Scenedesmus sp.

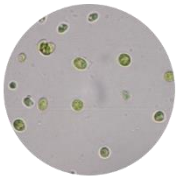

Synechococcus sp. PCC 7002


Synechocystis sp. PCC 6803


Thalassiosira weissflogii

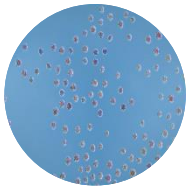

Tisochrysis lutea

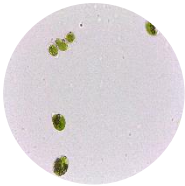

Prorocentrum Cassubicum

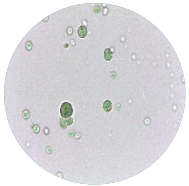

Scotiellopsis sp.


Tetraselmis sp.


Odontella sp.


Porphyridium cruentum


Euglena gracilis


Galdieria sulphuraria

Macroalgae production expertise at pilot and industrial scale

Fucus Vesiculosus

Ulva spp.

Gracilaria spp.

Porphyra spp.

A4F BIOREFINERY TRACK RECORD

Extracts production expertise at industrial scale

Carotenoids
> 3.5% Carotenoids

Phycocyanin
> 85% Protein
> 25% Phycocyanin

Protein
> 60% Protein

Omega-3
> 14% EPA

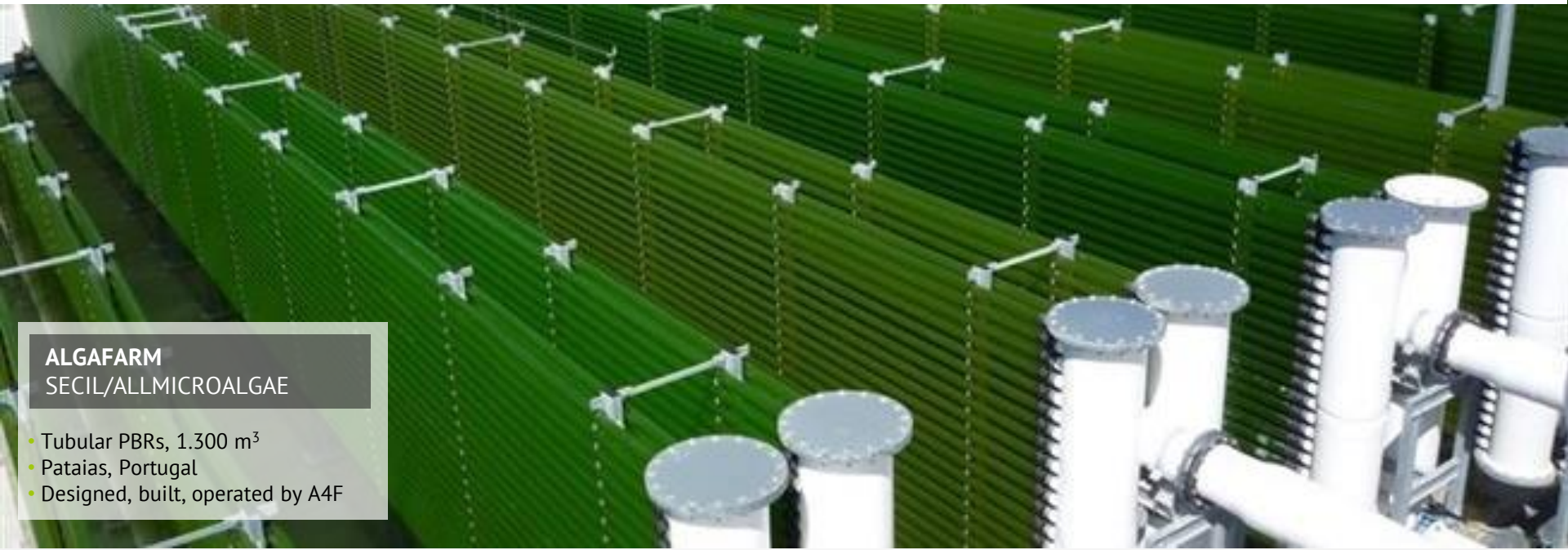
Bulk
50:50 Protein and Carbohydrate

INDUSTRIAL PRODUCTION

LARGE INDUSTRIAL PROJECTS

2009 — 2015 — Present

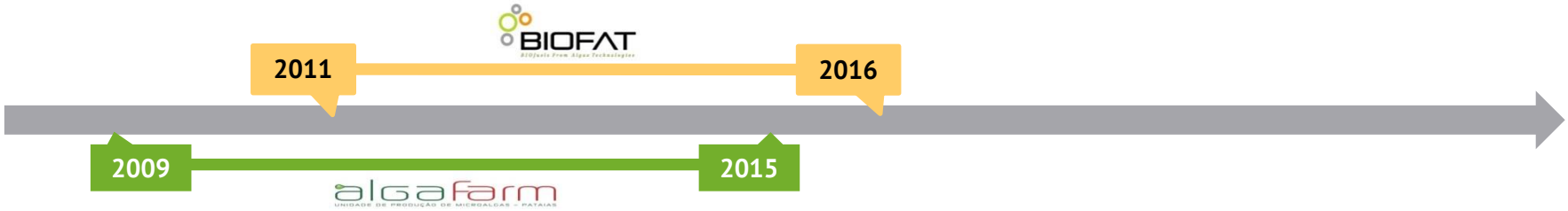
algafarm
UNIDADE DE PRODUÇÃO DE MICROALGAS - PATAIAS



ALGAFARM
SECIL/ALLMICROALGAE

- Tubular PBRs, 1.300 m^3
- Pataias, Portugal
- Designed, built, operated by A4F

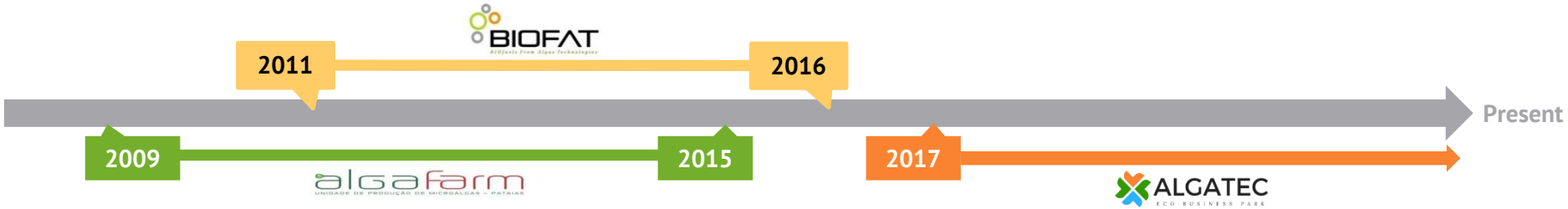
LARGE INDUSTRIAL PROJECTS



BIOFAT
FP7 PROJECT

- Cascade raceways, 3.000 m^2
- Pataias, Portugal
- Designed, built, operated by A4F

LARGE INDUSTRIAL PROJECTS



ALGATEC
ECO BUSINESS PARK

- Multi-technology production, 14 ha
- Biorefinery
- Póvoa de Santa Iria, Portugal
- Commissioning stage

Industrial Symbiosis in a Co-location Approach

Microalgae & Extracts

HYChem

Hydrogen Peroxide

Sodium Chlorate

Site Matacães

Hydrogen

Water& Salt

Energy

raw material — CO_2 — effluent

raw material — Nitrate — effluent

60kV

30kV

BIOFAT.PT

1 km

Vila Franca de Xira (15 km)

Lisbon (15 km)

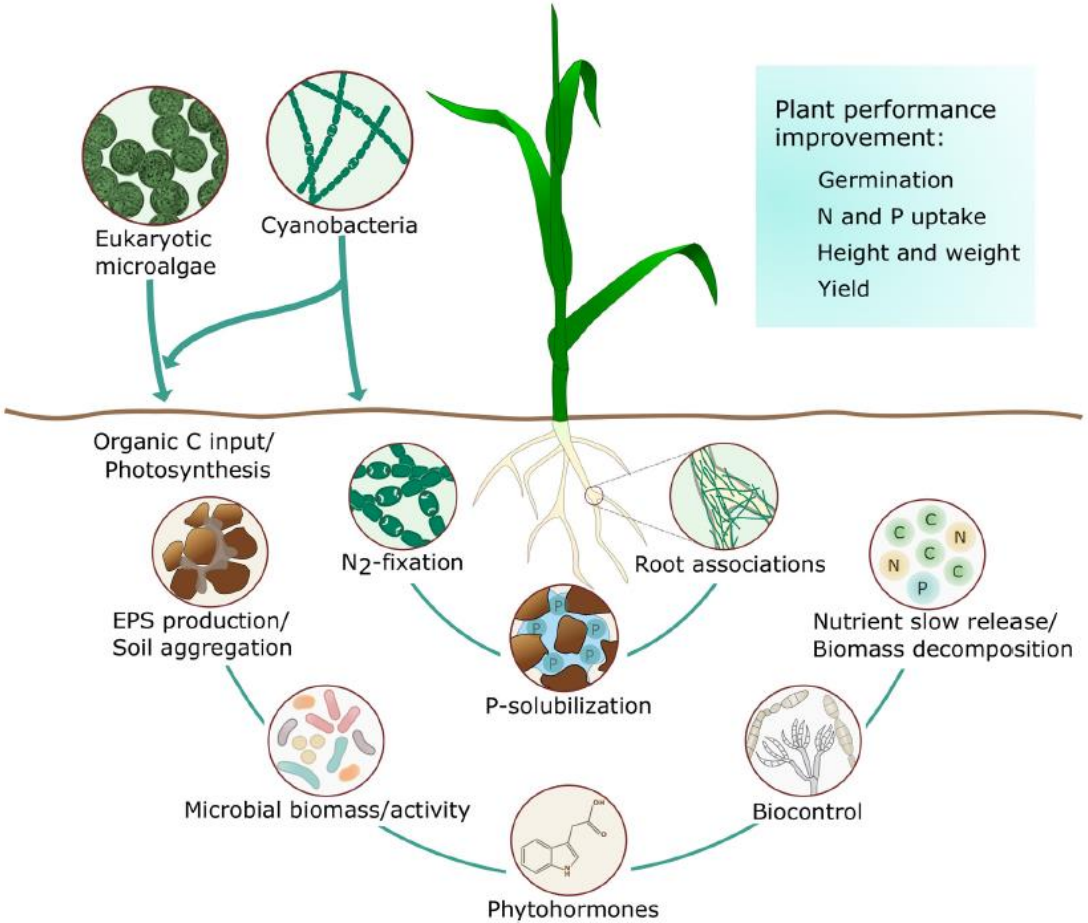
New bio-based products and circular economy

Recycling industrial effluents through microalgae production, improving the environmental performance of the whole industrial site and decreasing the costs of microalgae production

ALGAE-BASED BIOFERTILIZERS AND BIOSTIMULANTS

ALGAE-BASED BIOFERTILIZERS AND BIOSTIMULANTS

- Versatile resources for agriculture
- Input of organic carbon
- Improve soil aggregation and stabilization
- Positive influence on soil microbial populations
- Promote plant growth and health
- Help fixating N_2



Source: Alvarez et al 2021

ALGAE-BASED BIOFERTILIZERS AND BIOSTIMULANTS

Algae-based fertilisers present many advantages

Characteristics	Traditional Fertilizers	Biofertilizers		
		Bacteria	Fungi	Microalgae/Cyanobacteria
Environmental damage by degrading the soil, water contamination, and eutrophication induction.	✔	x	x	x
Creation of symbiotic bonds with the plant roots and microorganisms within the soil.	x	✔	✔	✔
Role in the nitrogen cycle making it available to the plant.	x	✔	✔	✔
Promotion of the solubilization of phosphorus.	x	✔	✔	✔
Soil fertility improvement.	x	✔	✔	✔
The slow rate of nutrient release for the consumption of the plant	x	✔	✔	✔
N fixation by individual strains, P solubilization, and hormone production for promoting the growth of the plant.	x	x	x	✔
CO_2 capture and greenhouse emissions reduction capability during the addition of organic carbon to the soil.	x	x	x	✔
Industrial production and widespread used in the agriculture field.	✔	✔	✔	x

Source: Osorio-Reyes 2023

ALGAE-BASED BIOFERTILIZERS AND BIOSTIMULANTS

Algae can act as biostimulant promoting plant growth

Algae can enhance soil fertility and microbiome properties

Original Article

Bacillus and microalgae biofertilizers improved quality and biomass of *Salvia miltiorrhiza* by altering microbial communities

Xuemin Wei [1], Xuanjiao Bai [1], Pei Cao, Gang Wang,

Institute of Medicinal Plant Development, Chinese Academy of Medical Sciences & Pek

ELSEVIER

Algal Research

Volume 59, November 2021, 102434

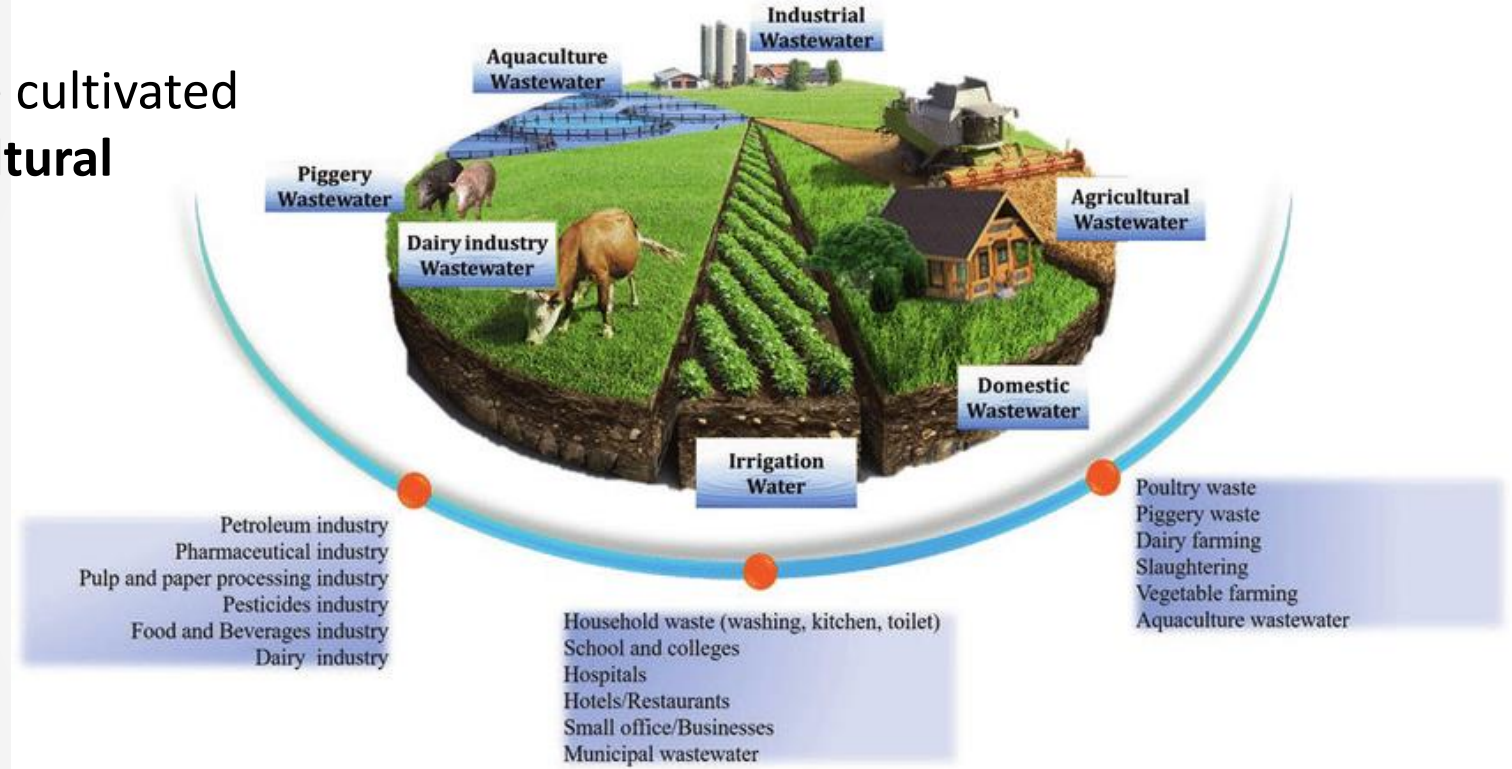
Plant growth biostimulant activity of the green microalga *Desmodesmus subspicatus*

Ester Mazepa [a b 1], Barbara V. Malburg [a c 1], Gilda Mógor [a], Amanda C. de Oliveira [a c], Juliana O. Amatussi [d], Diego O. Corrêa [a b], Jacqueline S. Lemos [a], Diogo R.B. Ducatti [a], Maria Eugênia R. Duarte [a], Átila F. Mógor [d], Miguel D. Noseda [a]

ALGAE FOR WASTE STREAMS VALORIZATION (AND BIOFERTILIZERS PRODUCTION)

ALGAE FOR WASTE STREAMS VALORIZATION

Algae can be cultivated using **agricultural** wastewaters



ALGAE FOR WASTE STREAMS VALORIZATION AND BIOFERTILIZERS PRODUCTION

"*Chlorella vulgaris* and *Scenedesmus obliquus* suspensions, grown in maize drainage water, can be used on-farm, as low cost slow-release organic fertilizers, doubling lettuce fresh biomass and improving soil health"

Maize field drainage with nutrients and pesticides

Drainage water collecting pond

Microalgae cultivation - selection in lab experiments

Outdoors scale up in flat panel photobioreactors

Microalgae used in lettuce fertilization

Nutrients and water recycling

Pesticides degradation

Reduced costs in mineral fertilizers

Improved productivity and soil health

Source: Alvarenga et al 2023

ALGAE FOR WASTE STREAMS VALORIZATION AND BIOFERTILIZERS PRODUCTION

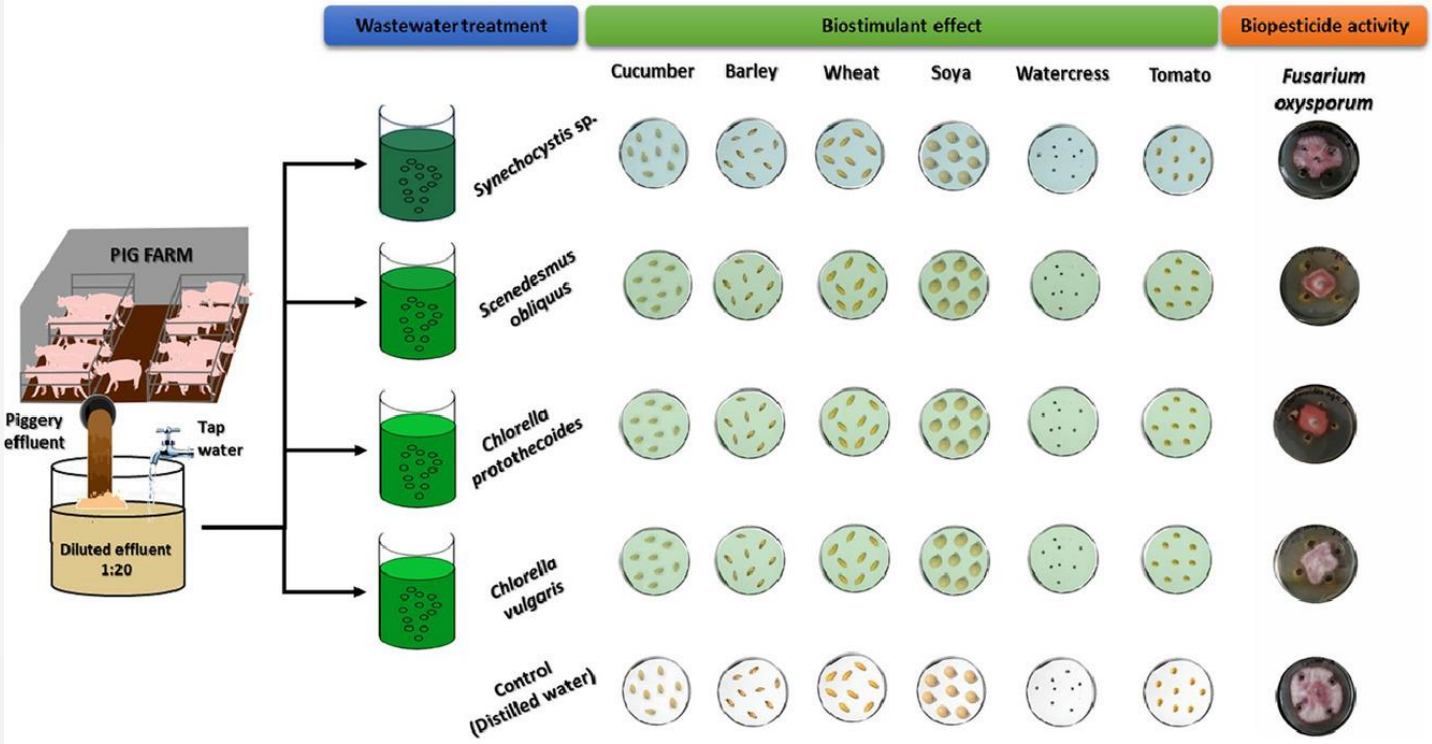
Combination of wastewater treatment, biofuel and biofertilizer production

- *Scenedesmus* sp. was cultivated using **domestic wastewater** and **coal-fired flue gas**
- Use of de-oiled microalgal biomass was efficient biofertilizer for rice crop
- Microalgae increased available nutrients in soil
- Microalga supplementation reduced chemical fertilizer

Source: Nayak et al 2019

ALGAE FOR WASTE STREAMS VALORIZATION AND BIOFERTILIZERS PRODUCTION

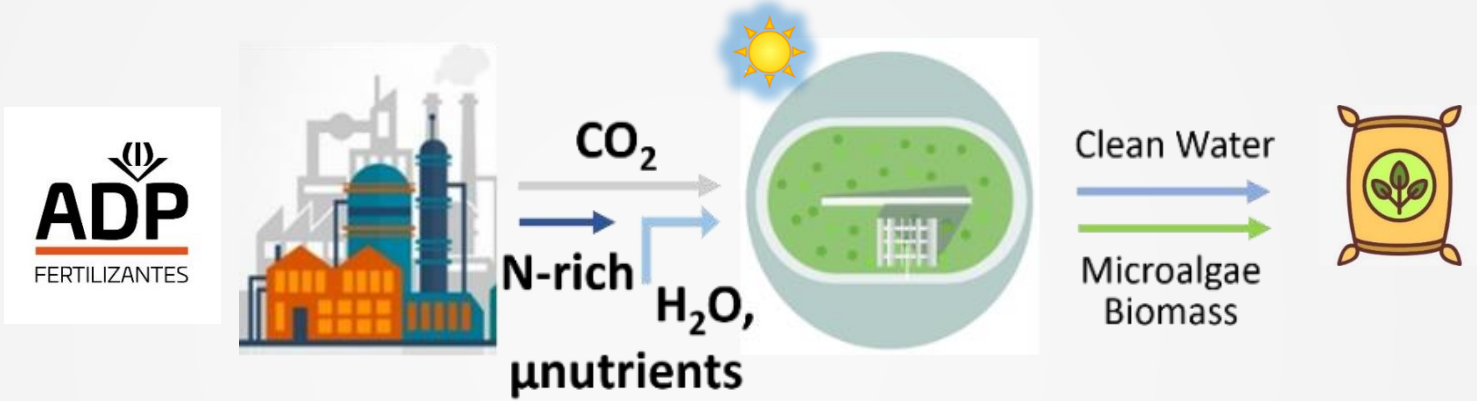
Biostimulant and biopesticide potential of microalgae growing in piggery wastewater



Source: Ferreira et al 2022

ALGAE FOR WASTE STREAMS VALORIZATION AND BIOFERTILIZERS PRODUCTION

Microalgae Cultivation for Bioremediation

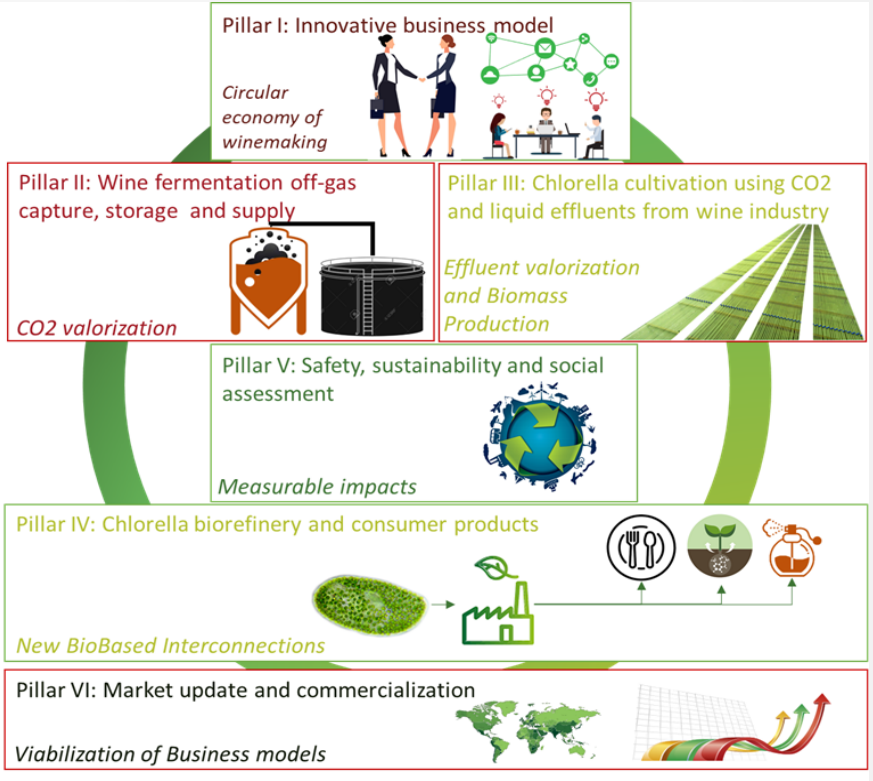


- Ongoing work: **characterization of the microalgal biomass for biofertilizer and biostimulant potential** on vegetables and fruit trees by ADP Fertilizantes. The valorization of the biomass will boost the **economic viability** of the overall process.
- Future work: **evaluate feasibility of using onsite available flue gas** as CO_2 source.

H2020 BBI-JU **REDWINE** PROJECT

REDwine aims to:

- implement a new business model for wine producers, where they will become microalgae producers by valorising their effluents.
- incentivise the transition of the wine production industry to an innovative, circular and sustainable model that will increase and diversify revenues for its stakeholders.



Horizon 2020 European Union Funding for Research & Innovation
BBI JU
Bio-based Industries Consortium

Thank You!

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