Bioremediation of industrial waste CO_2 via algae and demonstration of from that technology

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Platform yr Amgylchedd Cymru
Environment Platform Wales

Nature Based Solutions: Knowledge Exchange Workshop
16-17 Dec 2025, Sir Martin Evans Building, Cardiff

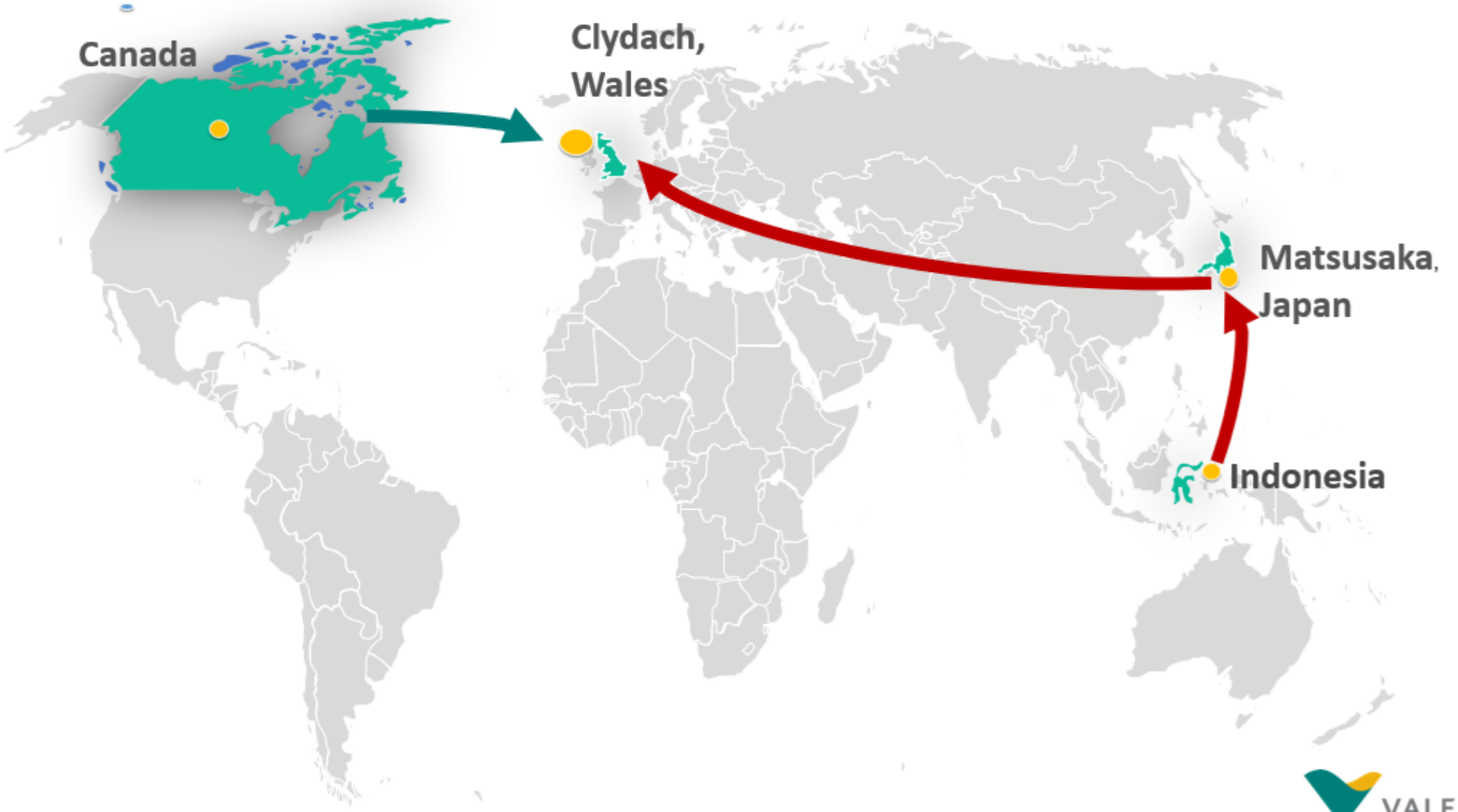
Vale Europe Ltd. North Atlantic Operations

UK:
Clydach, Wales

Japan:
Matsusaka, Japan

Indonesia:
Sorowako, Bahodopi, Suasua, Pomalaa

Canada:
Sudbury, Ontario
Long Harbour, Newfoundland & Labrador
Voisey's Bay, Newfoundland Labrador



VALE

The Process

Gas plant → **Kiln plant** → **Pellet and Powder plant**

Produces gases required in the refining process (H_2, CO, CO_2)

Produces nickel carbonyl gas ($Ni(CO)_4$)

Produces nickel products by thermal decomposition of $Ni(CO)_4$ gas

VALE

Vale Products

Used for a variety of applications across many industries

High Purity Products

Pellets / P-Pellets / S-Pellet

Discs / Chips

Powders

Turbochargers

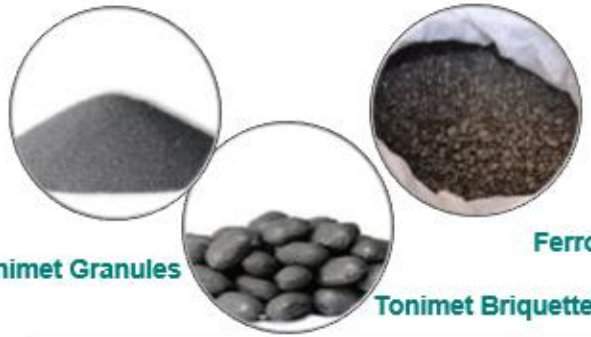
Plating Applications

Turbines

Powder Metallurgy

Batteries

Commodity Products



Tonimet Granules

Tonimet Briquettes

Ferronickel Shots

Industrial equipment and construction

Stainless Steel Goods

Conversion to Nickel Sulphate

High-purity nickel

Nickel Sulphate to pCAM

Cathode Material

Cell and pack

Electric Vehicle

Source: Vale BM Marketing

VALE

Some basic facts…

- The Clydach refinery began life in 1902
- The nickel refining technology is based on the ‘Mond’ process
- 1 kg of product nickel generates around 14 kg CO_2 emissions
- Global production of nickel was 2.8 million tonnes in 2021
- The Clydach operation generates ~65,000 tonnes of CO_2 annually*
- The refinery is a Tier 1 COMAH site

- The question was posed, could research into algae at SU be deployed industrially to mitigate some of this CO_2?

- The technology readiness could then be evaluated
  - Risk assessments
  - Cost benefit analysis
  - Business case generation

*Aspire: Industrial Fuel Switching: Project ASPIRE F435-WP11-2 Vale IFS Project ASPIRE Nov19 V1.

Growing Algae

Autotrophic consumption of nitrates, phosphates and CO_2 via photosynthesis i.e consuming waste from human activities

Industrial waste CO_2

Energy

ALGAE

Output

Useful high value products e.g lipids, food supplements, animal feed, colour dyes

Agricultural waste
Nitrates (NO_x)
Phosphates (PO_x)

Domestic waste
Nitrates (NO_x)
Phosphates (PO_x)

RICE
Reducing Industrial Carbon Emissions
Lleihau Allyriadau Carbon Diwydiannol

What are Algae ?

- They are fastest photosynthetic organism on the planet
- They can consume 1.8 kg CO_2 kg^{-1} of biomass produced
- They also need nitrates and phosphates to grow
- They do not compete with terrestrial food crops
- They are natures natural pollution control agents
- They produce a range of products that are very useful

Food and Feeds

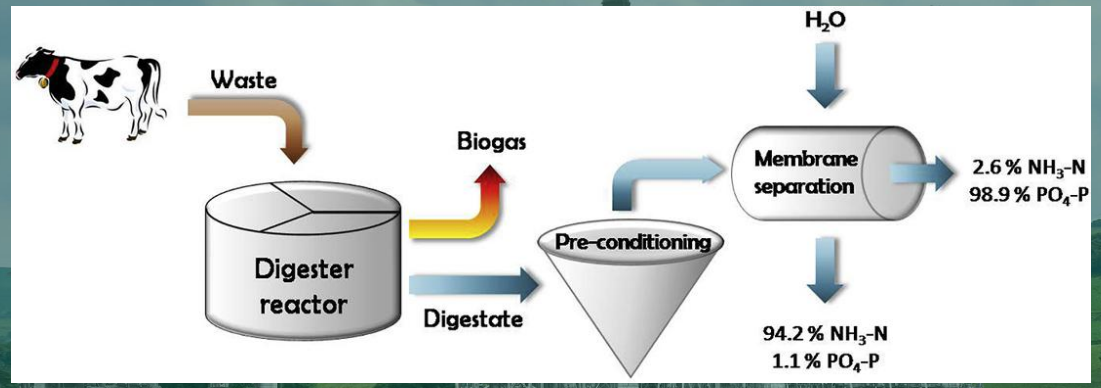
Cosmetics

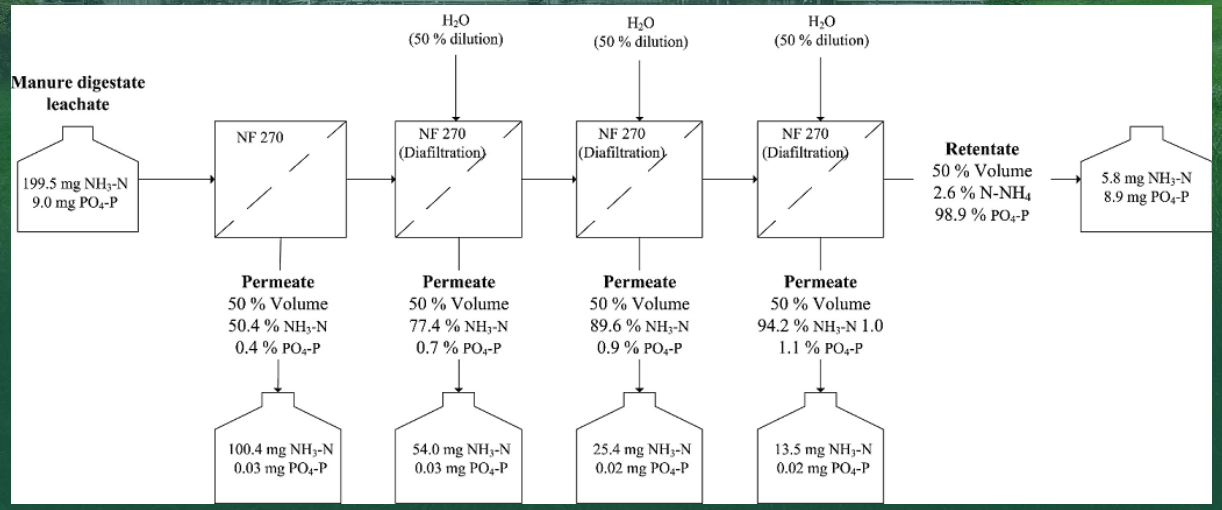
Fertilisers

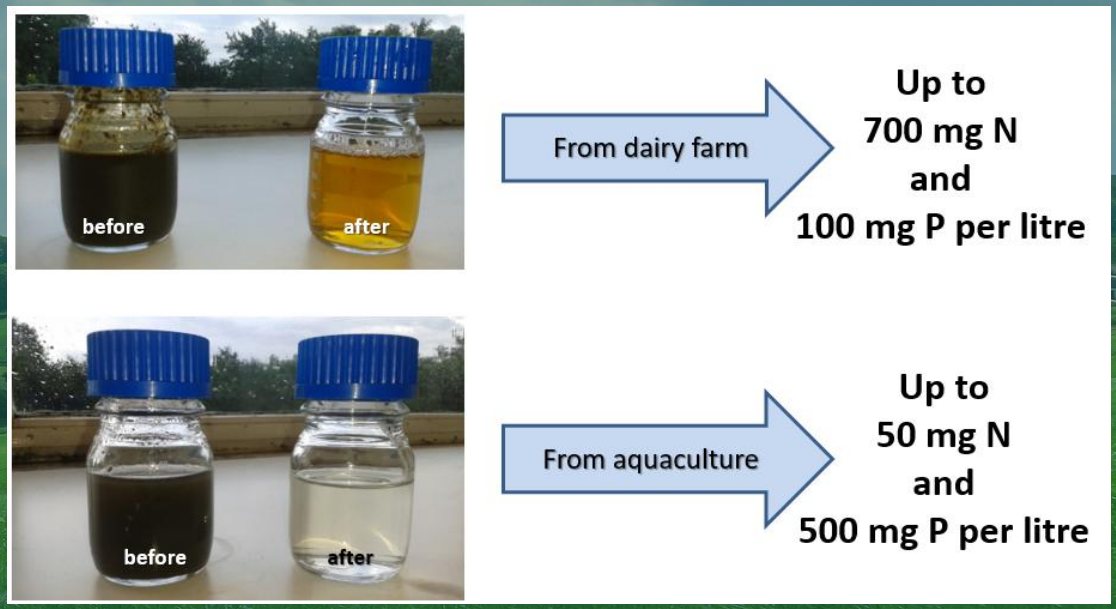
and a range of others: fuels, proteins, lipids, anti-oxidants…etc.

What have we done so far:

- Nutrient recovery
- Highly successful at recovering and formulating algae feeds from anaerobic digester wastes







Reformulation using membranes

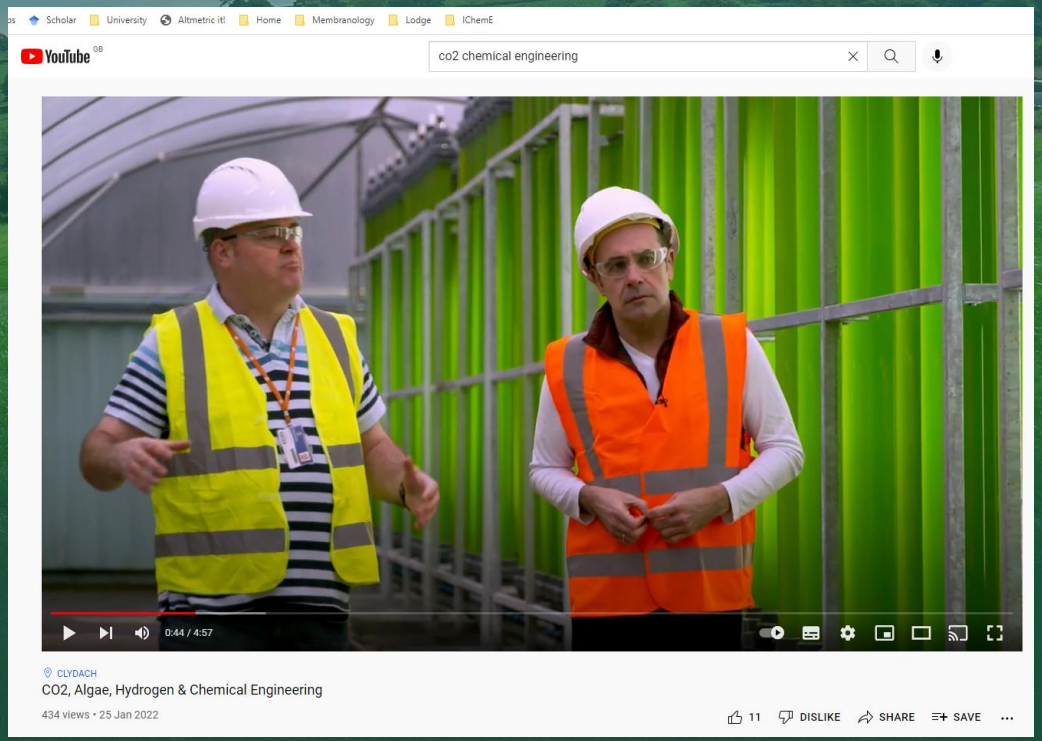
See

Water Research, 80, 80-89.
J. Membr. Sci., 464, 86-99.

Activities at Vale:

- **Scaled up to 15,000 L Photobioreactor using industrial CO_2 emissions**

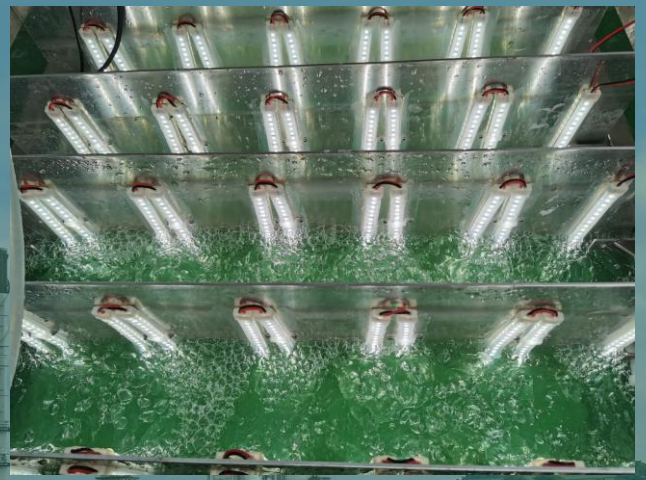
Membrane plant for algal harvesting

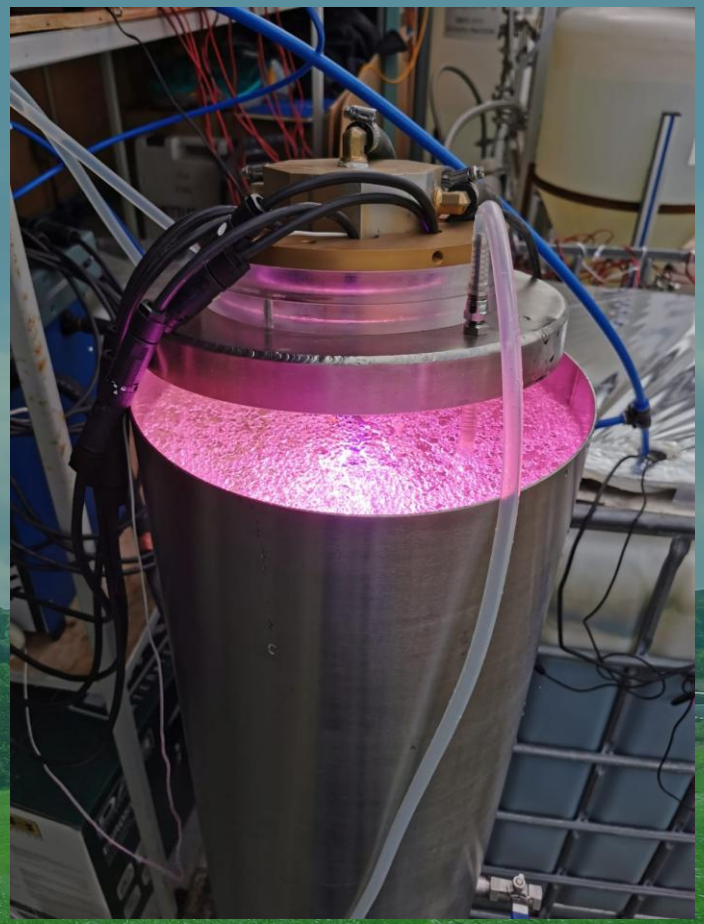


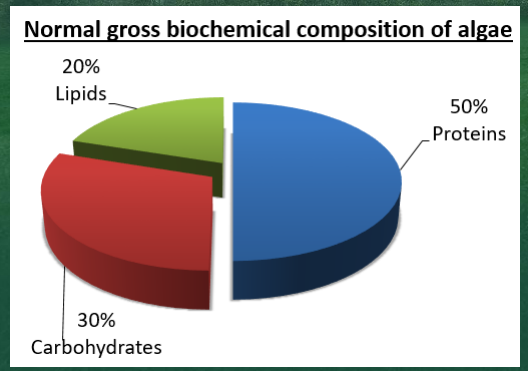
Check us out on youtube
https://www.youtube.com/watch?v=agbypkuv3os

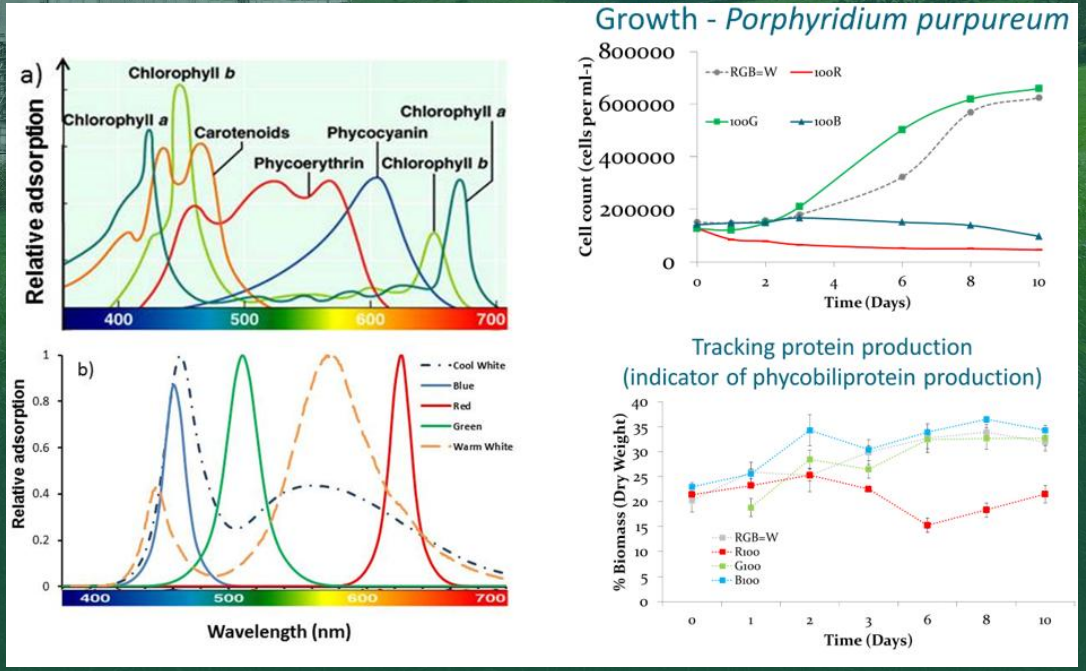
Current activities:

- Tailored production using light stress







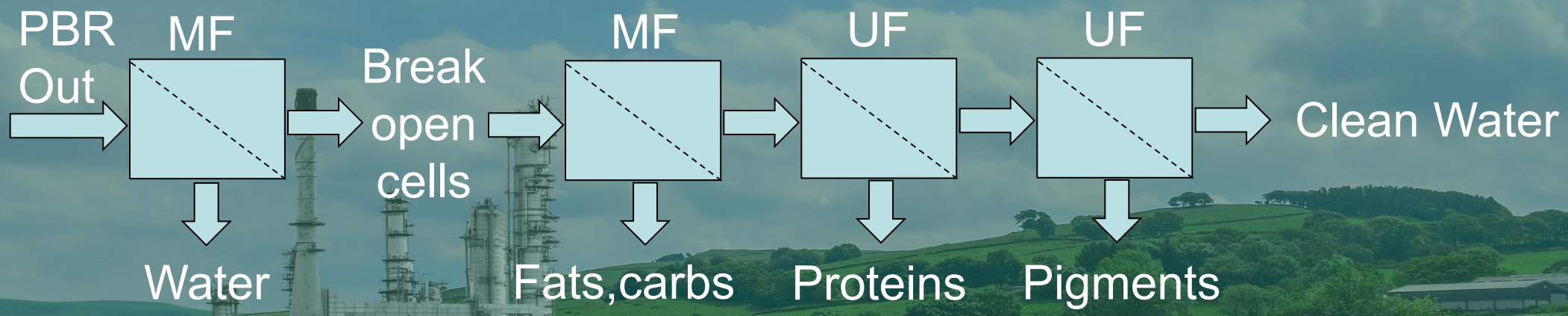


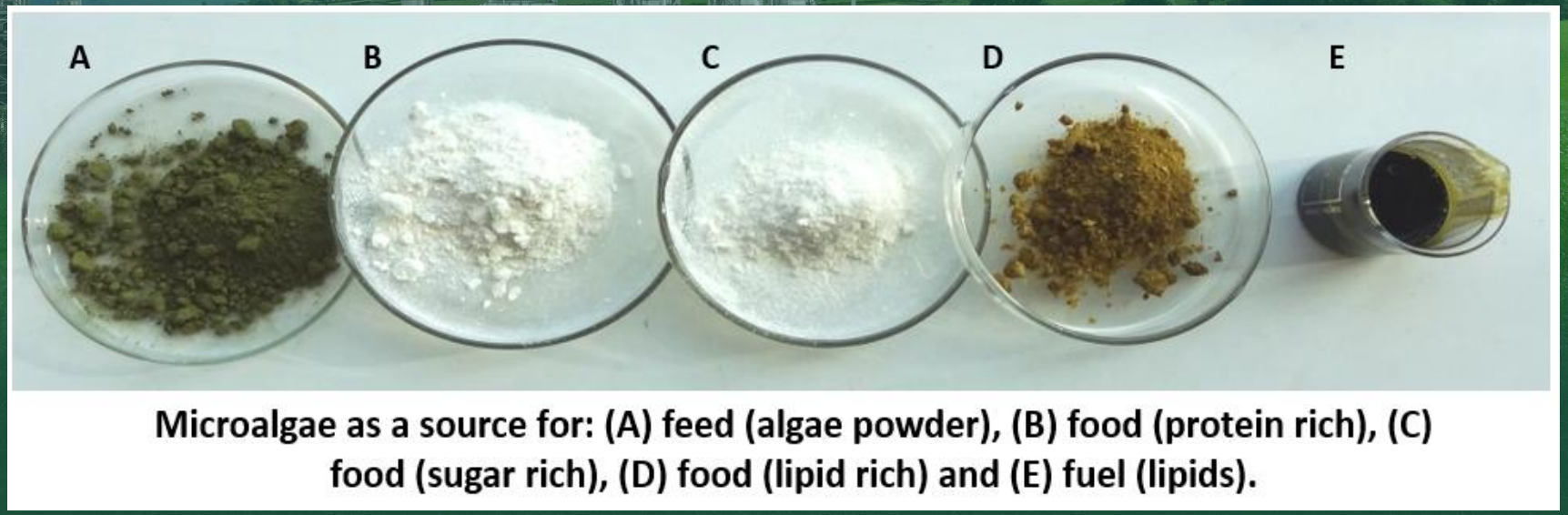
Increased protein by 30%

See
Bioresource Technology, 221, 607-615.

Product formation from algae:

- **Downstream harvesting and recovery using membranes**



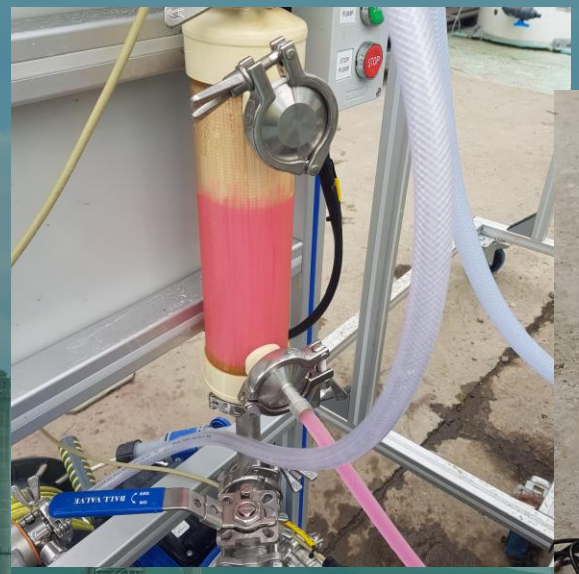


Microalgae as a source for: (A) feed (algae powder), (B) food (protein rich), (C) food (sugar rich), (D) food (lipid rich) and (E) fuel (lipids).

See: Bioresource Technology, 221, 607-615 and Environ. Sci. Technol., 48, 845-853.

Making the business case – high value products:

Phycoerythrin production



***R*-Phycoerythrin**

CAS No.: 11016-17-4

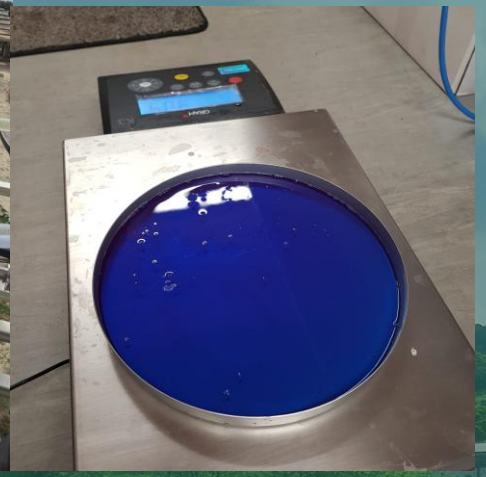
All Photos (1)

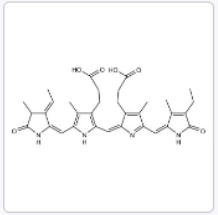
Compare	Product No.	Description
☐	52412	BioReagent, passes test for gel electrophoresis

Sign In to View Organizational & Contract Pricing

SKU	Pack Size	Availability	Price
52412-1MG-F	1 mg	1 Estimated to ship on 06 November 2024 Details...	£169.00
52412-5MG-F	5 mg	1 Estimated to ship on 06 November 2024 Details...	£577.00

Phycocyanin production





All Photos (4)

Documents

SDS

P2172 Sigma-Aldrich.

C-Phycocyanin from *Spirulina* sp.

(0) Write a review

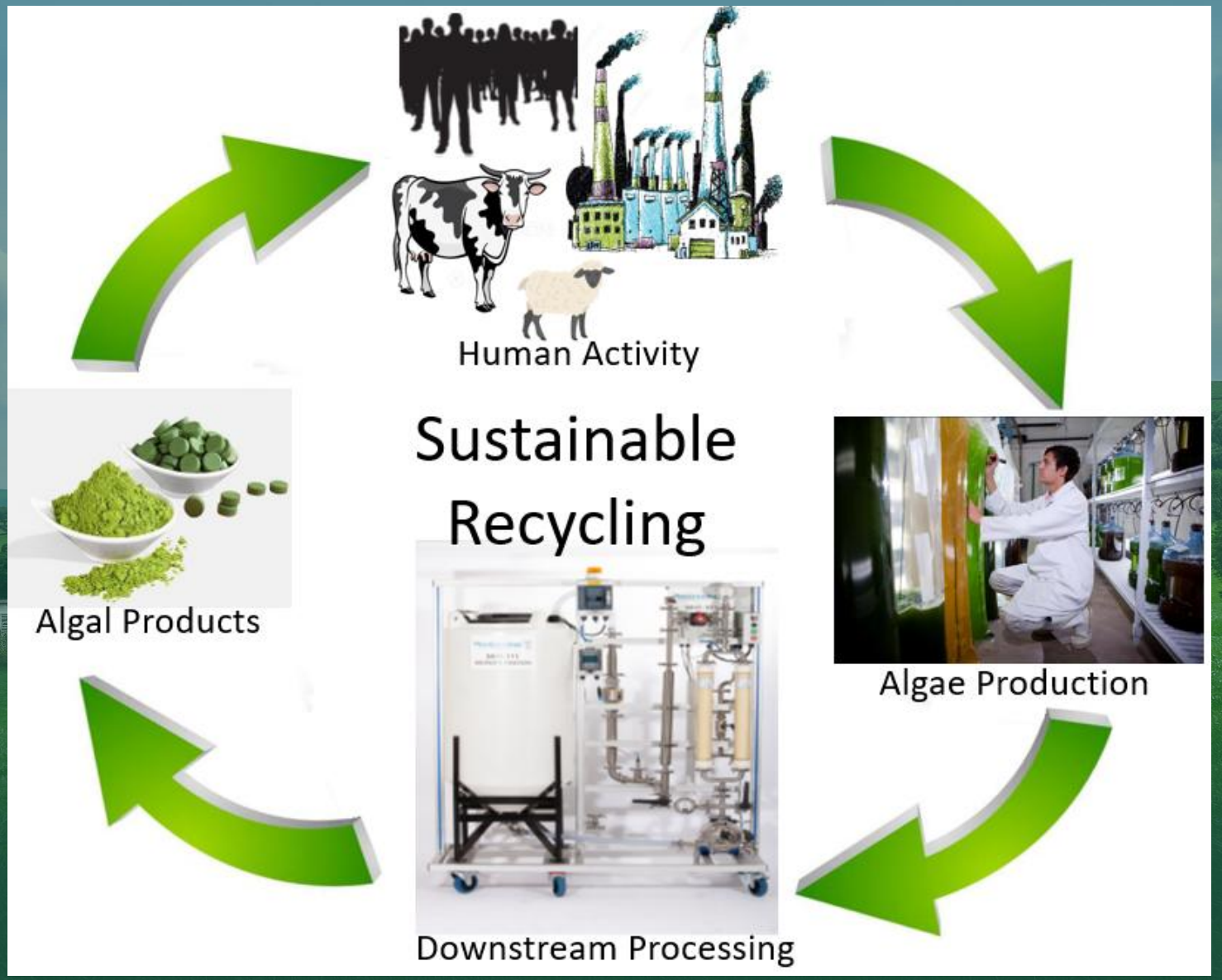
lyophilized powder

CAS Number: 11016-15-2 MDL number: MFCD00130691

Sign In to View Organizational & Contract Pricing

SKU	Pack Size	Availability	Price
P2172-10MG	10 mg	Estimated to ship on January 04, 2024 Details...	£149.00

Overall algae can create a true circular economy



Acknowledgements

Swansea University
Prifysgol Abertawe

The team: Jose Gayo Pelaez, Veronica Smith, Dr. Emily Preedy, Dr Alla Silkina, Prof. Andrew R. Barron.
The team at Algae Products International (https://algae-products.com/).

Project Funding:

RICE
Reducing Industrial Carbon Emissions
Lleihau Allyriadau Carbon Diwydiannol

www.rice.cymru
A £9.2m project with the ambition to revolutionise decarbonisation of Industry

Department for Business, Energy & Industrial Strategy

Department for Energy Security & Net Zero

Carbon Capture, Usage and Storage (CCUS) Innovation 2.0 competition: Call 2 successful projects
Updated 28 June 2023

LightARC - algae remediation of CO_2

Led by Remediiate (UK) Ltd in partnership with Swansea Univeristy and Vale-Europe Ltd - £2,126,795.00