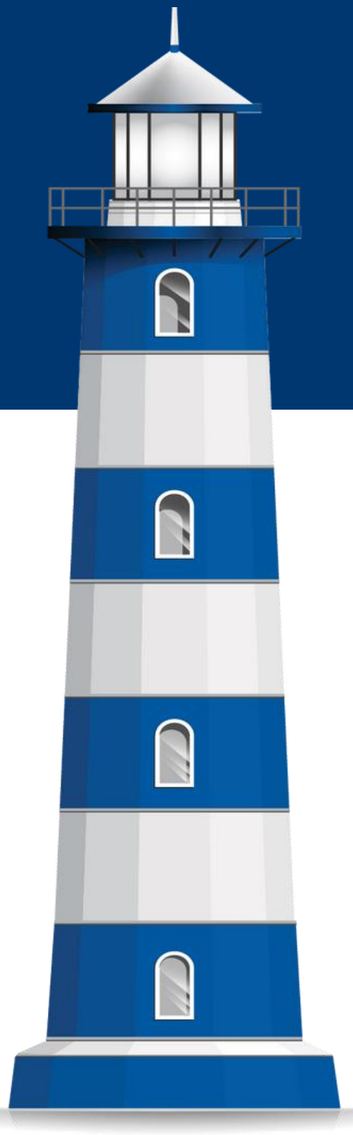
EU MISSIONS
RESTORE OUR OCEAN & WATERS

BLUE MISSION BANOS

Supporting the Mission Ocean Lighthouse in the Baltic and North Sea Basins



3rd MISSION ARENA

26-27 November 2024

Amsterdam

REGIONAL FOCUS ARENA 3

The Netherlands
BELGIUM
DENMARK I West
GERMANY I West
FRANCE I North

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BLUE MISSION BANOS

3rd MISSION ARENA
26-27 November 2024 | Amsterdam

The Blue on Land: Agriculture Applications of Algae Produced with Circular Resources

Efthalia Arvaniti – s.Pro// SUBMARINER Network

27. November, 11:15-13:00 am
Hall 4 Apartment

#MissionArena3

Funded by the European Union

Why this – why now?

- Multiple EU Strategies ask for the blue on lalalaland
  - Algae Initiative
  - Circular Economy Action Plan
  - Critical Material
  - Empower EU
- Complex value chain using residues
- Market/Technology Readiness Levels 6-8
- Regulatory obstacles are acknowledged

Agenda

Time	Title	Speaker/ moderator
11:15-11:25	Welcome, intro setting the stage,	Efthalia Arvaniti, s.Pro// SUBMARINER
11:25-11:35	Challenges for scaling seaweed based biostimulants	Dr. Andrea Romero Pérez, University of Ghent)
11:35- 11:40	Genetic Approaches and cultivation protocols to unravel MEtabolite production of Porphyra spp. targeted towards human and plant health applications	Jessica Knoop, NIOZ/Ghent University
11:40-11:50	Seaweed biostimulants Q&A and disussion	Moderated by Efthalia Arvaniti
11:50-12:00	Circular sources for algae fertilising products	Efthalia Arvaniti
12:00-12:10	Transforming Brewery Waste into Agricultural Solutions: Circular Biotechnology with Algal Remediation	Alla Silkina (Swansea University)
12:10-12:20	Algae-based Biostimlants from algaeponic effluents	Cristina Brito Lopez, Wageningen University
12:20-12:30	Circular Microalgae fertilising products Q&A and disussion	Moderated by Efthalia Arvaniti
12:30-12:50	Panel discussion with audience	Moderated by Efthalia Arvaniti

Slido poll

2616816

Circular sources for algae fertilising products

Efthalia Arvaniti (s.Pro) // Marcella de Souza (Ghent Uni)

Amsterdam, 27/11/2024

#EU4Algae

Algae in the European Green Deal

Do not require arable land

Do not require freshwater

Capture CO_2

Reduced seasonality

Current algae production is not sustainable

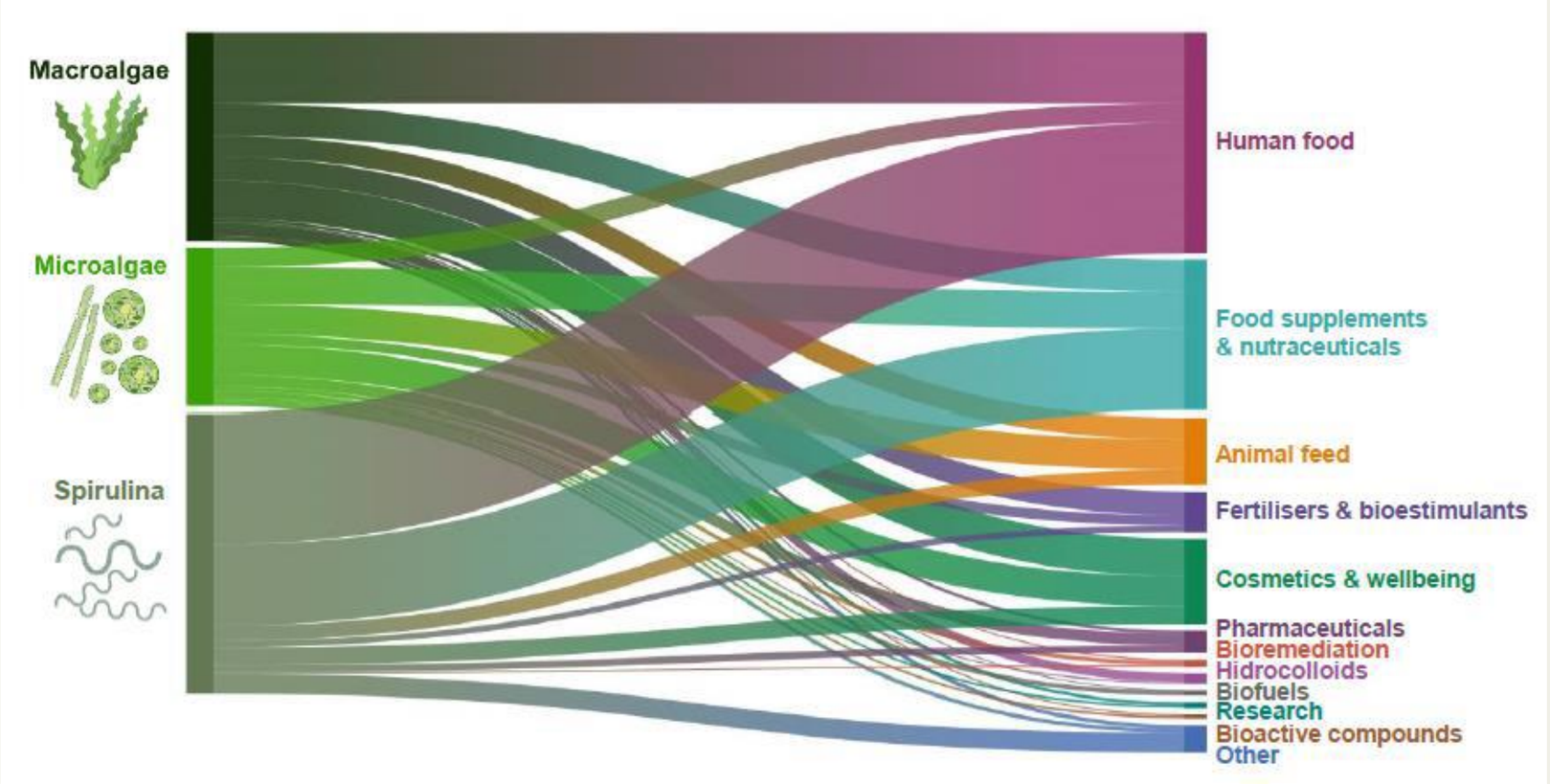
Objectives

1. Assessment of alternative sources of carbon & nutrients, including wastewaters, for (organic) microalgae cultivation for fertilising product applications.

2. Viable alternative sources of carbon & nutrients considering economic, legal and environmental dimensions

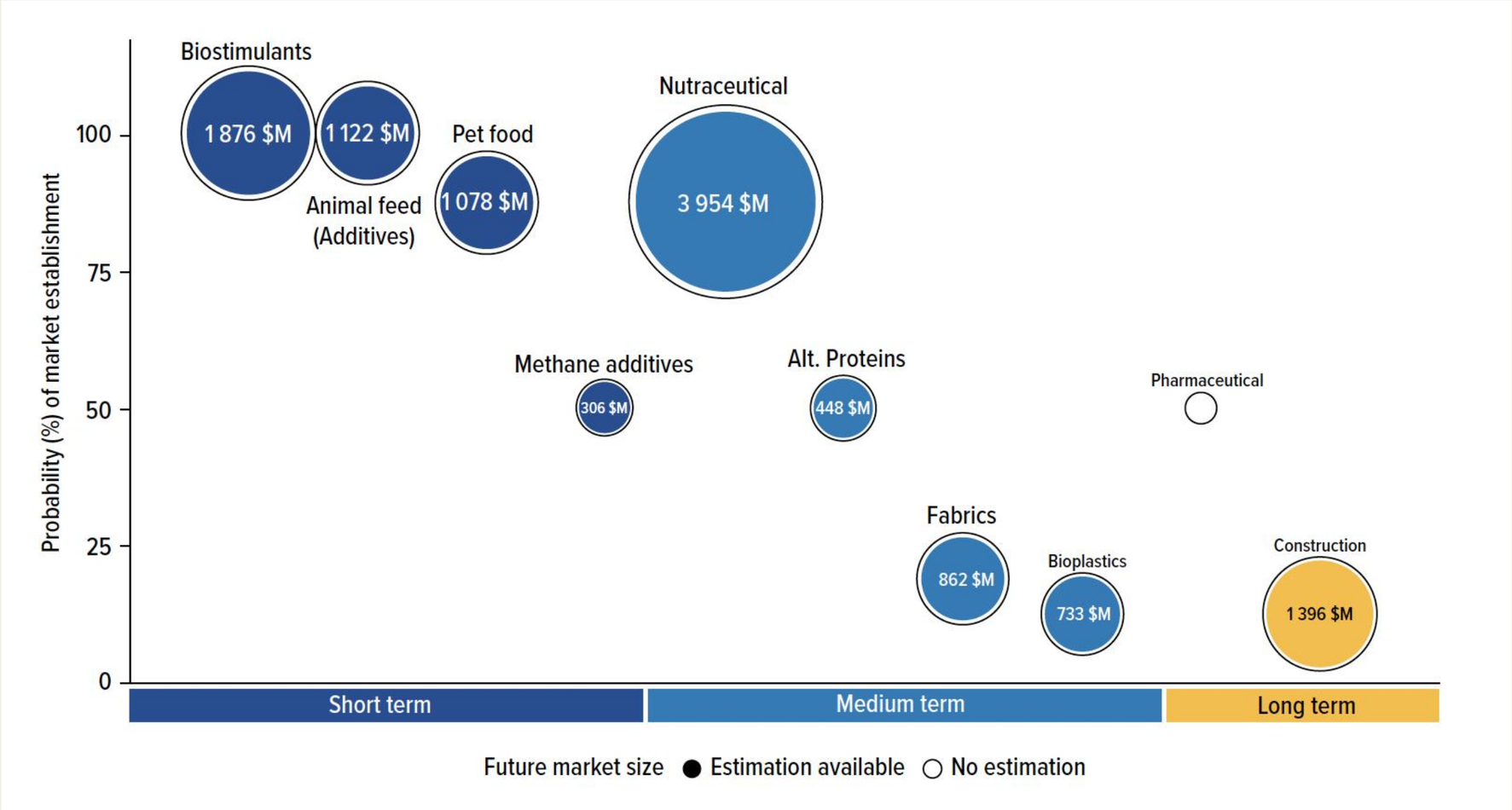
ea@sustainable-projects.eu

Algae biomass uses in Europe



based on the number of companies supplying biomass for these uses
(Vazquez Calderon and Sanchez Lopez 2022)

Global Seaweed Market Projections to 2030+



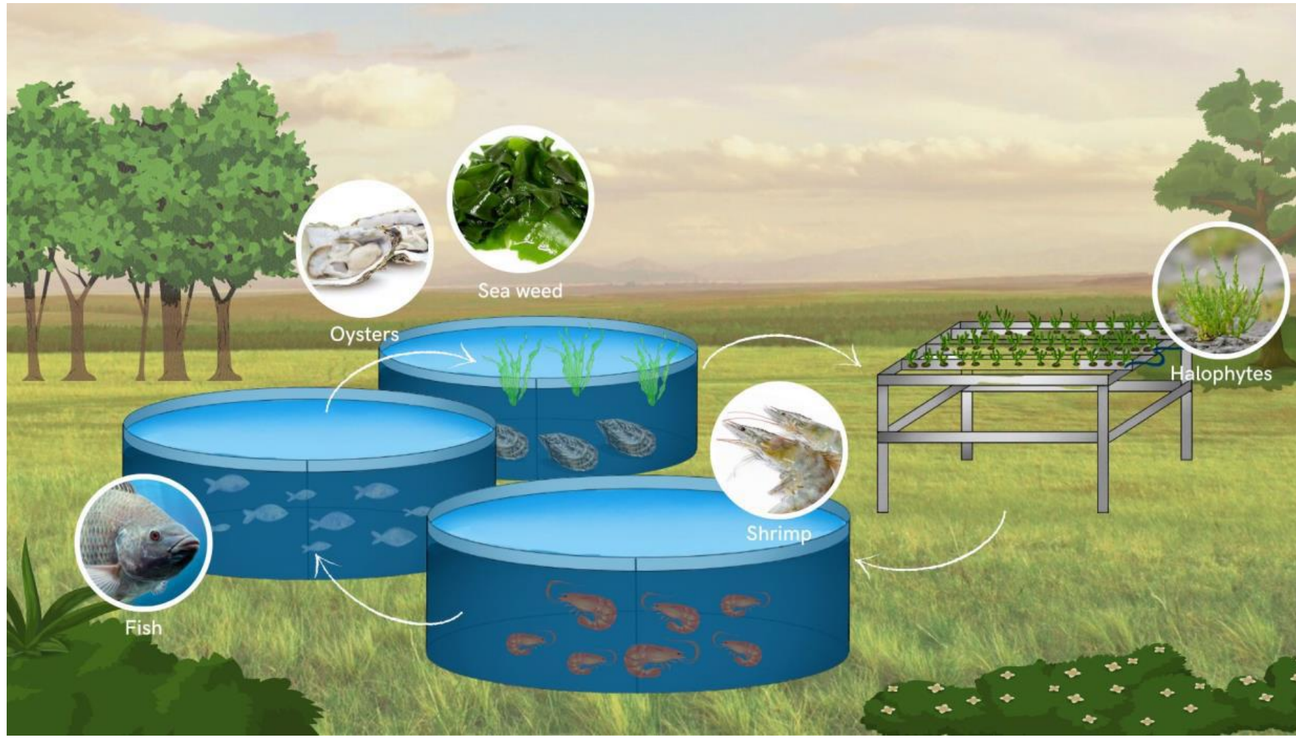
For mor info on EU4Algae outcomes and new activities:

Develop supply chain scenarios for North and South Europe

- North Europe
  - Supply chain
  - Legal
  - Economic
  - Environmental
- South ~Europe
  - Supply chain
  - Legal
  - Economic
  - Environmental

North Europe #1

Solution #1	Industrial Symbiosis using industrial nutrient-rich side-streams at enclosed industrial systems	TRL7-8
Relevant EU projects:	Alg-AD, SCALE, AlgaeNauts, LOCALITY, REALM, AlgaeProBanos, CIRCALGAE, SEMPRE-BIO, AlgaeBrew, IDEA, , GENIALG, SEAMARK, SEABIOPLAS, INTEGRATE, SEACOLORS	
Industry practitioners:	Necton (PT), Biorizon Biotech (SP), A4F (PT), Pure Algae (DK), Swedish Algae Factory (SE), Sotenas Symbiose (SE), Power Algae (EE)	



North Scenario #2

Solution #2	Use of a mixture of microalgae and aerobic bacteria in open ponds for treating (urban) wastewaters	TRL 8-9
Relevant EU projects:	SABANA, AlgaeNauts, Water2Return, All-Gas, AGORA, WALNUT	
Industry practitioners:	Industry practitioners: Aqualia (SP), Biorizon Biotech (SP), Veolia (SP), CASRTIF (SP), Algen (SL)	

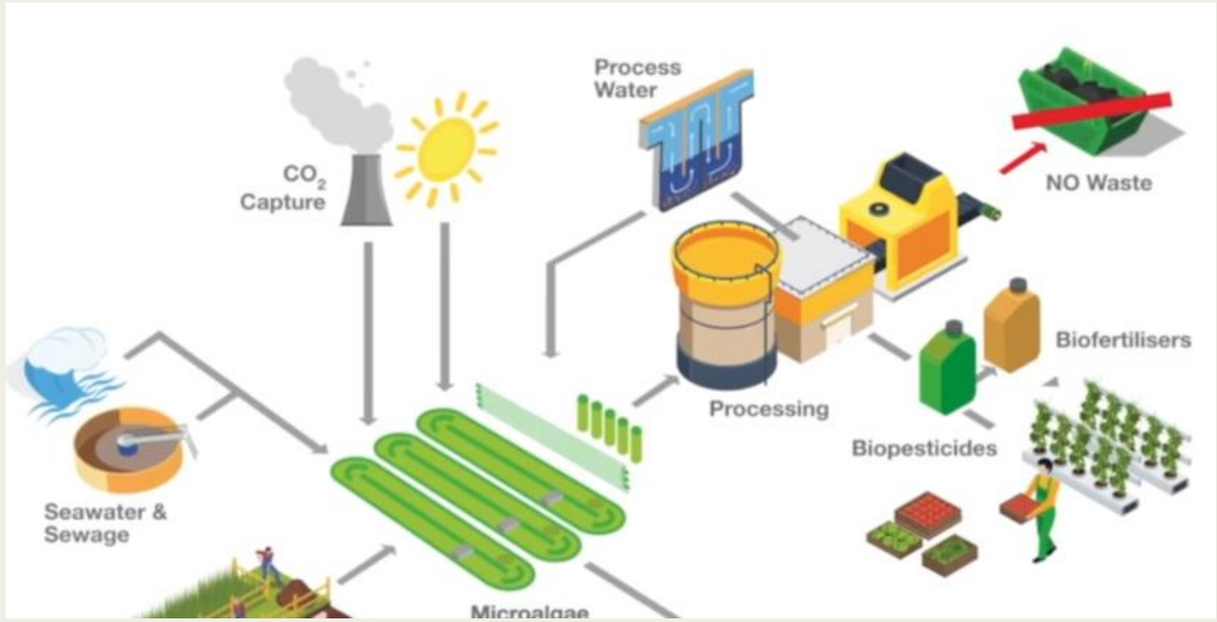


Figure 6 Recovery of e.g. nitrates, phosphates from effluents for production of algae-based biostimulants (AlgaeNauts project)

AlgaeNauts

Solution #3: Collection of algae beach-cast for nutrient removal

Solution #3	Collection of algae beach-cast for nutrient removal	TRL: 7-8
Relevant EU projects:	CONTRA, SeaBiogas, SalFar	
Industry practitioners:	Søuld (DK), Est-Agar (EE), Grogenics (Canada), Ökowerk (DE)	

NatureScot

Slido poll for you: Rate solutions

2616816

Stay in touch

DG MARE

@EU_MARE

@ourocean_eu

EU Maritime & Fish

EU4Algae

CINEA

@cinea_eu

CINEA - European Climate, Infrastructure and Environment Executive Agency

#EU4Algae

Thank you

#EU4Algae

Challenges for scaling seaweed-based biostimulants

Prof. Dr. Margriet Drouillon & Dr. Andrea Romero Pérez

BLUEGent

BIOMARES

Challenges in biostimulants industry

Technical:

- Lack of **evidence** of efficacy
- **Targeted** applications for optimal bioactivity
- Variability in **application mode**

Market:

- Higer **cost** of fertilization per hectare (near future)
- **Risk** of adopt new and expensive product
- More information needed regarding **market's demands**
- **Regulatory clarity**

Consumer/Buyer:

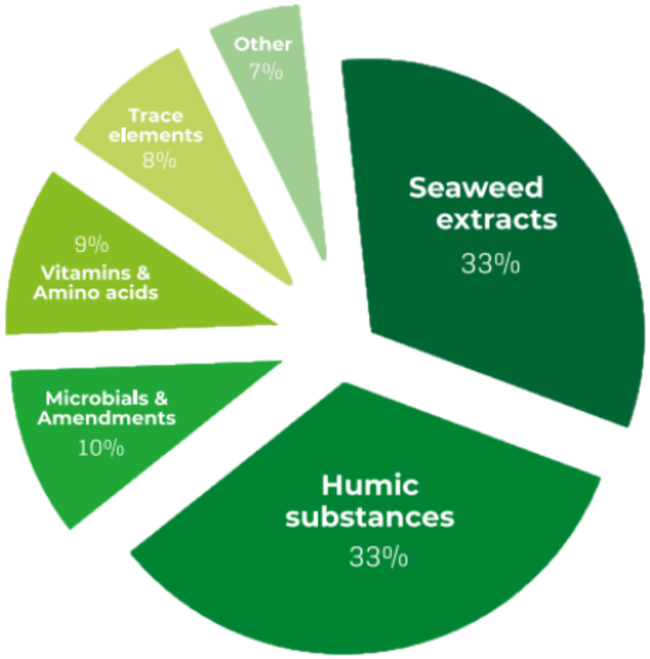
- Reduced level of **trust** in effectiveness
- Not always properly **educated** about the use of the product

Seaweed-based biostimulants industry

- The seaweed-based biostimulant market is projected to grow at **13%** per year.
- Valuation:
  - Current value (2023): **$1 billion** – **30-40% market share** of the biostimulants market
    - Requiring **250,000 to 500,000 tons** of seaweed per year
  - Expected value by 2030: **$1.8 billion**

TABLE 5: The market share of biostimulant categories, according to interviews and adapted from S&P Global 2022

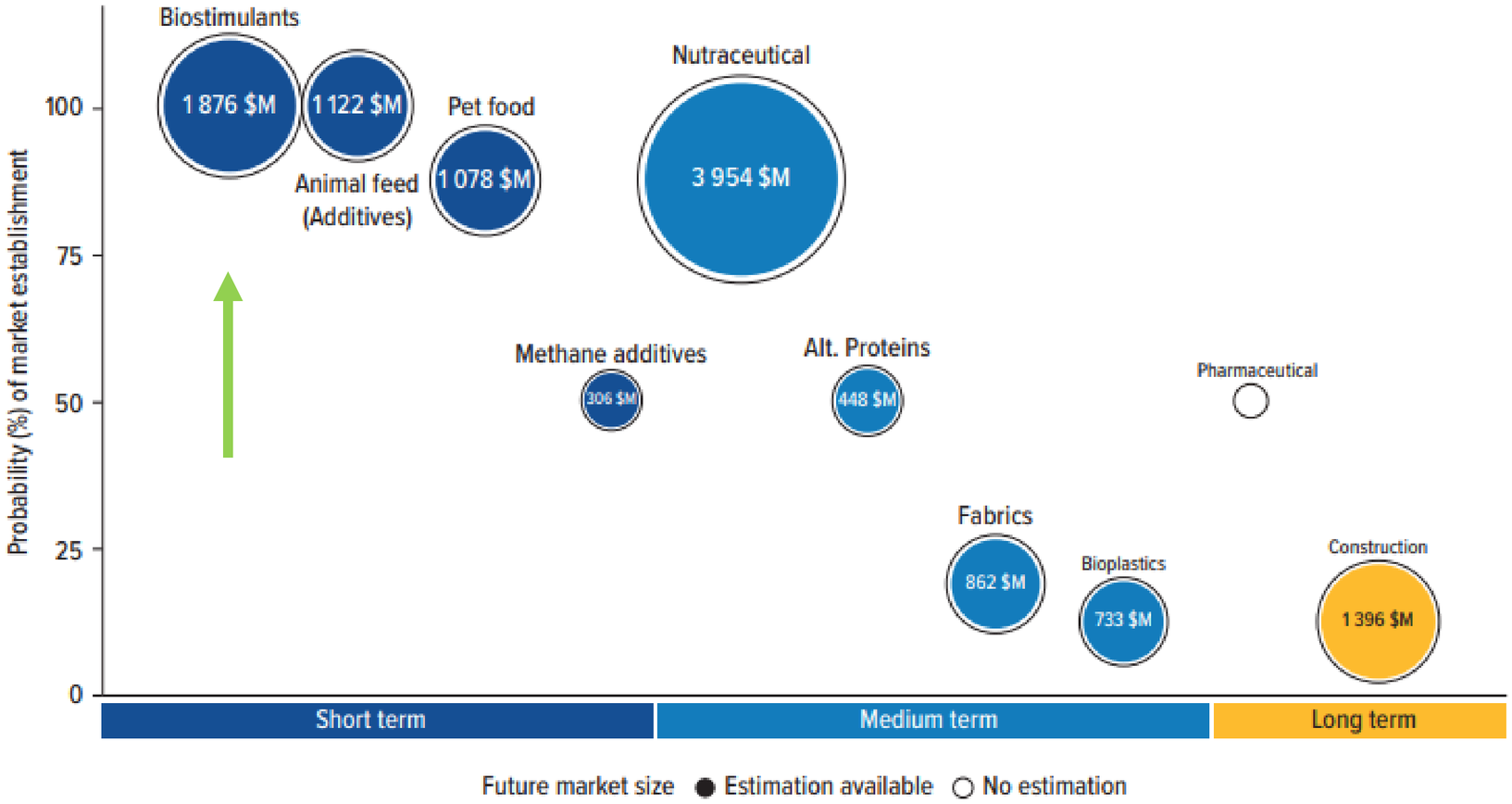
Category	Market share	Market value 2021
Seaweed extracts	40%	$935 million
Fulvic/humic acids	36%	$843 million
Microbial biostimulants	10%	$233 million
Amino acids	10%	$233 million
Trace minerals and others	4%	$100 million



Global Seaweed New and Emerging Markets Report 2023

Seaweed market

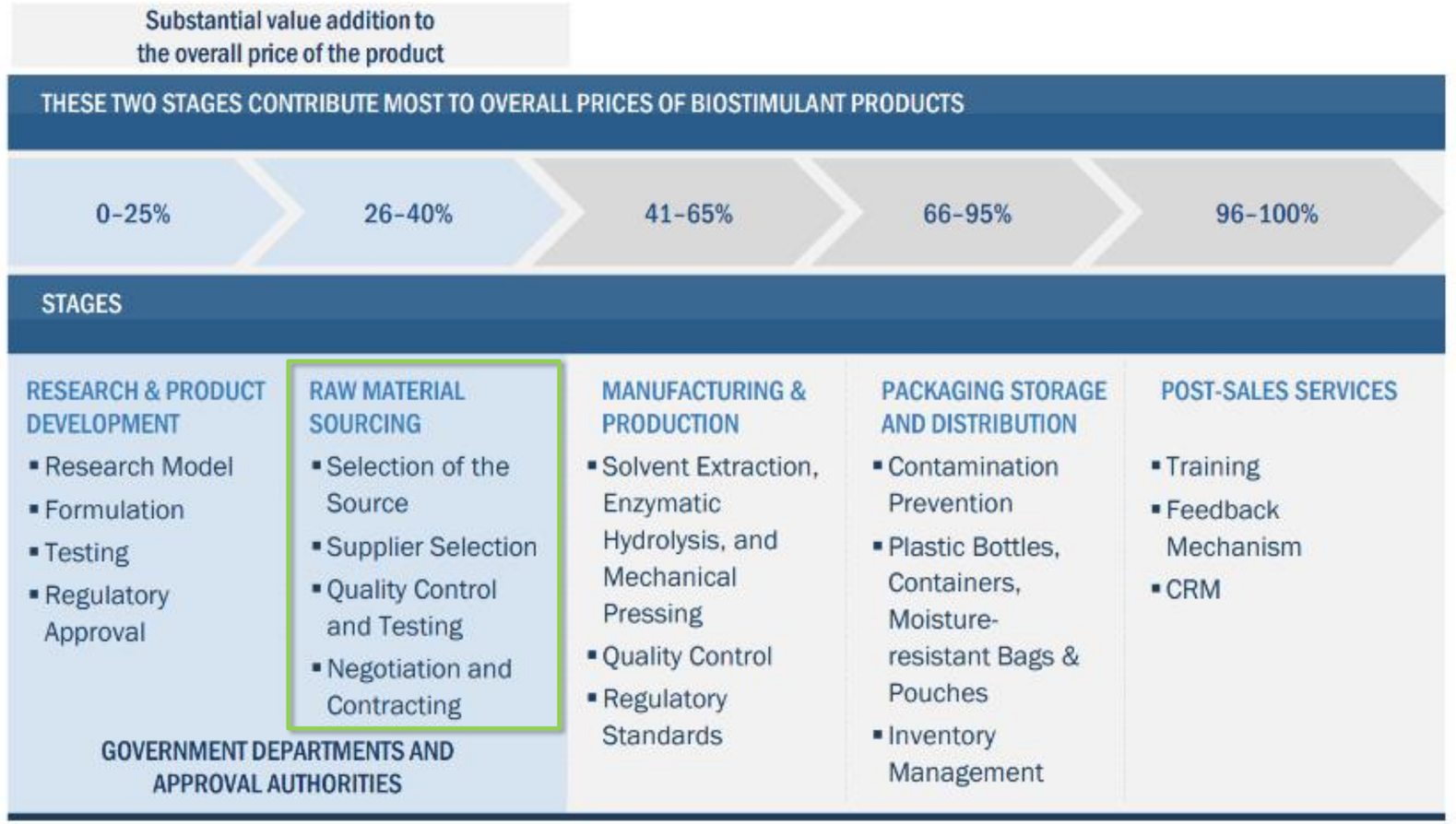
FIGURE A: Predicted seaweed market size by 2030 ($ millions) with chance of market establishment indicated by color on a high-level market horizon timeline



Global Seaweed New and Emerging Markets Report 2023

Biostimulants Value chain: Seaweed?

FIGURE 36 BIOSTIMULANTS MARKET: VALUE CHAIN ANALYSIS



Source: Secondary Research, Primary Interviews, Industry Journals, Related Research Publications, Press Releases, and MarketsandMarkets Analysis

Markets and Markets, 2024

Biostimulants Value chain: Seaweed?

Wild harvesting: major source for seaweed-based biostimulants

Wild populations can't fulfill the demands in the EU market

- Wild sources are being regulated
- But demands continuously grow

New source? Seaweed farming

- Off-shore farms
- Multi-use of space at the sea
- In-land production

CASE: vetik

Vetik is a biotechnology startup **from Saaremaa, Estonia**, dedicated to sustainably valorizing **local red seaweed** into high value, high-quality products.

Arvi Talk
Seaweed harvester

Tanel Ilmjärv
CEO, CTO

Valmar Kasuk
Sales, Marketing

CASE: vetik

Vetik is a biotechnology startup **from Saaremaa, Estonia**, dedicated to sustainably valorizing **local red seaweed** into high value, high-quality products.

- Why seaweed?
  - Abundant, underutilized red seaweed resources in Saaremaa
  - **Local resource → High-value products + promoting sustainability and rural development**

- Why biostimulant?
  - Other ideas were explored (ex: pigment for cosmetics)
  - Biostimulants have best **performance, market traction,** and potential for a **strong business case**.
    - Effective and natural solutions for enhancing plant growth and yield in a sustainable way

- Regulatory hurdles:

  - Understanding of regulations like **CE certification** and **REACH**
  - Extensive testing and detailed documentation to validate product claims and ensure compliance.

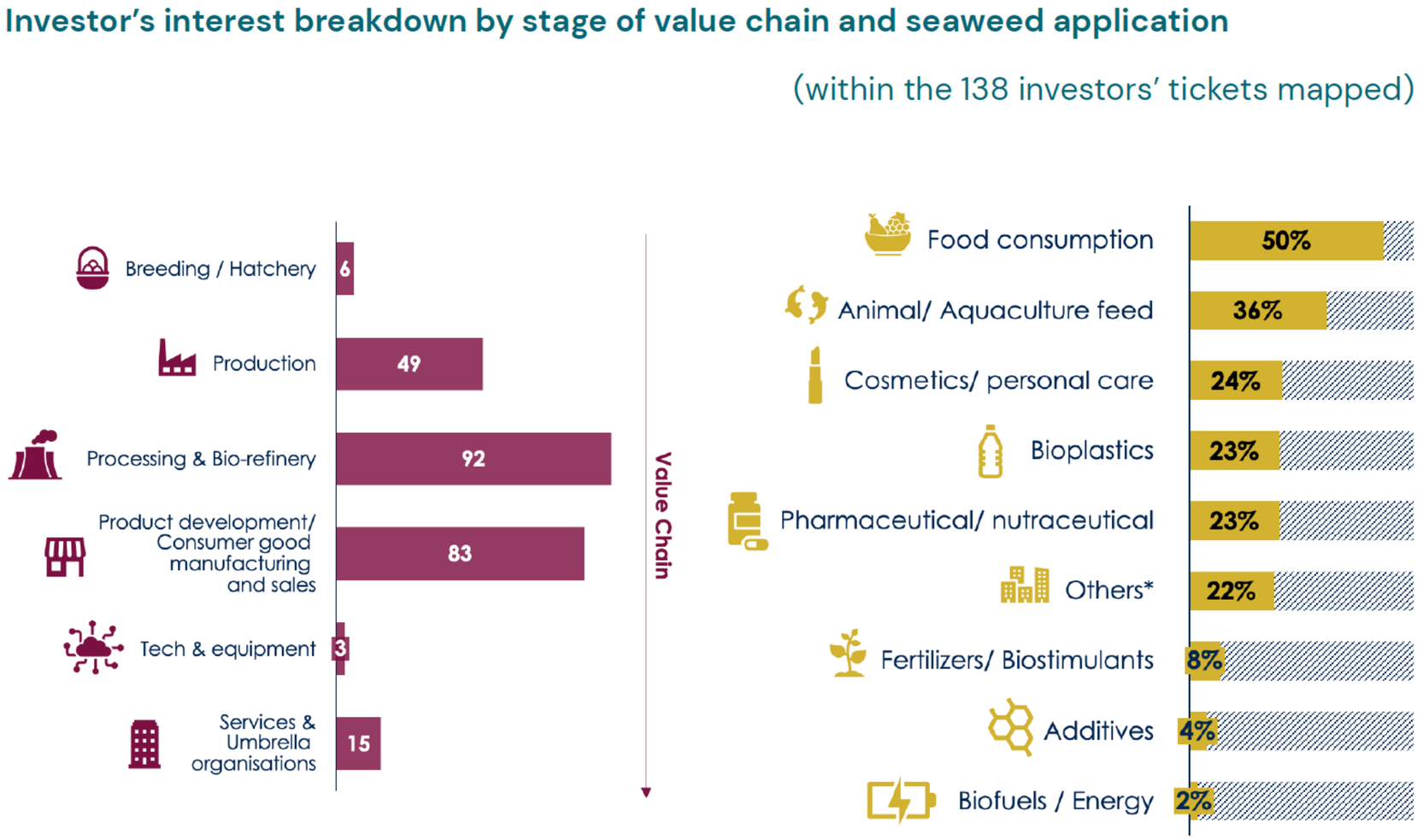
Upscaling in the blue economy: not straightforward

- **Global phenomenon**:
  - Much research TRL 2 – 5, little scale-up to pilot or commercial scale
  - Slower than in similar sustainable technology areas
  - Corporates and financial institutions are reluctant

- **Barriers partially identified**:
  - Sea as investible topic: not visible
  - Economies of scale, risk / return unknown, no parameters or benchmarks
  - Lack of talent ready to lead technically complex, longer-horizon company development
  - Understanding of and trust in blue economy related investments with asset owners / managers (patient capital)
  - A complex operating environment leading to a long development and funding cycle → Inherently more risky and capital intensive

- **Seaweed is exception: 'on trend'**

Investor’s interest in seaweed companies by stage of value chain and application

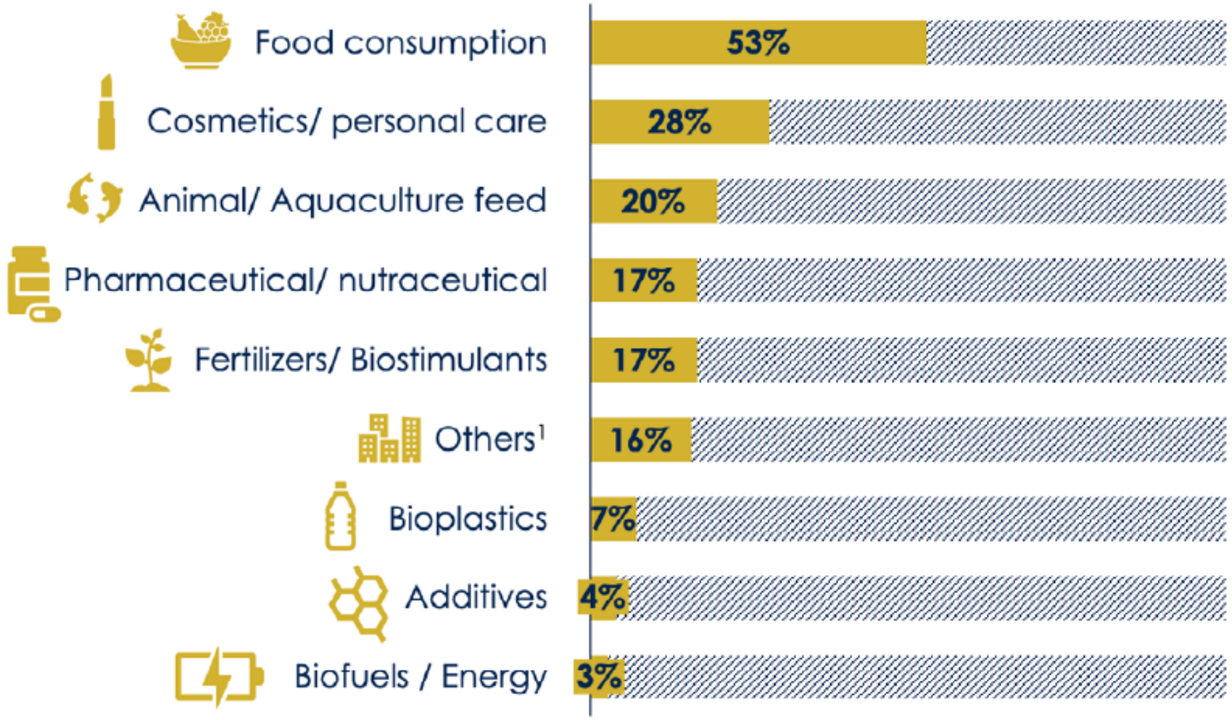


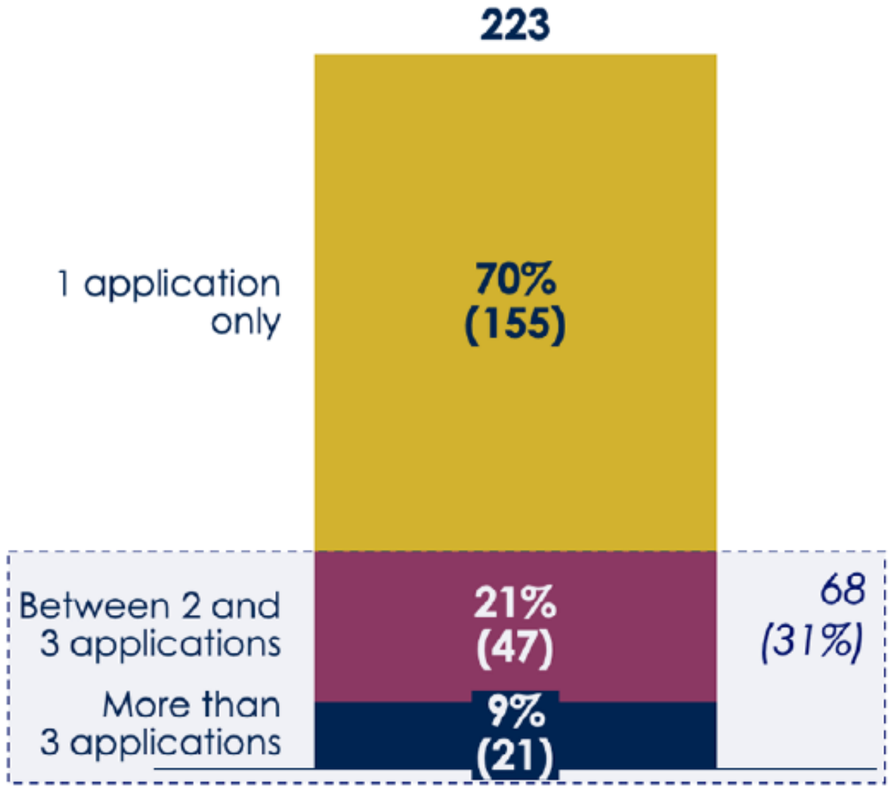
Seaweed for Europe, 2021

applications – single vs. multiple

– Single application focus prevails

Pipeline breakdown by type of application
(% of companies within the 223 organisations screened)





Seaweed for Europe, 2021

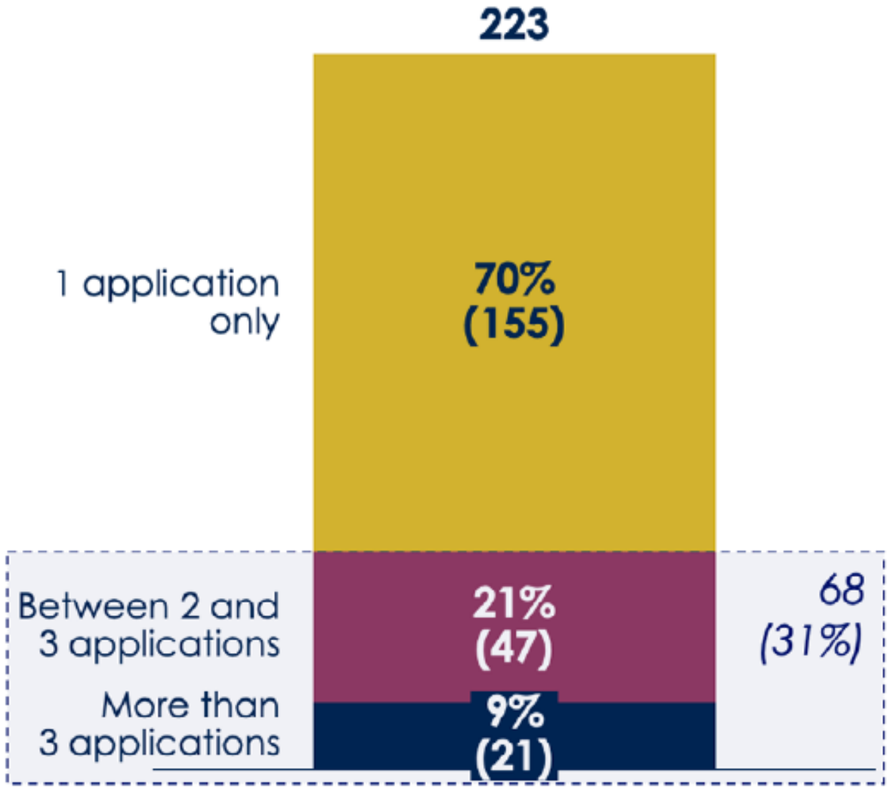
Multiple applications

Combinations:

- 10% cosmetics, pharma & food
- 10% cosmetics and food consumption
- 9% pharma/nutraceutical and food consumption business
- 7% animal feed and fertilizer business

Seaweed biostimulant (184 companies, 2023):

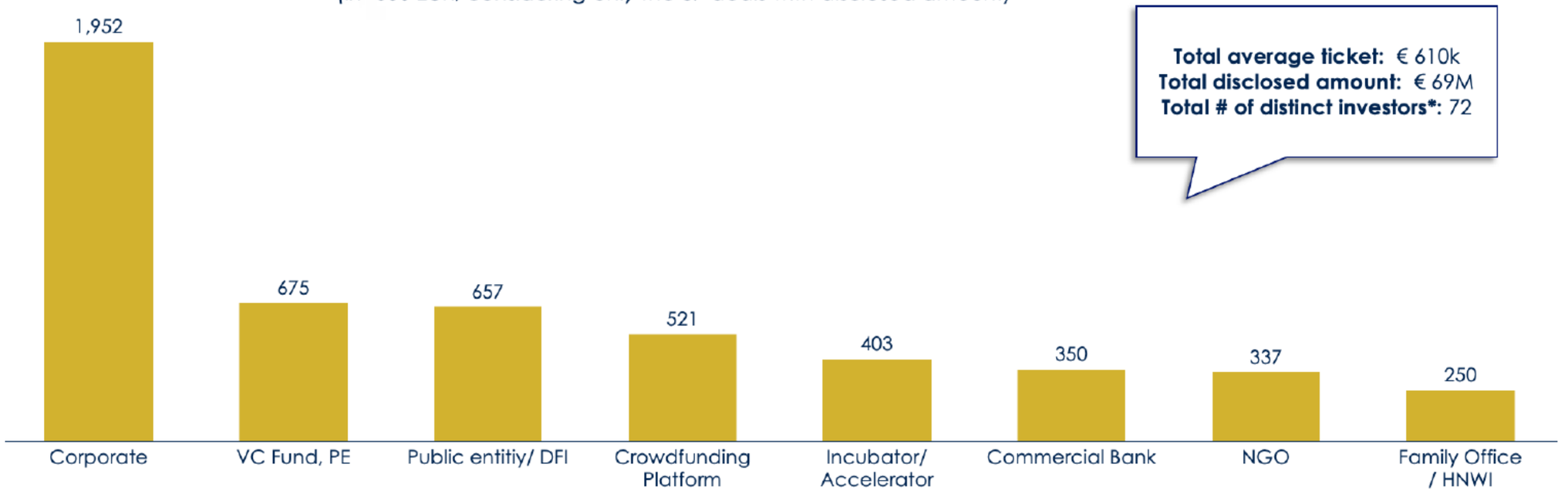
- 42% has other applications in portfolio
- Feed > Food ~ Hydrocolloids > Personal care



Seaweed for Europe, 2021 & own research

Average ticket size in seaweed business

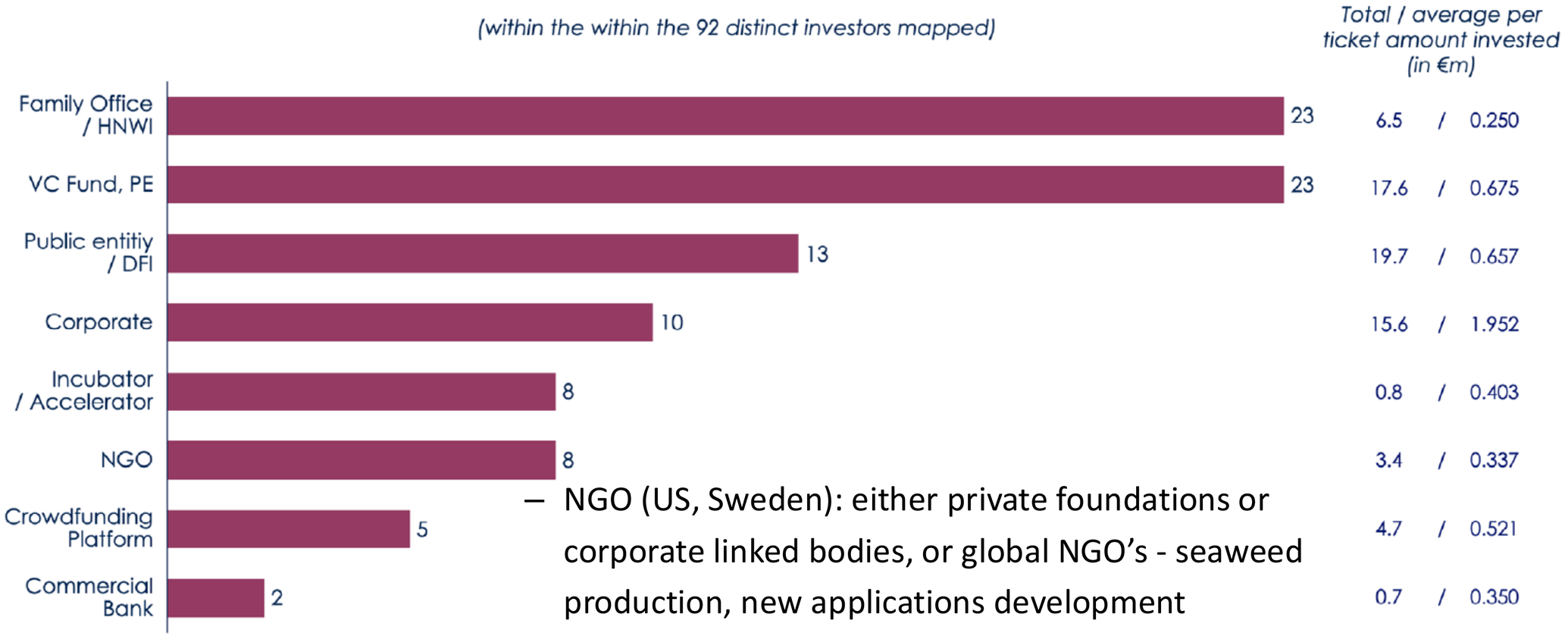
(in '000 EUR, considering only the 67 deals with disclosed amount)



Total average ticket: € 610k
Total disclosed amount: € 69M
Total # of distinct investors*: 72

Total disclosed amount invested ('000 EUR)							
15,618	17,557	19,719	4,693	806	700	3,374	6,504
# of distinct investors per background							
6	19	12	5	2	2	7	19

Investor types



- NGO (US, Sweden): either private foundations or corporate linked bodies, or global NGO's - seaweed production, new applications development
- Public entities: EU (EASME, EMFF), national bodies (UK coastal communities fund, regional (conseil regional d'acquitaine)

GAME

Genetic Approaches and cultivation protocols to unravel MEtabolite production of *Porphyra* spp. targeted towards human and plant health applications

Jessica Knoop, NIOZ/Ghent University
(Jessica.knoop@nioz.nl)

Olivier De Clerck (UGent), Jana Asselman (UGent), Kris Audenaert (UGent), Klaas Timmermans (NIOZ), Ilias Semmouri (UGent), Silke Deketelaere (Ugent), Noémie De Zutter (UGent), Silke Bouckenooghe (UGent), Jordi Morcillo (UGent), Dorien Derksen (NIOZ), Jesse van Groenigen (NIOZ), Andrea Romero Pérez (Biomares), Maaike Perneel (Business Developer), Margriet Drouillon (Business Developer), Ximena Reynafarje (Innovation Officer)

VLAIO

BLUE CLUSTER

CATALISTI
WE MEAN BUSINESS

GHENT UNIVERSITY

RESEARCH GROUP PHYCOLOGY

BGRL

LAMP
Laboratory of Applied Mycology and Phenomics

BIOMARES

NIOZ

Provision of consistently high-quality bioactive compounds…

…for nutraceuticals, biostimulants and biocontrol industries

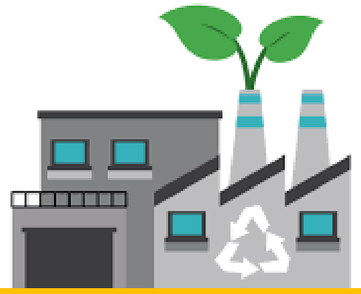
- Seaweeds = essential link in the development of a circular bioeconomy

- *Porphyra* (red alga):
  - occurs in the North Sea
  - fast growth
  - rich in bioactive metabolites
  - dynamic physiological response
  - can be cultivated on land and at sea

Our approach:
Optimise, identify and develop

***Porphyra* biomass**

Controlled cultivation & tailoring metabolite composition



Optimise pre-treatment, storage & Biorefinery

Extractions & analysis

Identify *Porphyra* bioactives for potential as

Nutraceuticals

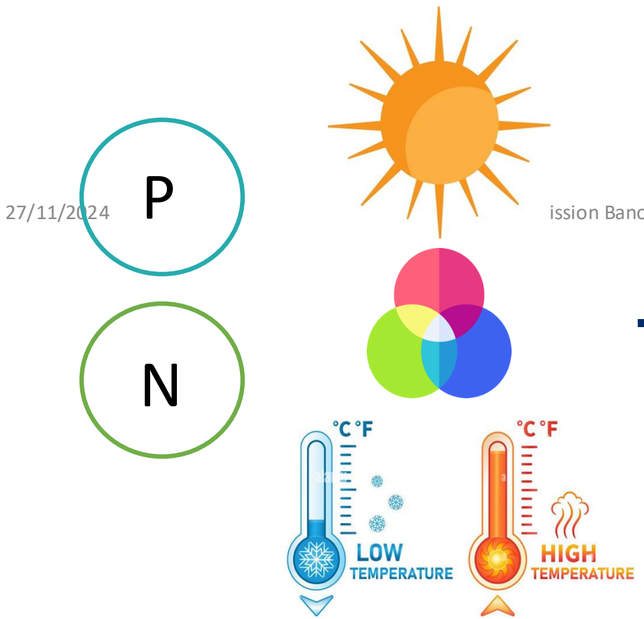
Agricultural Biologicals

Develop *Porphyra* based biostimulants and biopesticides

Controlled cultivation & tailoring metabolite composition

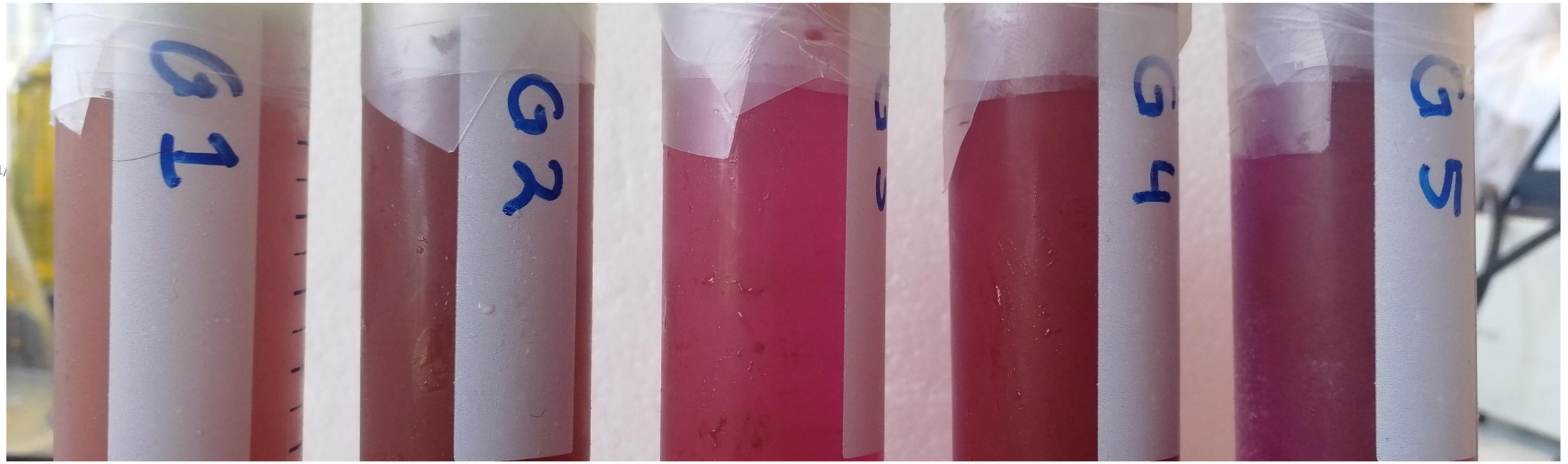
- close the existing knowledge gaps on the life cycle variations
- define environmental conditions to trigger asexual or sexual reproduction
- define optimal abiotic stressors for enhanced bioactive compound content

RESEARCH GROUP PHYCOLOGY



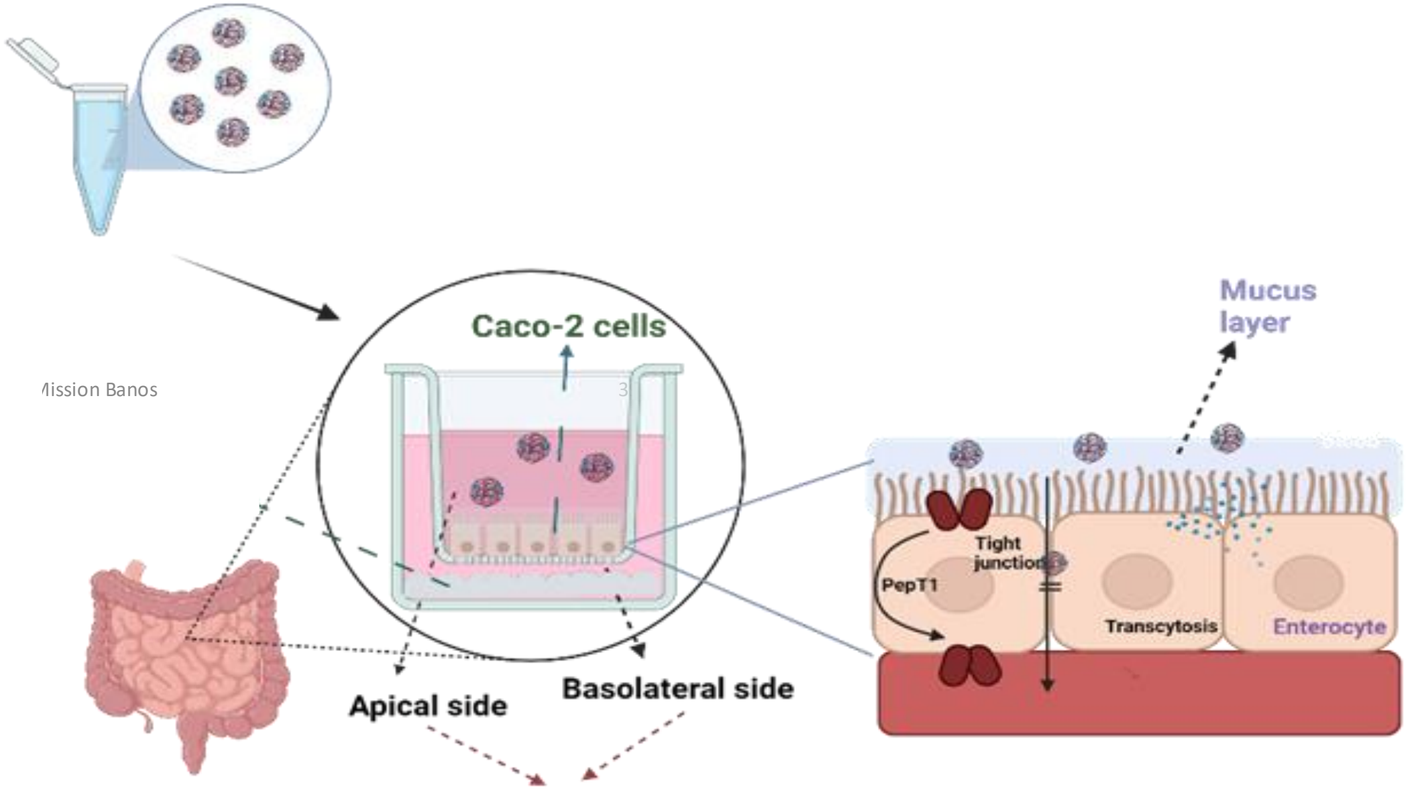
Extractions & analysis

- Effects of post-harvest treatments
- Extraction and fractionation
- Biochemical analysis (C/N, pigments, MAAs, antioxidants, amino acids)



Evaluate bioactivity of extracts for nutraceutical activity

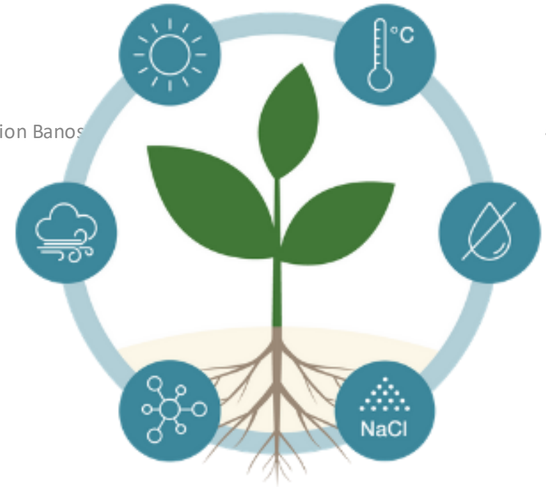
- confirm stability and uptake of seaweed bioactive compounds in the human digestive system



Evaluate Porphyra extracts as biostimulants and biopesticides

- Evaluate the crude *Porphyra* extracts for selected traits
  - Fungicidal activity, UV protectant, resistance inducers, biostimulants
- Bioactivity-based extract optimization/fractionation

LAMP
Laboratory of Applied Mycology and Phenomics



Thank you!

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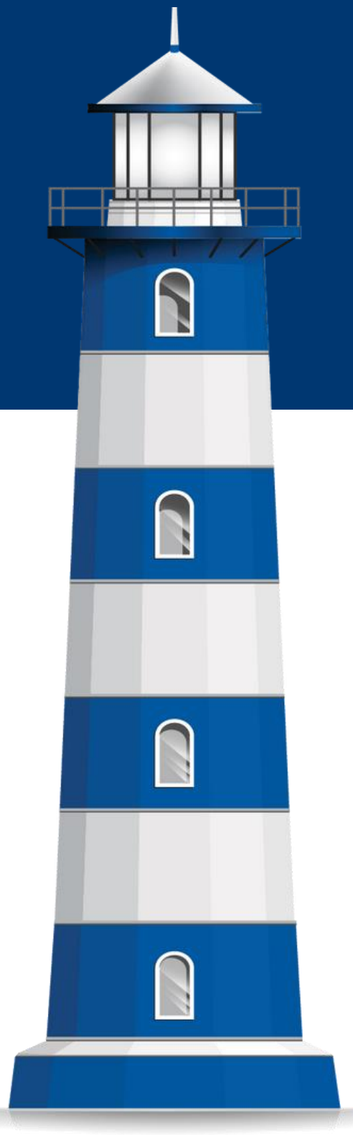
Supporting the Mission Ocean Lighthouse in the Baltic and North Sea Basins



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3rd MISSION ARENA
26-27 November 2024 | Amsterdam

TRANSFORMING BREWERY WASTE INTO AGRICULTURAL SOLUTIONS: CIRCULAR BIOTECHNOLOGY WITH ALGAL REMEDIATION

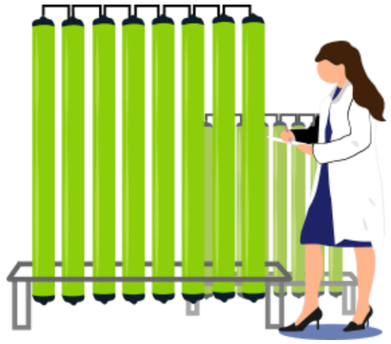
Dr Alla Silkina, Swansea University

27 November, 11:15-13:00am
Hall 4

Swansea University
Prifysgol Abertawe

Funded by the Europe

MicroALGAE



BIOFERTILASERS

BIOSTIMULANTS

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

Interreg North-West Europe IDEA
European Regional Development Fund

Algaebrew

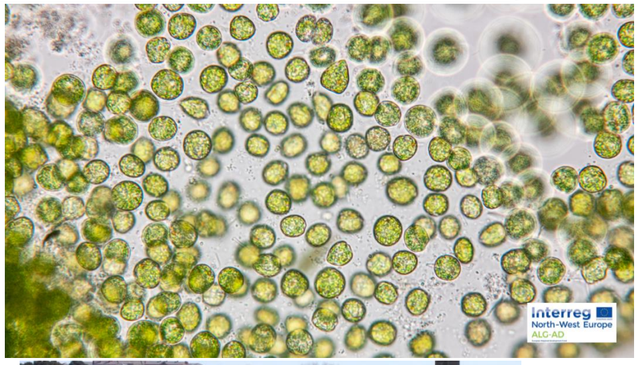
TRANSFORM WASTE NUTRIENTS to Valuable PRODUCTS

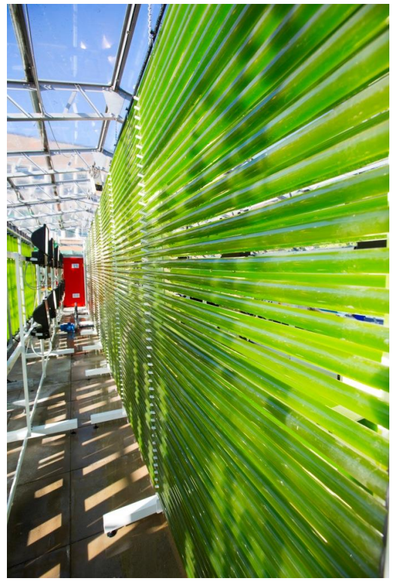
CIRCULAR BIOECONOMY

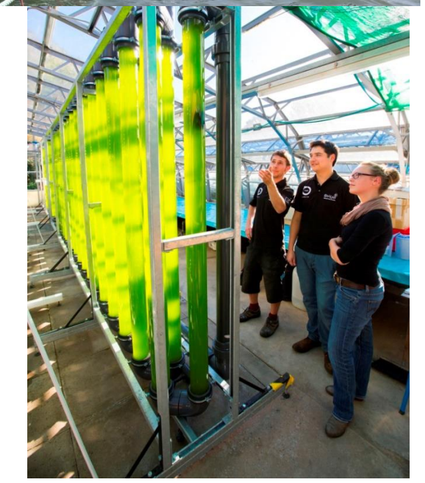
Swansea University Algal Biotechnology

- Algal collections ~ 27 species for mass cultivation (Sterile cultures 20ml → 2L → 20L Carboys)
- 20 x 100L batch culture capacity, controlled environment lab
- 2 x 800L Biofences, greenhouse
- 1 x 1000L Phyco-Flow glass PBR,
- 1 x 2000L PBR, greenhouse
- 1 x 4000L vertical PBR, form industrial location
- 3 x 1,000L Phyco-Ponds Raceways

- Pilot dewatering facilities membrane filtration: MF, UF, DF
- Continues flow-centrifuge 200 L/hours
- Industrial freeze dryer /Spray drier
- Homogeniser and bead mill



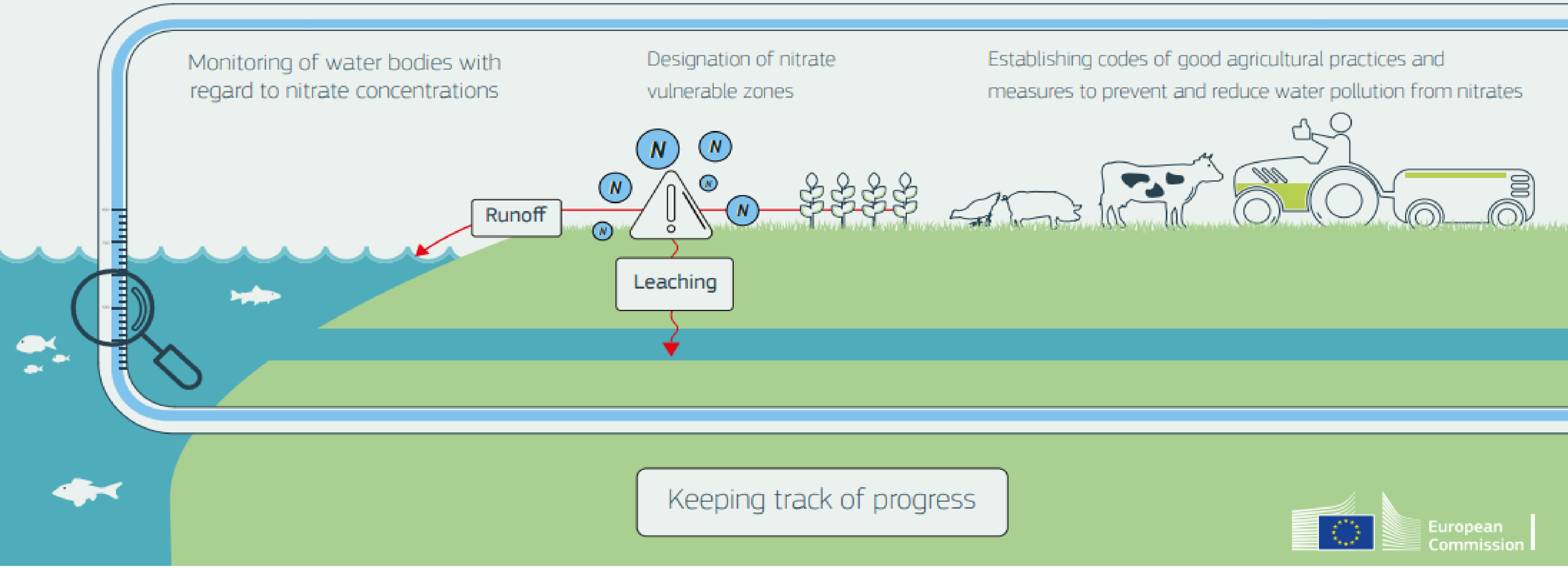




Swansea University
Prifysgol Abertawe

ALG – AD BACKGROUND

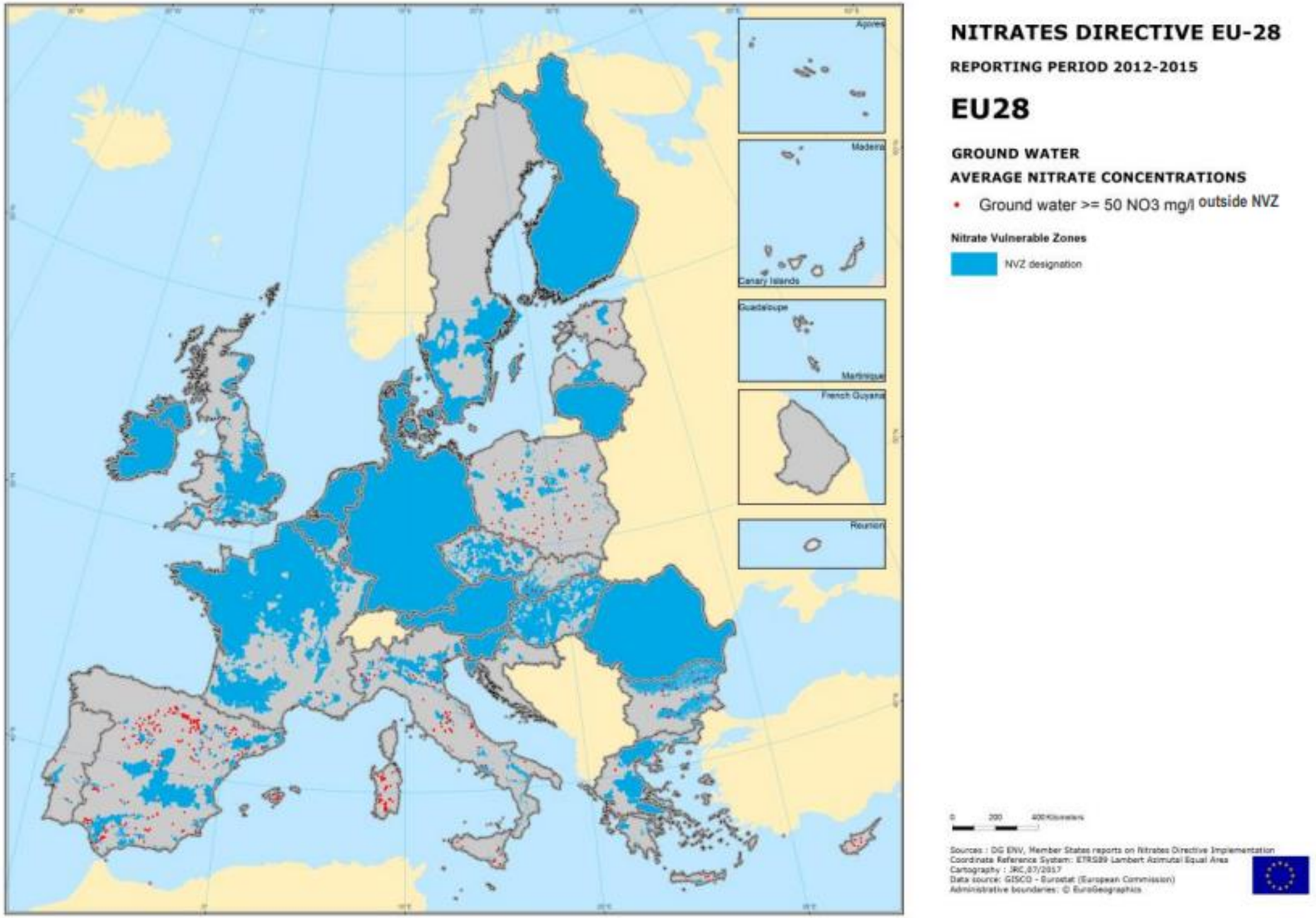
The EU wants to reduce water pollution caused by nitrates used in agriculture and sets out steps for EU countries to take



Keeping track of progress

European Commission

NITRATES VULNERABLE ZONES IN EUROPE



NITRATES DIRECTIVE EU-28

REPORTING PERIOD 2012-2015

EU28

GROUND WATER

AVERAGE NITRATE CONCENTRATIONS

- Ground water >= 50 NO3 mg/l outside NVZ

Nitrate Vulnerable Zones

NVZ designation

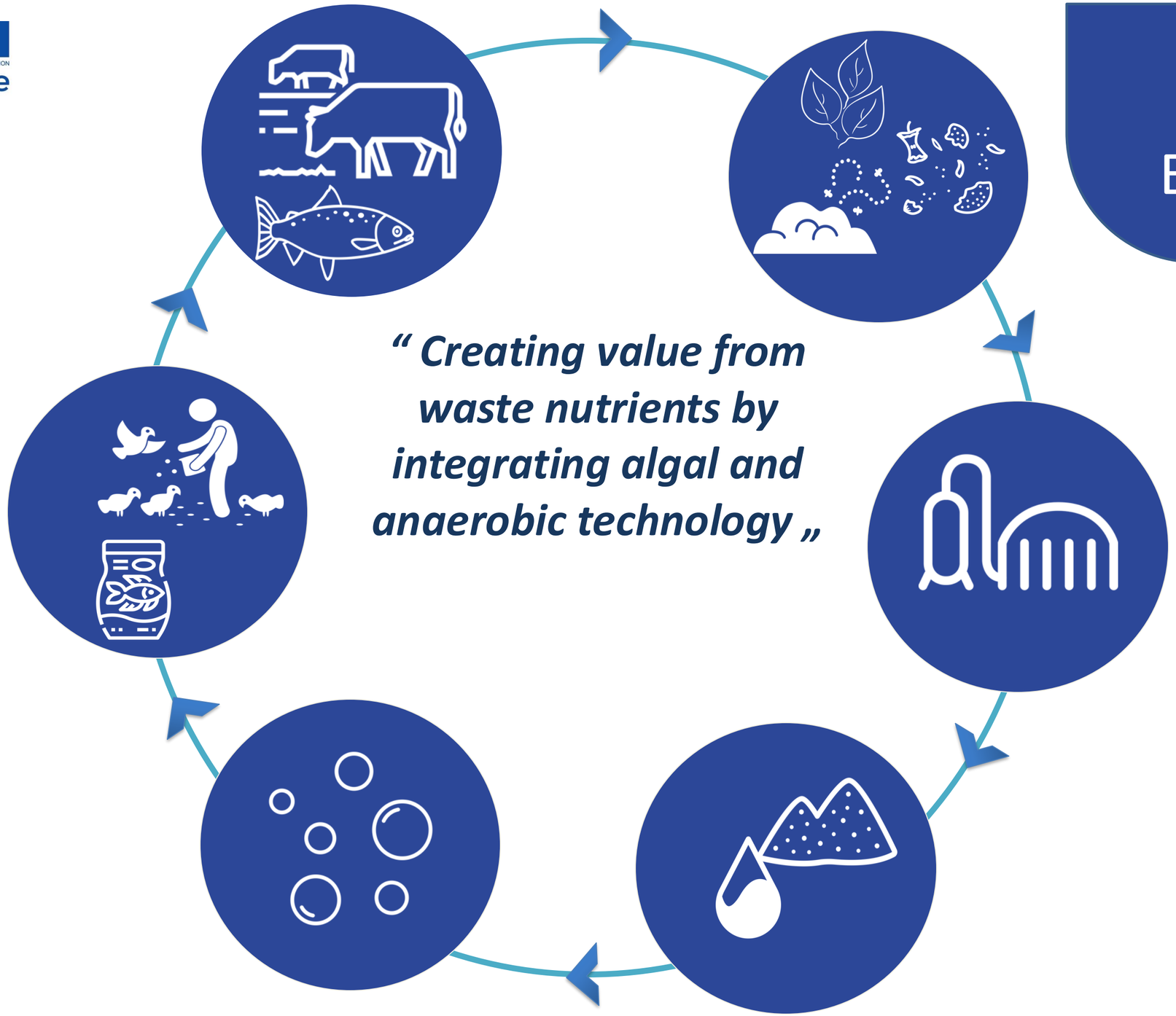
0 200 400 Kilometers

Sources : DG ENV, Member States reports on Nitrates Directive Implementation
Coordinate Reference System: ETRS89 Lambert Azimutal Equal Area
Cartography : JRC,07/2017
Data source: GISCO - Eurostat (European Commission)
Administrative boundaries: © EuroGeographics

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].

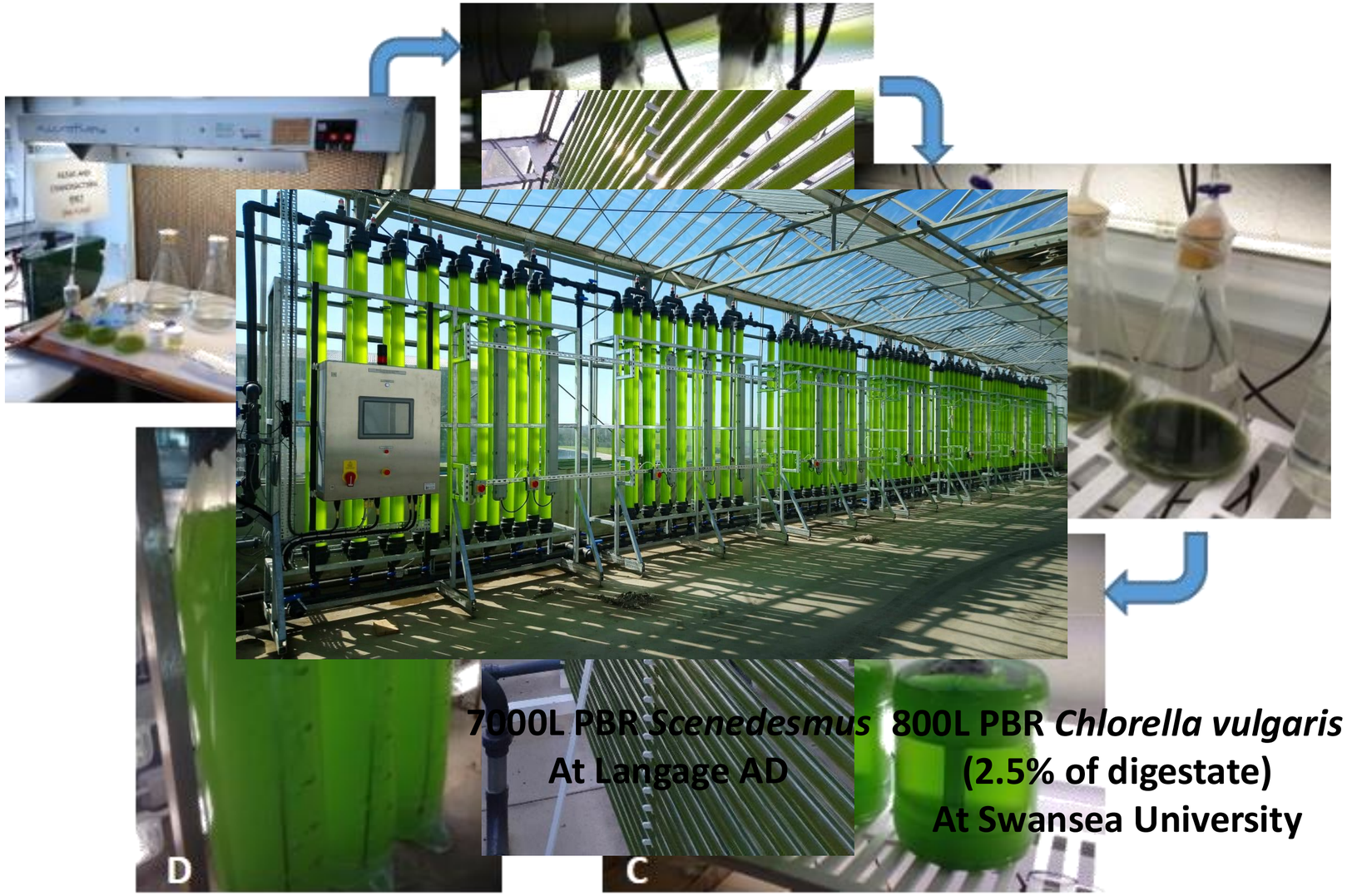
Interreg North-West Europe
ALG-AD
European Regional Development Fund

CIRCULAR ECONOMY



“ Creating value from waste nutrients by integrating algal and anaerobic technology „

FROM LAB TO PILOT SITE



7000L PBR *Scenedesmus*
At Langage AD

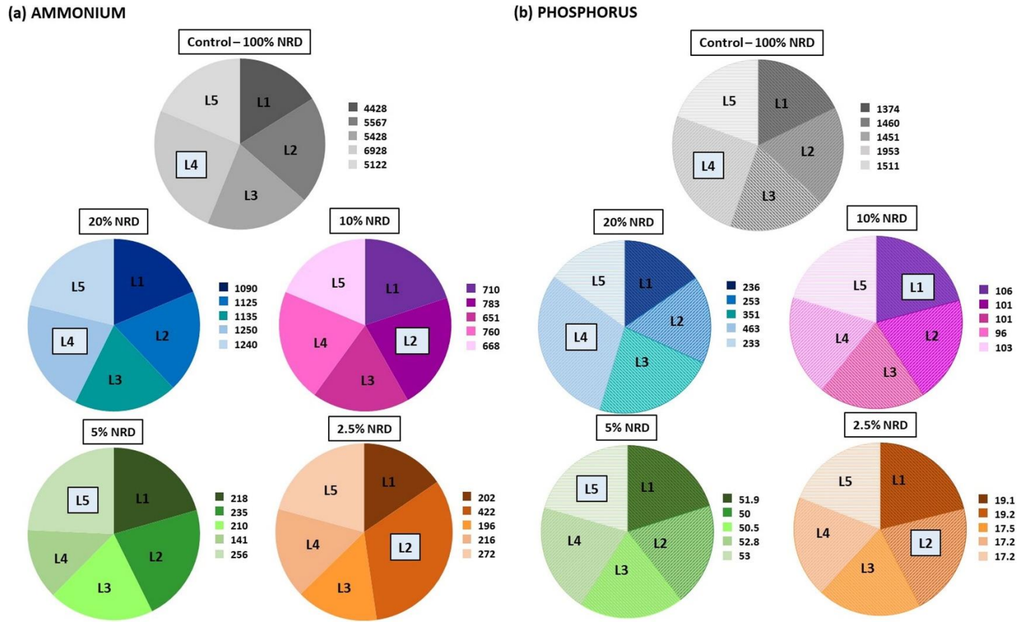
800L PBR *Chlorella vulgaris*
(2.5% of digestate)
At Swansea University

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

Agricultural waste remediation

- Liquid waste after the AD process, initial feedstock: food waste, milk by-products and others
- Pre-treatment of the waste and digestate
- Com hods: filtration

	Ammonium NH4+ (g/L)	Total Nitrogen N (g/L)	Phosphorus P (g/L)
Raw waste	**4.01**	**5.17**	**0.66**
Micro-filtered	**3.15±0.22**	**4.05±0.28**	**0.05±0.001**
Ultra-filtered	**1.43±0.33**	**1.84±0.43**	**0.02±0.001**
Nano-filtered	**1.94±0.18**	**2.49±0.23**	**0.02±0.0002**



Silkina, 2019; Fernandes et al, 2020

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

THREE PILOTE FACILITIES

Langage AD, Plymouth

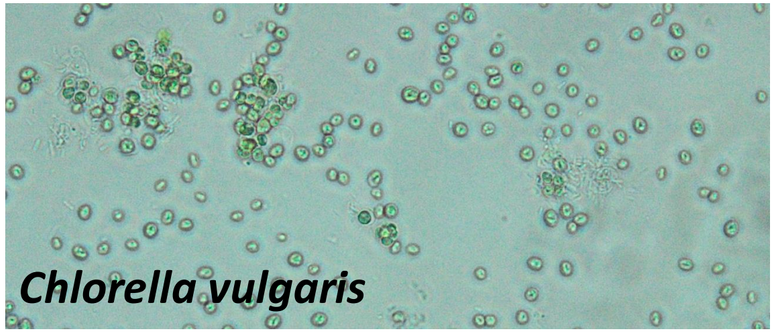
Cooperl, Lamballe

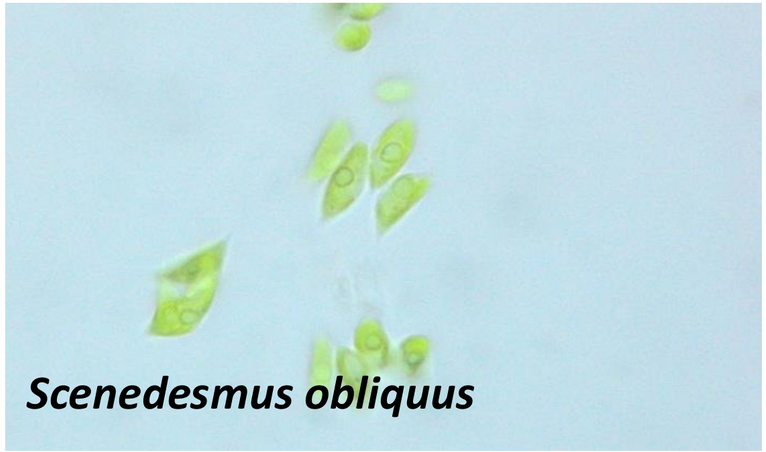
Innolab, Ghent

THREE PILOTE FACILITIES

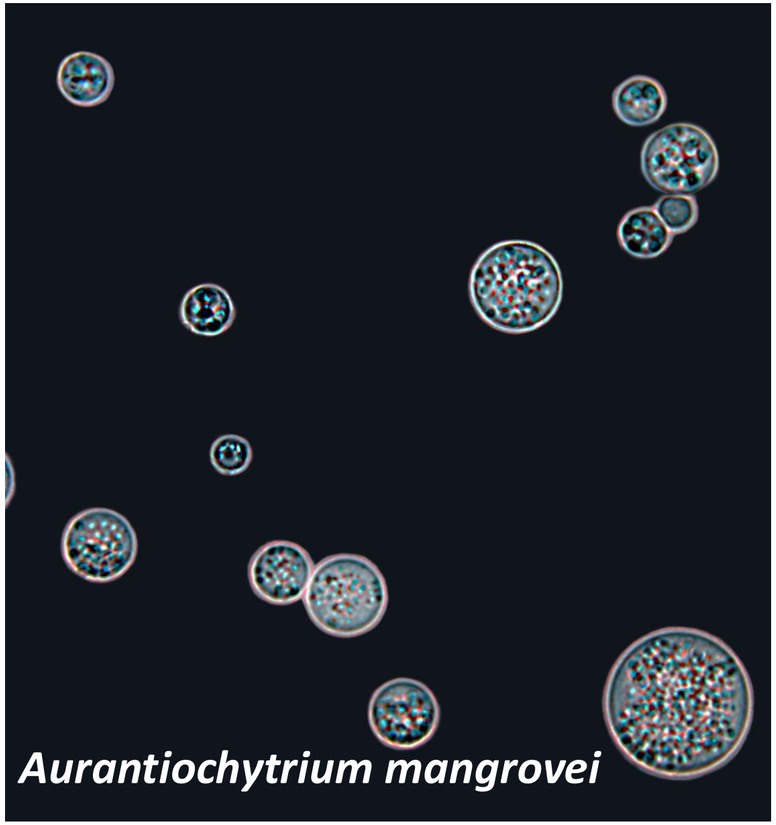
Interreg North-West Europe ALG-AD
European Regional Development Fund

Langage AD, Plymouth

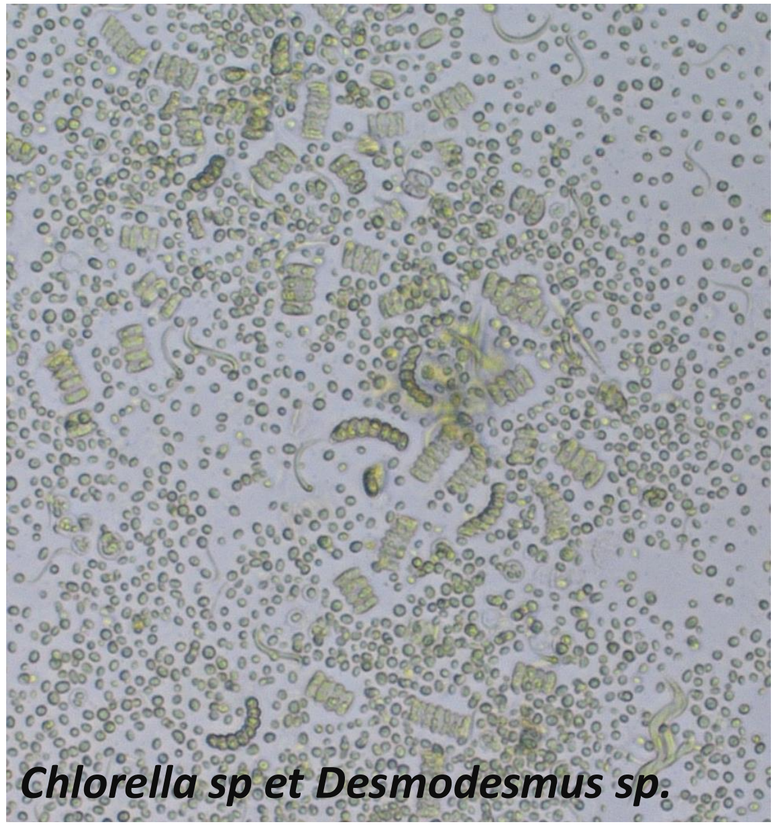

Chlorella vulgaris


Scenedesmus obliquus

Cooperl, Lamballe


Aurantiochytrium mangrovei

Innolab, Ghent


Chlorella sp et Desmodesmus sp.

THREE PILOTE FACILITIES

Langage AD, Plymouth

2.5% digestate (80 mg/L $NH4^+$)

7 days of cultivation

10 g/L glucose in mixo phase

14 g/L final biomass

20 mg/L/day N uptake

Cooperl, Lamballe

2.5% digestate (70 mg/L $NH4^+$)

2 days of cultivation

20 g/L glucose, 2 g/L yeast extract, 2 g/L peptone

4 g/L final biomass

35 mg/L/day N uptake

Innolab, Ghent

2.5% digestate (50 mg/L $NH4^+$)

7 days of cultivation

No external nutrients

1.7 g/L final biomass

20 mg/L/day N uptake

ALGAL BIOMASS USE

- High concentration of proteins, pigments and fatty acids

  70% of protein content

- Hydrolysation for the functional protein fractionation

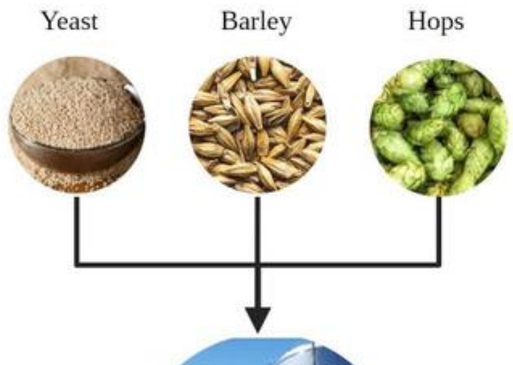
- Animal feed development and testing for pigs and fish

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

Interreg North-West Europe IDEA European Regional Development Fund

Same concept was tested in IDEA project for the BIFERTILAZERS APPLICATION

The Problem: Breweries and wastewater



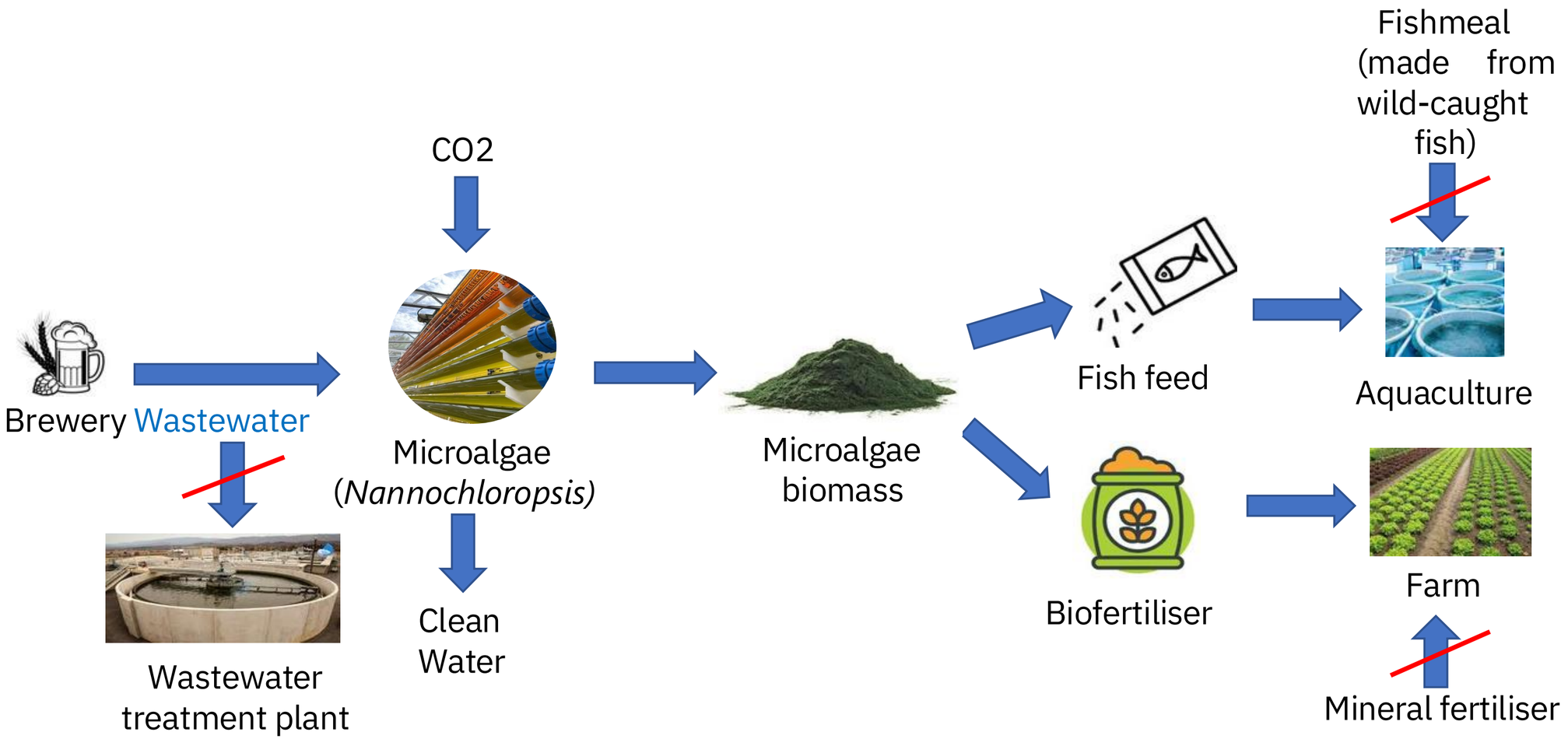
Beer | Wastewater | Spent Grain

52B. Litres | 156-520B. Litres | 10B. Kilograms

Brewery Wastewater Treatment

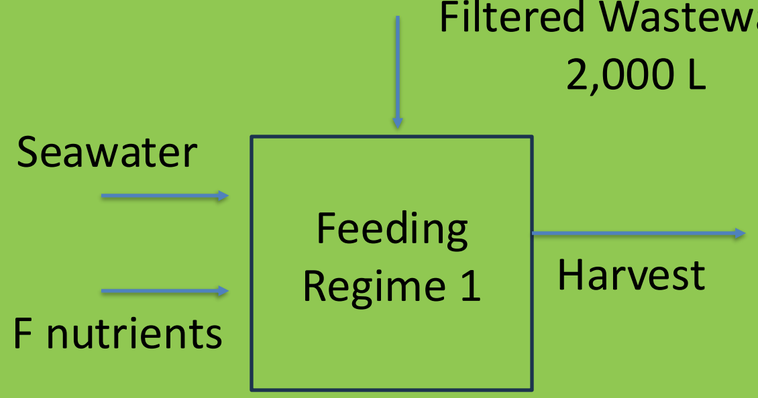
Complex multi-step treatment
Energy intensive
Long residence time
Chemical heavy

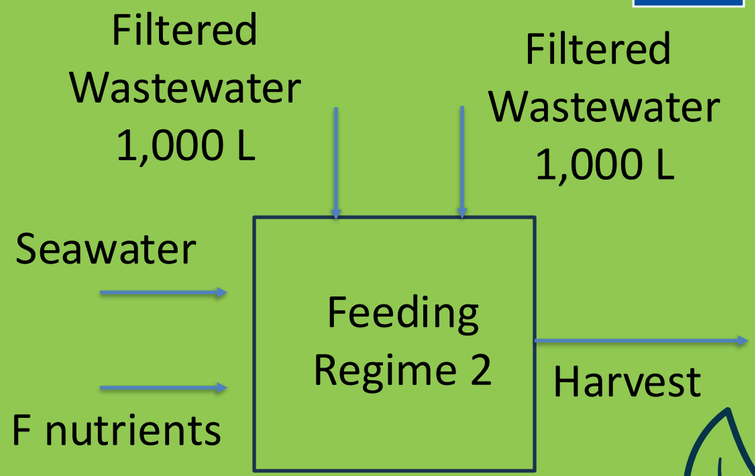
AlgaeBrewProject Scope

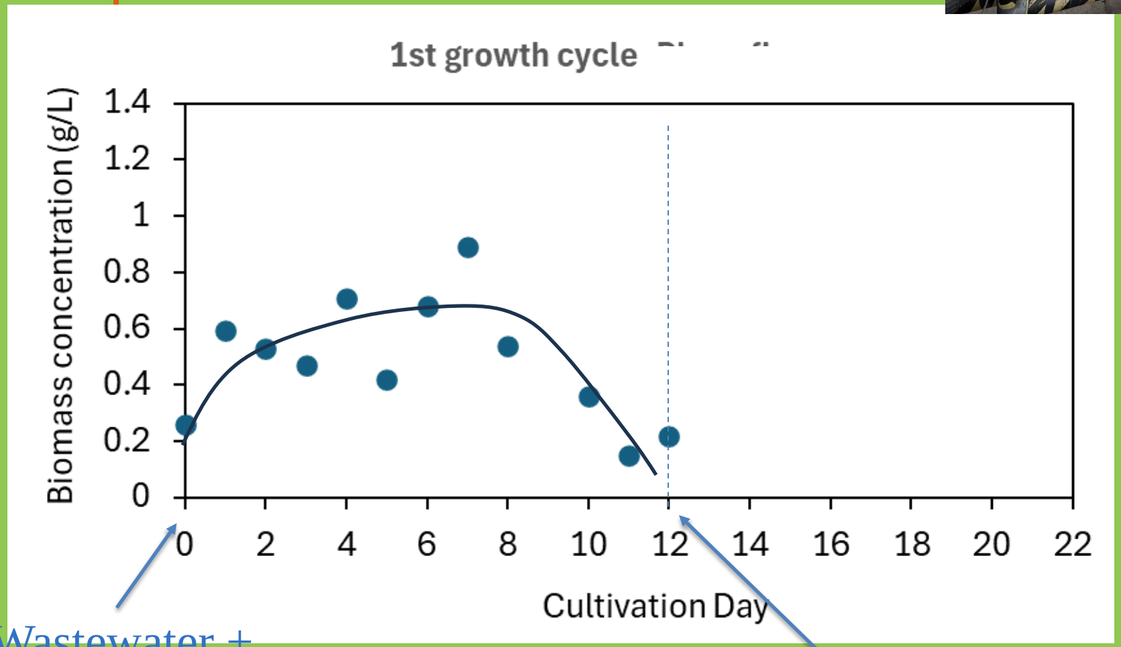


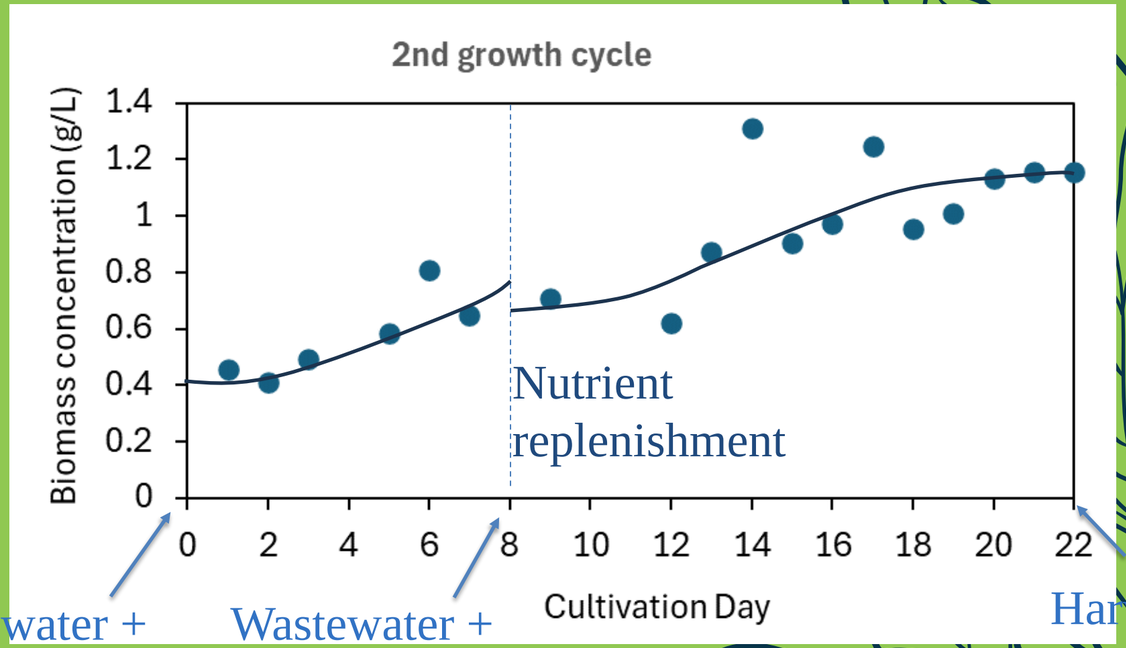
Pilot scale-up

#EU4Algae









BIOFERTILASERS from microalgae

Optimum C/N ratio:
C/N ratio = 9-12

Elemental Analysis:
C/N ratio = **6.74**

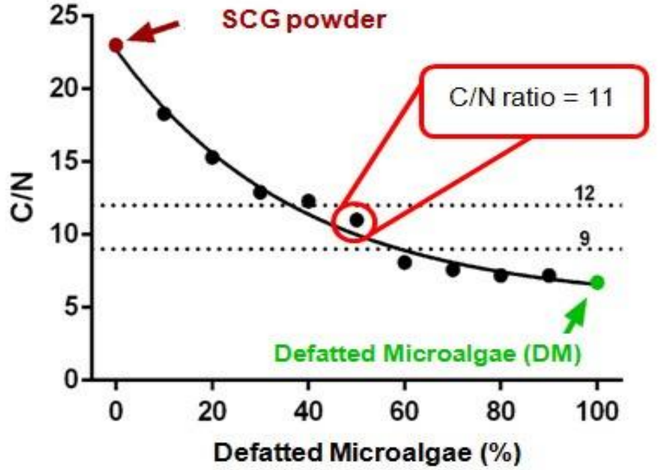
Microalgae
Biomass Residues

9 Formulations

Granulation

Elemental Analysis:
C/N ratio = **23**

Spent Coffee
Grounds (SCG)



>Another organic waste from Coffee brewing industries >Cost-effective material

Plant health effects: Phyto-toxicity Tests

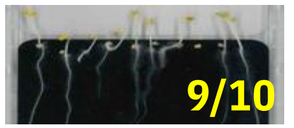
Measures the decrease (or the absence) of *seed germination* and of the growth of the *young roots* after a few days of exposure of fertilizer (treatment) in comparison to the controls (reference soil)

Three Plant Species

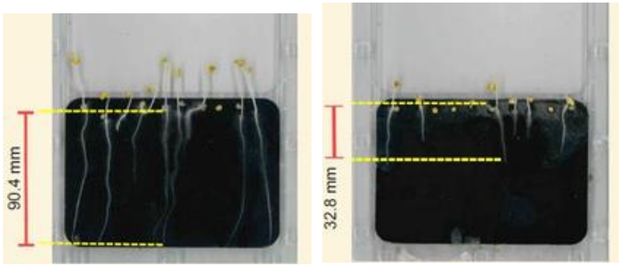
1) *Sorghum (Sorghum saccharatum)*
2) *Cress (Lepidium sativum)*
3) *Mustard (Sinapis alba)*

ISO standard 11269-1

- Seed Germination Rate



- Root Length



Control ➡ Standard Soil with no fertilizer Addition

Treatments ➡
- >1.25% Fertilizer
- >2.5% Fertilizer
- >5% Fertilizer
- >10% Fertilizer
- >15% Fertilizer

>Plate Preparation
>Ten seeds in each plate

Climatic Chamber
>Dark
>Temperature: 25 ±0.5°C
>Time: 72 hours

Plates are scanned by using a flatbed scanner and analyzed by

ImageJ https://imagej.net/ij/

CIRCULAR BIOECONOMY

Microalgae - sustainable way to produced the biomass

Transformation of AD and brewery WASTE nutrients demonstrated at the industrial locations

BIOFERTILASERS from microalgae are validated

a.silkina@swansea.ac.uk

Algaebrew

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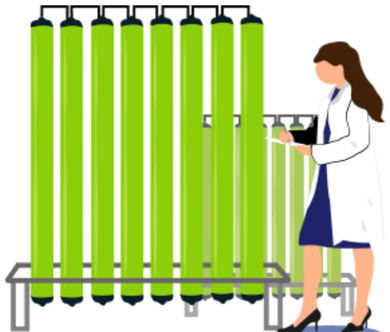
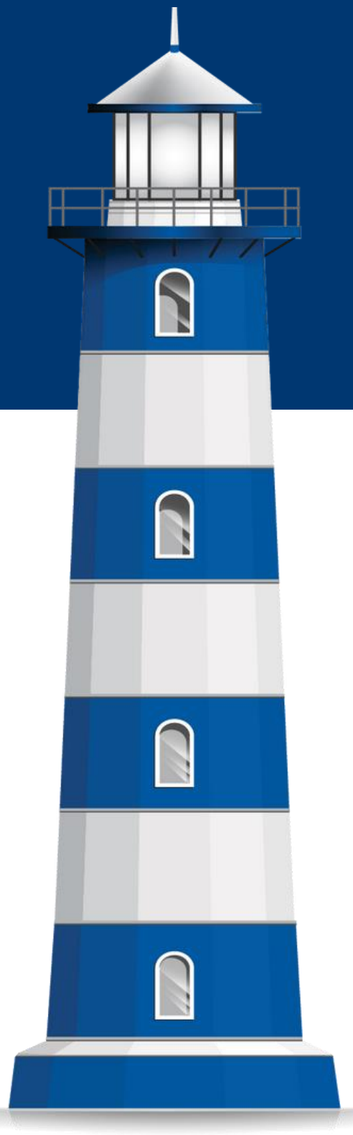
Interreg North-West Europe IDEA
European Regional Development Fund



EU MISSIONS
RESTORE OUR OCEAN & WATERS

BLUE MISSION BANOS

Supporting the Mission Ocean Lighthouse in the Baltic and North Sea Basins



3rd MISSION ARENA

26-27 November 2024

Amsterdam

REGIONAL FOCUS ARENA 3

The Netherlands
BELGIUM
DENMARK I West
GERMANY I West
FRANCE I North

EU MISSIONS
RESTORE OUR OCEAN & WATERS

BLUE MISSION BANOS

3rd MISSION ARENA
26-27 November 2024 | Amsterdam

The power of microalgae in agriculture

Biostimulants: A sustainable boost for plant health

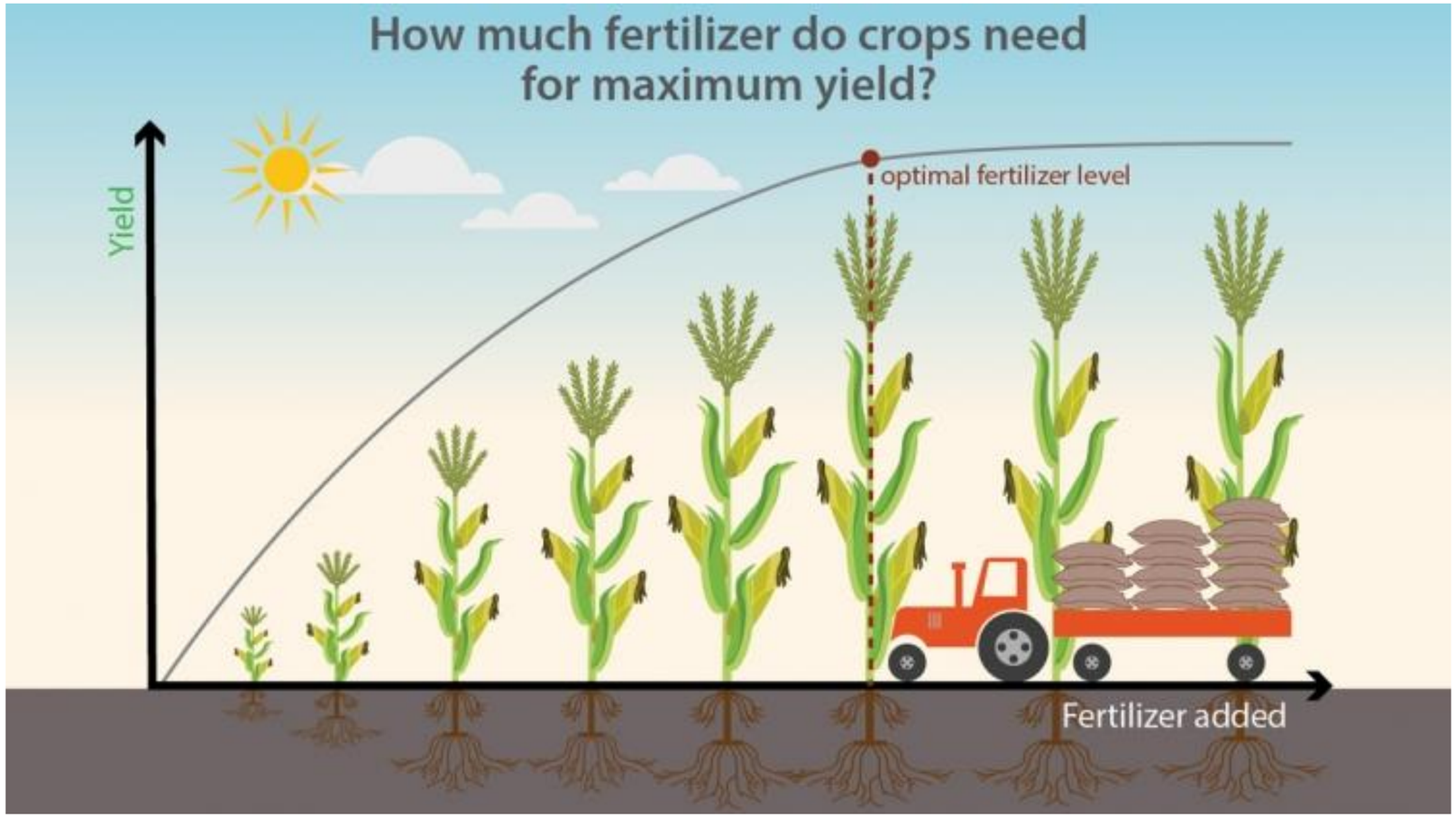
27 November, 12:10-12:20am
Hall 1

#MissionArena3

WAGENINGEN

Funded by the Europe

Traditional plant nutrition



(IAEA, 2023)

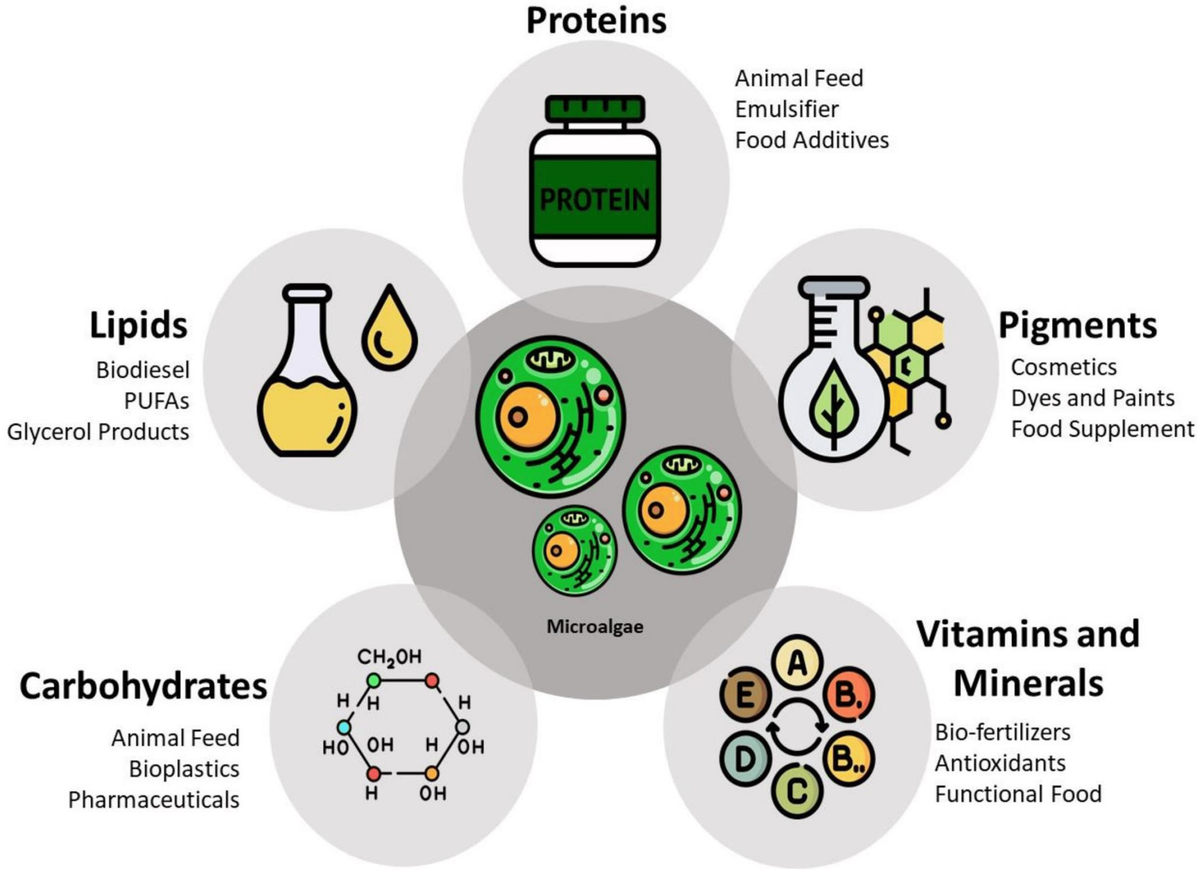
Traditional plant nutrition

(IAEA, 2023)

Biostimulants

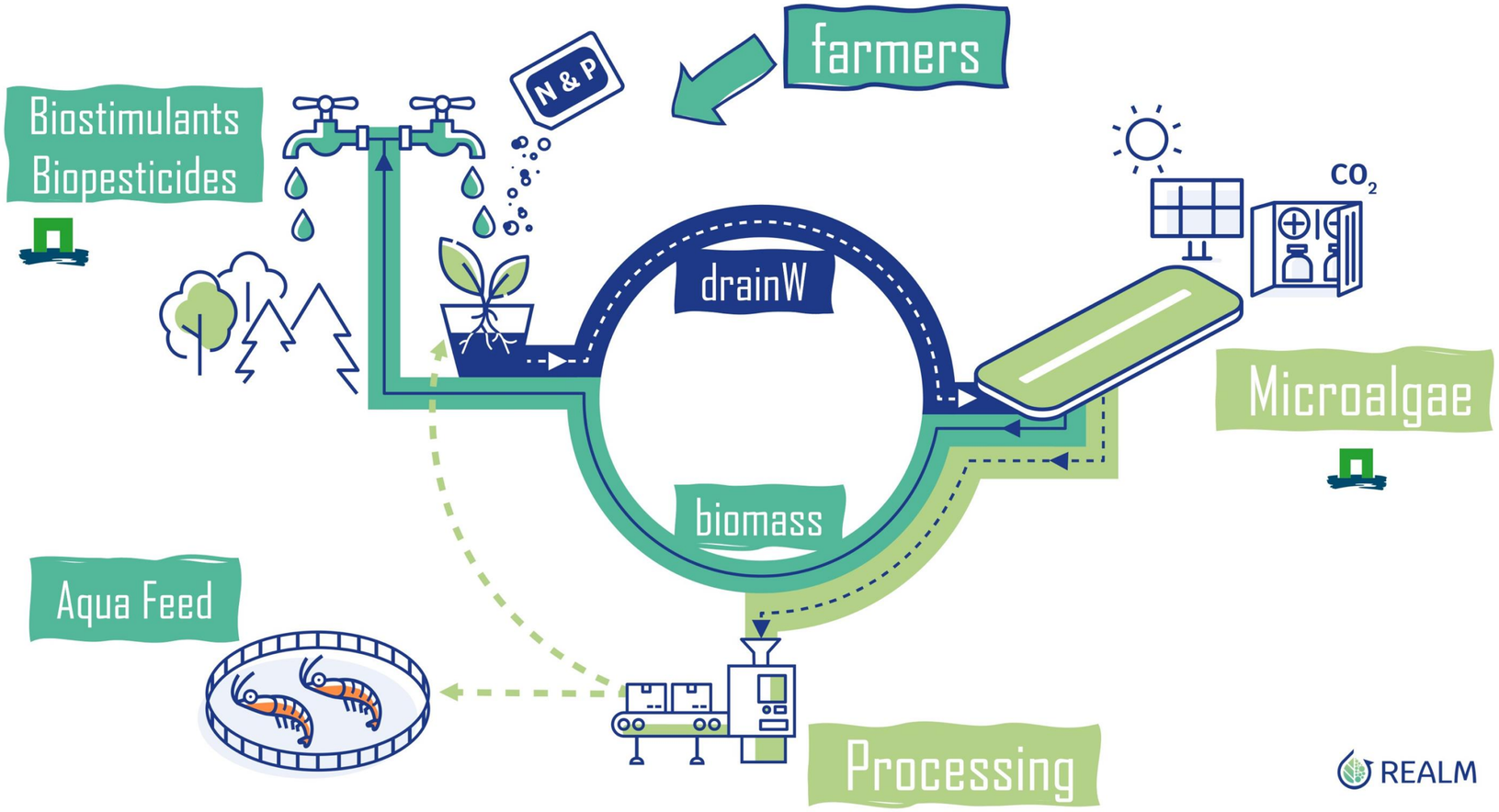
"Any substance or microorganisms applied to plants with the aim to enhance nutrient efficiency, abiotic stress tolerance, and/or crop quality traits, regardless of its nutrient content"

(Du Jardin, 2015)

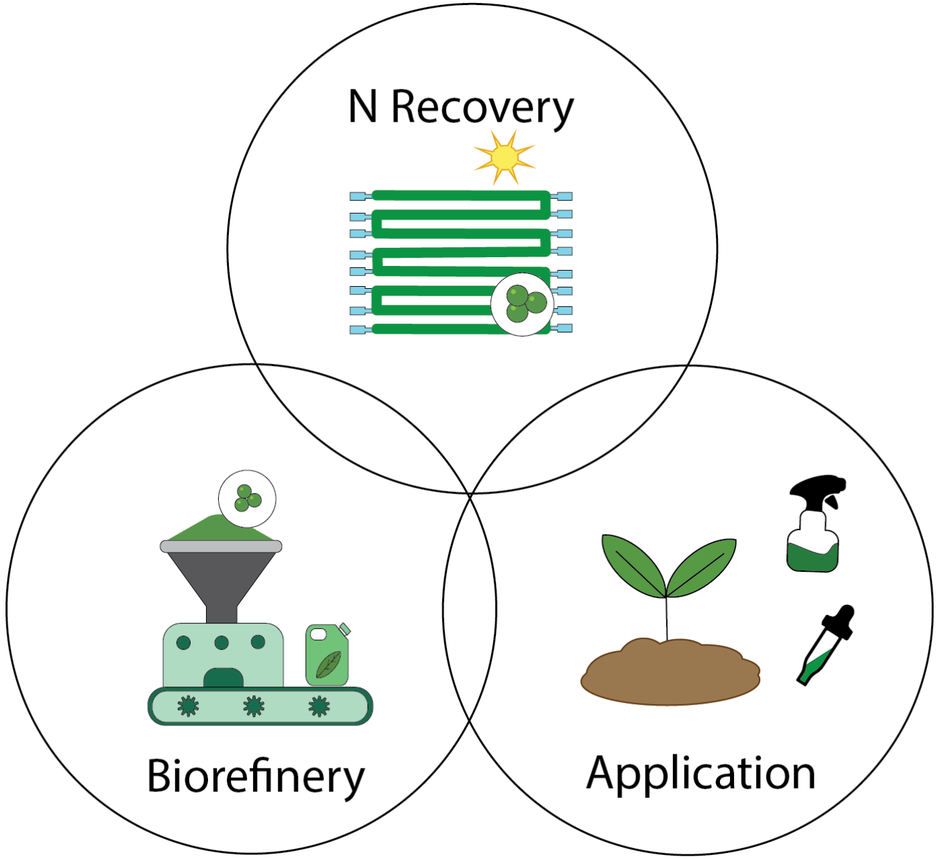


Olguin, et al (2022)

REALM-concept



Challenges for developing biostimulants

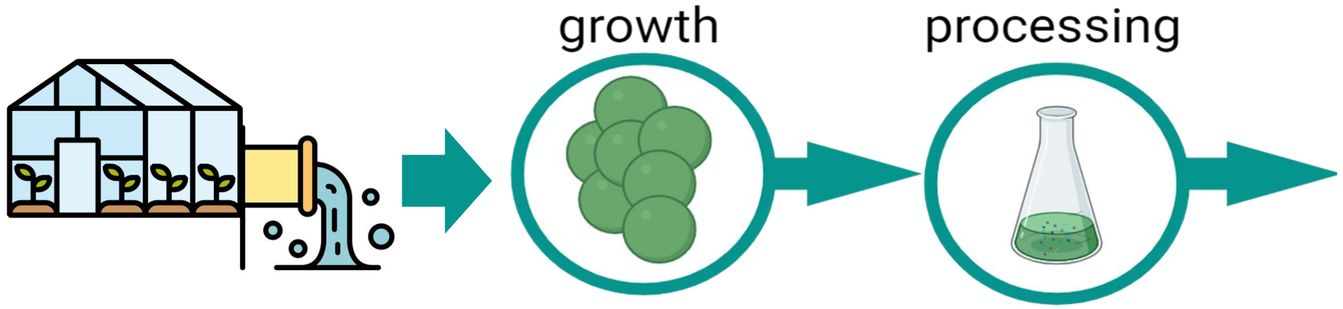


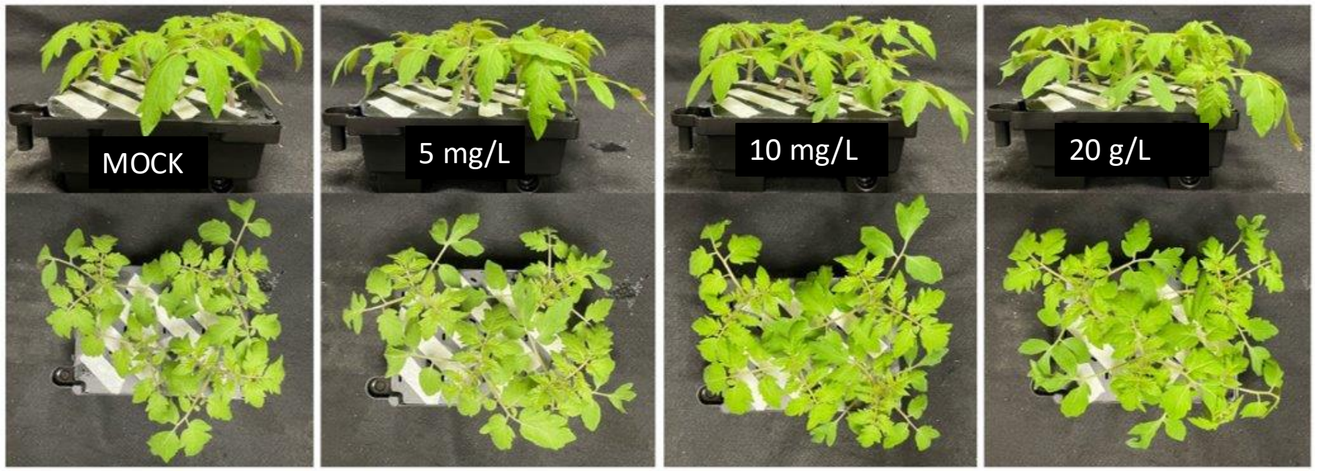
Nutrient recovery
- Microalgae growth conditions
- Composition of the wastewater

Biorefinery
- Fractions
- Composition biomass

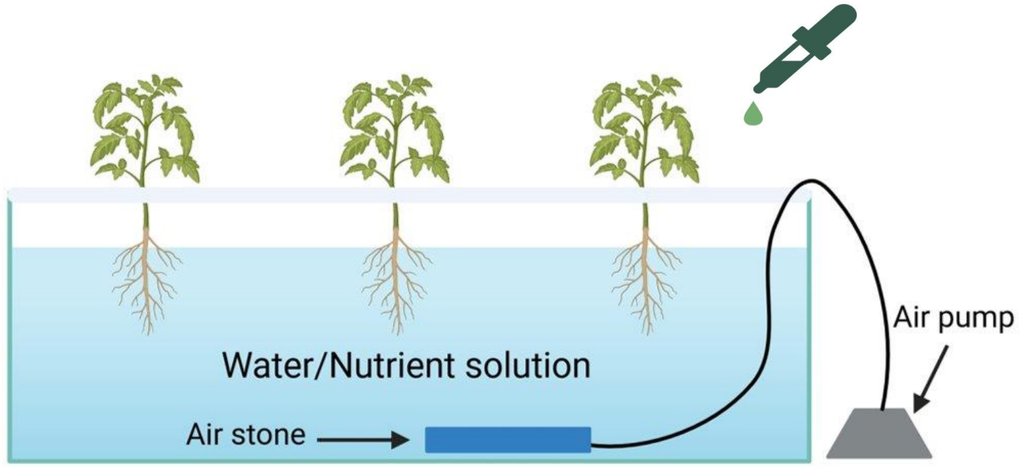
Application
- Dosage
- Foliar/soil drench
- Molecular mechanisms
- Metabolic pathways

Do they work?



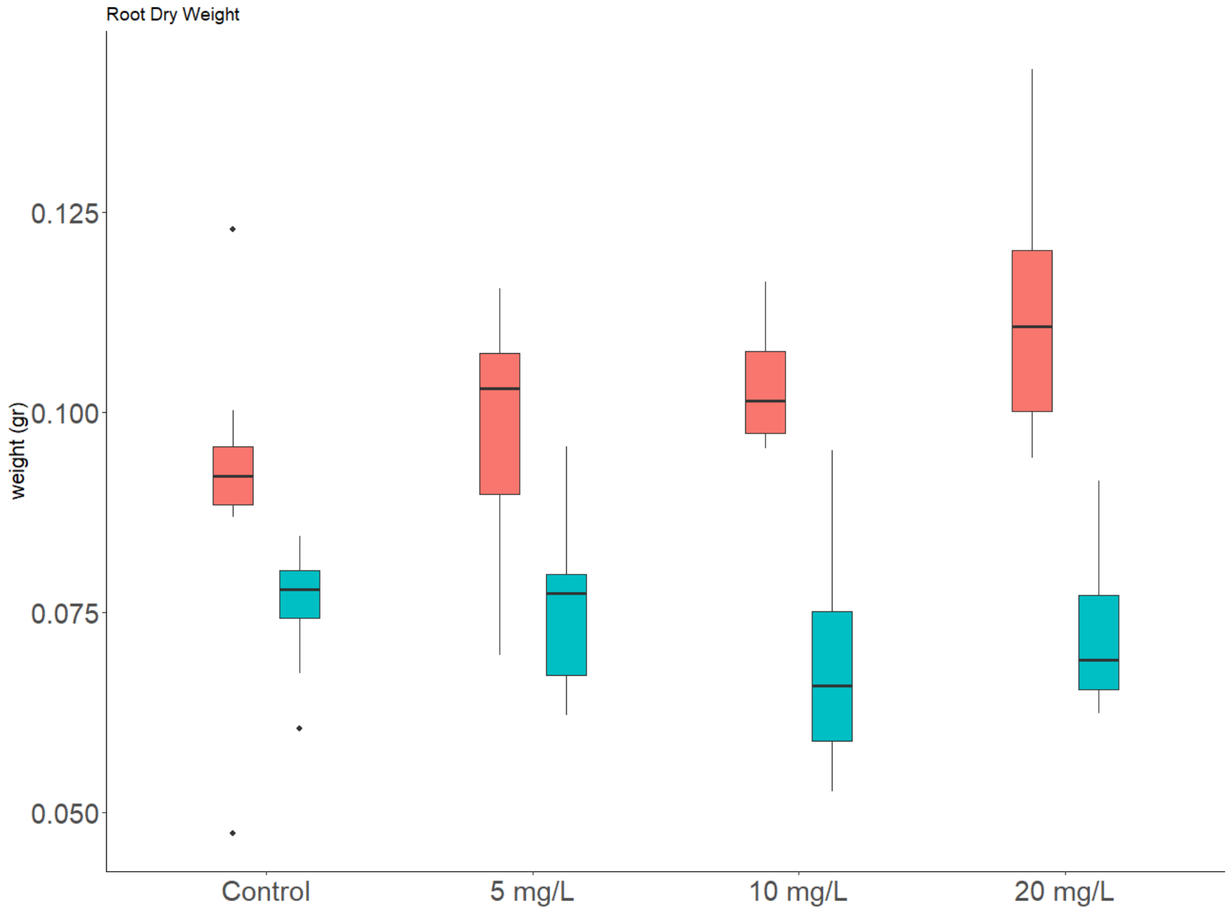


Optimization of dosage



- ☒☑ Biostimulatory activity
- ☒☑ Sweet spot?
- ☒☑ Reduce nutrient input

Do they work?

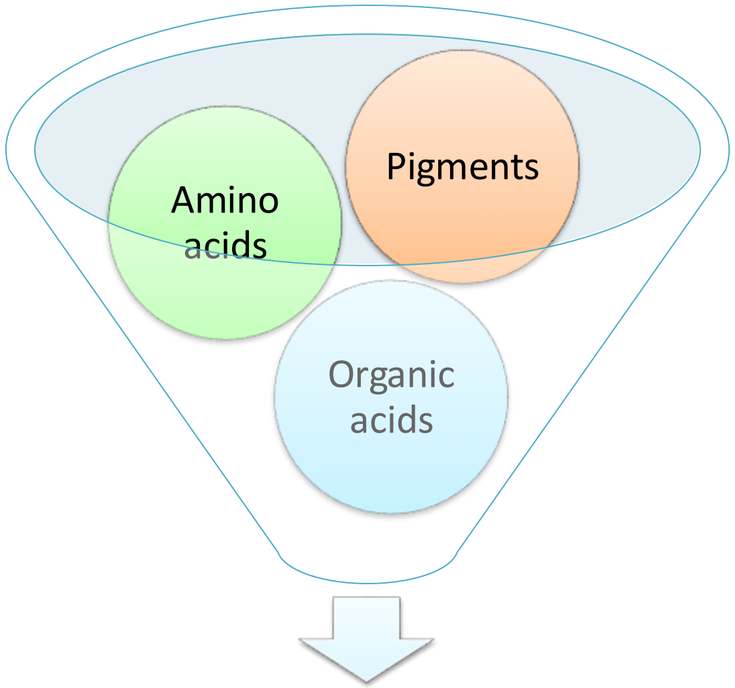


Criteria	Value
Treatments	5, 10, 20 mg/L Salinity stress
Best performance	20 mg/L
Variables	Root FW, DW Shoot FW, DW Root area, Leaf A.
Worst performance	Salt + 20mg/L

RFW 27.2%
RDW 24.2% *
SFW 19%
SDW 14.3%
LA 16%

20 mg/L

Finding the one



Biostimulatory activity?

Sweet spot

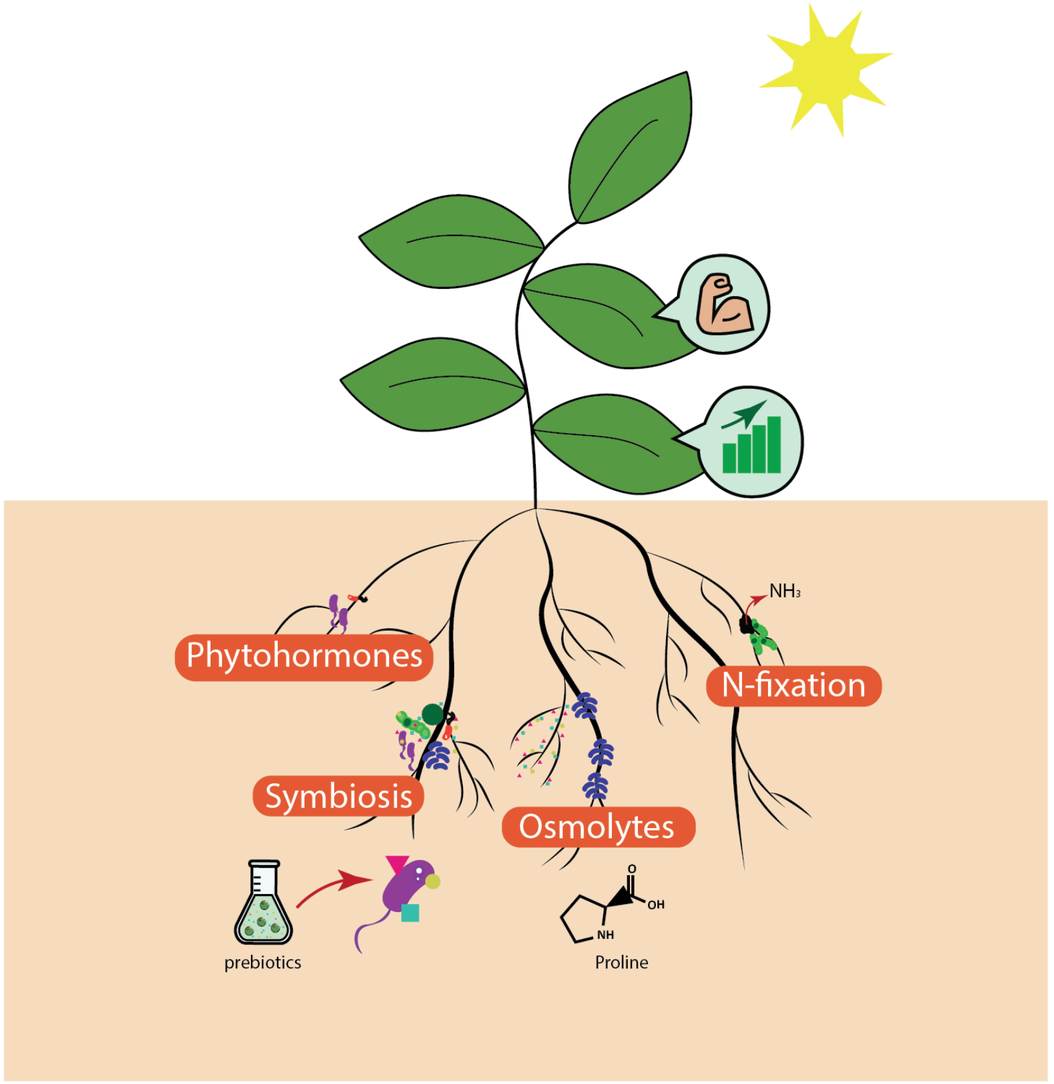
How they work?

Phytohormones
- Auxins
- Cytokinin

Symbiosis
- Prebiotics
- Plant-microbe interactions

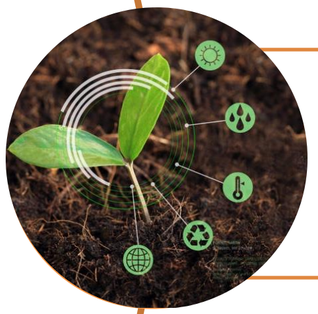
Osmolytes
- Proline
- Tolerance to abiotic stress

Nitrogen-fix
- Cyanobacteria
- Nodules



Reduce agrochemical input

Improve tolerance to abiotic stress



High crop productivity

Sustainable and renewable solution

dr. Maria Barbosa
dr. Rumyana Karlova

Microalgae biostimulants

Cristina Brito Lopez
cristina.britolopez@wur.nl

WAGENINGEN
UNIVERSITY & RESEARCH

REALM