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Accelerating circular bio-based solutions integration in European rural areas

Structure and technological properties of biomass streams: aquatic systems

Maja Berden Zrimec & Robert Reinhardt, Algen

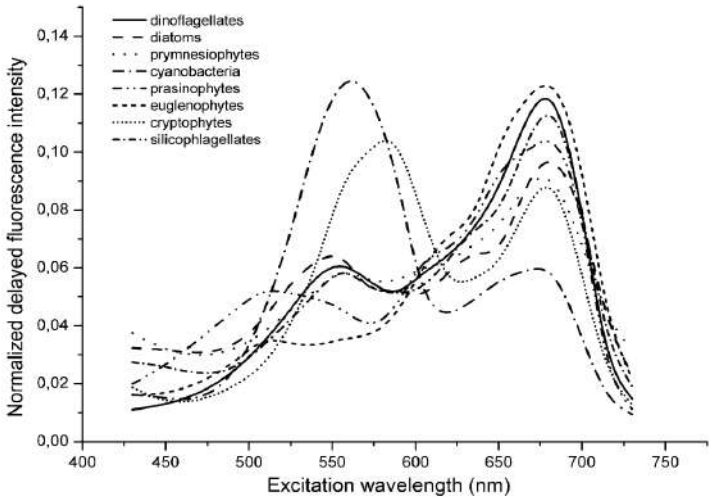
October 25th 2023, webinar

BIOrural

algen

- SME, founded in 2010
- Development and integration of algal technologies
- Consulting and tech support for commercial algae production
- Optimisation of algal system performance

Algal culturing and wastewater treatment



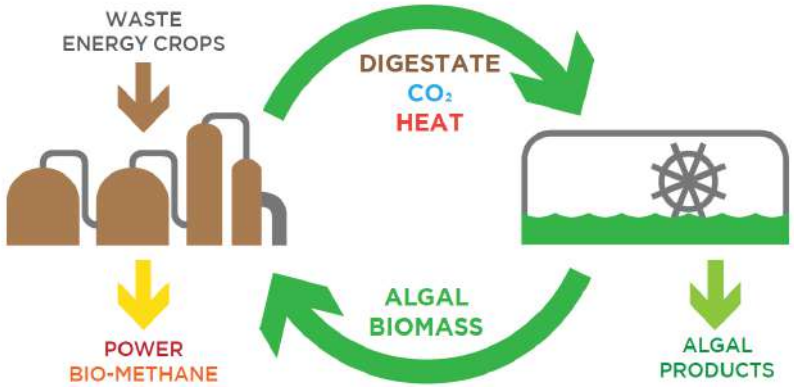
Algal:

- **physiology**
- **ecology**
- **population dynamics**

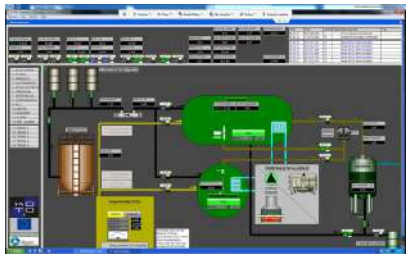
algen
algal technology centre

ABG
AlgaeBioGas

Algae park for university research and education



Large scale raceway ponds



Large Scale Demonstration Centre for Algal-Bacterial Digetate Treatment and Algae Biomass Production

Spirulina production

algica
spirulina

One of the success stories in BioRural

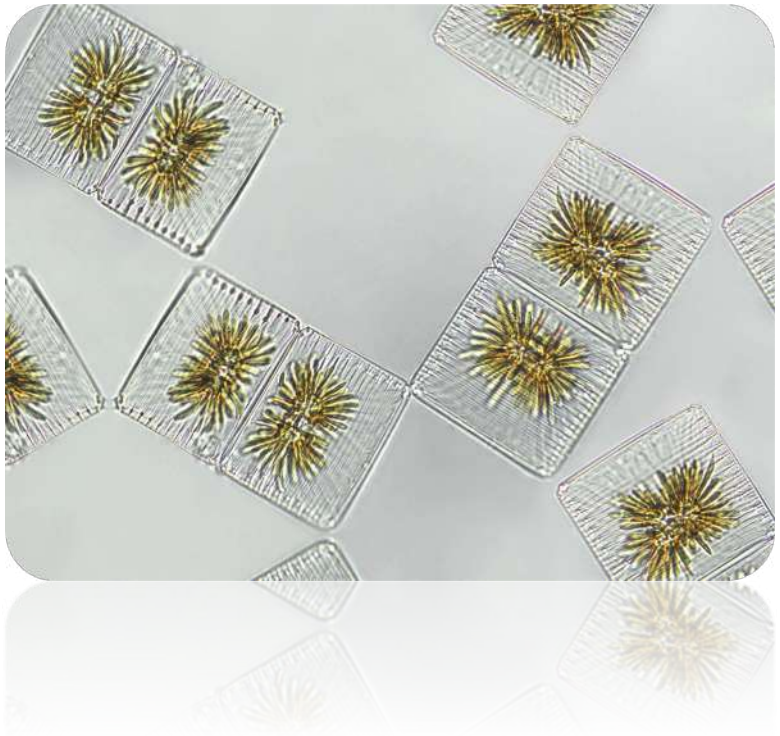
ABG
AlgaeBioGas

Aquatic Systems

Biochemicals and biomaterials derived from Aquatic Systems

Aquatic biomaterials are biological materials that are derived from aquatic organisms, such as marine animals, plants, and microorganisms.

These materials are characterized by their biocompatibility, biodegradability, and often unique chemical and physical properties.



Biochemicals and biomaterials from Fish

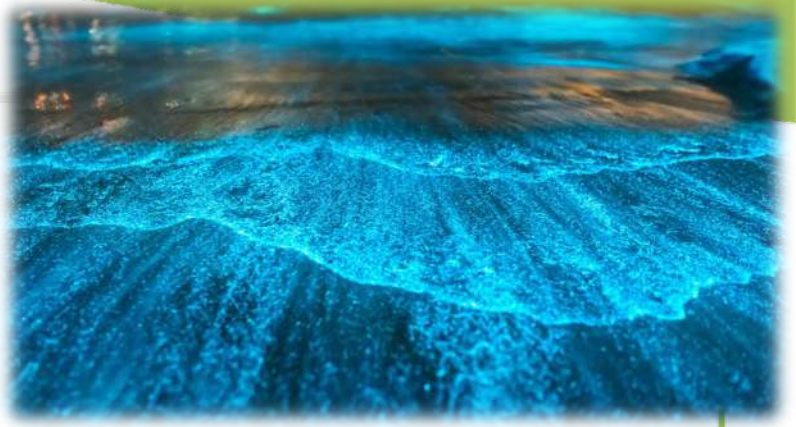
- **Omega-3 Fatty Acids**: Essential fatty acids found in fish oil, particularly from fatty fish like salmon and mackerel. They play a crucial role in brain function and reduce the risk of heart diseases.
- **Collagen**: A protein extracted from fish skin and scales. Fish-derived collagen is used in cosmetics for its anti-aging properties and in medicine for wound healing and tissue engineering.
- **Gelatin**: Derived from fish collagen, it's a gelling agent used in food products, pharmaceuticals, and cosmetics.
- **Chondroitin Sulfate**: Extracted from fish cartilage, it's used as a dietary supplement for joint health and osteoarthritis relief.
- **Fish Peptides**: Short chains of amino acids derived from fish proteins. They have potential health benefits, including antihypertensive and antioxidant properties.
- **Fish Leather**: A sustainable alternative to traditional leather, made from fish skin. It's durable, unique in texture, and used in fashion products like shoes and handbags.
- **Fish Meal & Fish Oil**: Produced from ground fish and used as a high-protein feed ingredient in aquaculture and livestock farming.

Biochemicals and biomaterials from water Invertebrates

- **Chitin and chitosan**: exoskeletons of crustaceans like *shrimp* and *crabs*. It's used in medicine for wound healing, in agriculture as a natural pesticide, and in water purification.
- **Spongin** from sponges. It has potential applications in tissue engineering and as a natural scaffold for cell growth.
- **Conotoxins**: Peptides from *cone snail* venom. They have potential as painkillers and in neurological research.
- **Coral Calcium:** Extracted from corals, this form of calcium is used as a dietary supplement and is believed to offer superior absorption.
- **Collagen:** Extracted from marine invertebrates like *jellyfish* and *sea anemones*. It's used in cosmetics and has potential in biomedicine due to its biocompatibility.
- **Natural Adhesives**: Some *freshwater invertebrates*, like caddisfly larvae, produce natural adhesives to build protective cases. These adhesives are being studied for potential *biomedical* applications.

Biochemicals and biomaterials from Aquatic plants

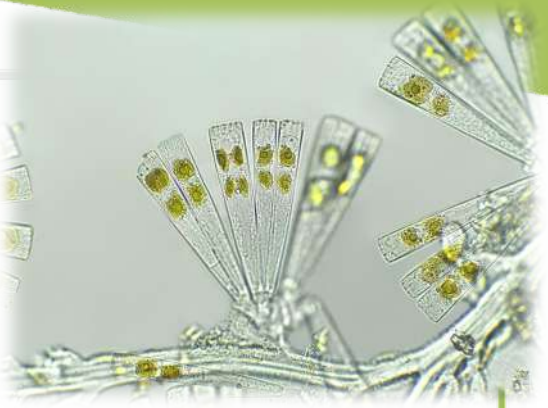
- **Cellulose**: Extracted from aquatic plants like cattails and reeds. Used in *paper* production, *textiles*, and as a base material for some *bioplastics*.
- **Phytoremediation**: Many aquatic plants, such as water hyacinth or duckweed, have the ability to absorb and concentrate heavy metals and pollutants, making them valuable for water purification.
- **Essential Oils**: Extracted from plants like water lilies and lotus. Used in aromatherapy, cosmetics, and traditional medicines.
- **Starch**: Extracted from plants like arrowroot. Used as a thickener in the food industry and for producing biodegradable plastics.
- **Biofuel**: Some aquatic plants, like duckweed, have the potential to be used as a raw material for biofuel production due to their rapid growth rate.
- **Natural Fibers**: Fibers from plants like water hyacinth can be used to make *ropes, mats*, and even *furniture*.



Biochemicals and biomaterials from Aquatic Microorganisms

- **Exopolysaccharides (EPS)**: Sugary substances produced by certain bacteria. Used in the food industry as thickeners and stabilizers, and in biomedicine for their anti-inflammatory properties.
- **Polyhydroxyalkanoates (PHAs)**: *Bioplastics* produced by certain bacteria. They are biodegradable and serve as eco-friendly alternatives to conventional plastics.
- **Antibiotics**: Many aquatic bacteria produce compounds with antibacterial properties, which can be harnessed for medical applications.
- **Enzymes**: Microorganisms produce a variety of enzymes that have industrial applications, including in detergents, food processing, and biofuel production.
- **Bioluminescent Proteins**: Extracted from bioluminescent bacteria. Used in research as markers and in various industries for their glowing properties.
- **Bioremediation Agents**: Some microorganisms can degrade pollutants, making them valuable for cleaning up contaminated water and soils.

Biochemicals and biomaterials from Algae



- **Alginates**: Polysaccharides extracted from brown algae. Widely used as *thickeners* and *stabilizers* in the *food* and *pharmaceutical industries*.
- **Agar**: A *gelatinous* substance derived from red algae. Essential in microbiology as a *growth medium* and popular in the food industry as a *vegetarian gelatin substitute*.
- **Carrageenan**: Extracted from red algae. A common *stabilizer* and *thickener* in dairy products and plant-based milks.
- **Carotenoids - beta-carotene, astaxanthin, fucoxanthin, peridinin, violaxanthin, diadinoxanthin, and zeaxanthin**: pigments found in various algae, powerful antioxidants.
- **Omega-3 Fatty Acids**: Microalgae are a primary source of these essential fatty acids, which are crucial for brain function and cardiovascular health.
- **Phycobiliproteins & bilins**: Phycocyanin, allophycocyanin & phycourobilin (blue pigments), phycoerythrin & phycoerythrobilin (red pigments).
- **Mycosporine-like Amino Acids** (MAAs): UV-protective compounds found in many marine. They absorb UV radiation and protect the cells from damage – interesting for cosmetics.
- **High protein or lipid content:** food, feed, biofuels

Bioresources and circular economy

Algae grown on wastewater

Processing of organic waste

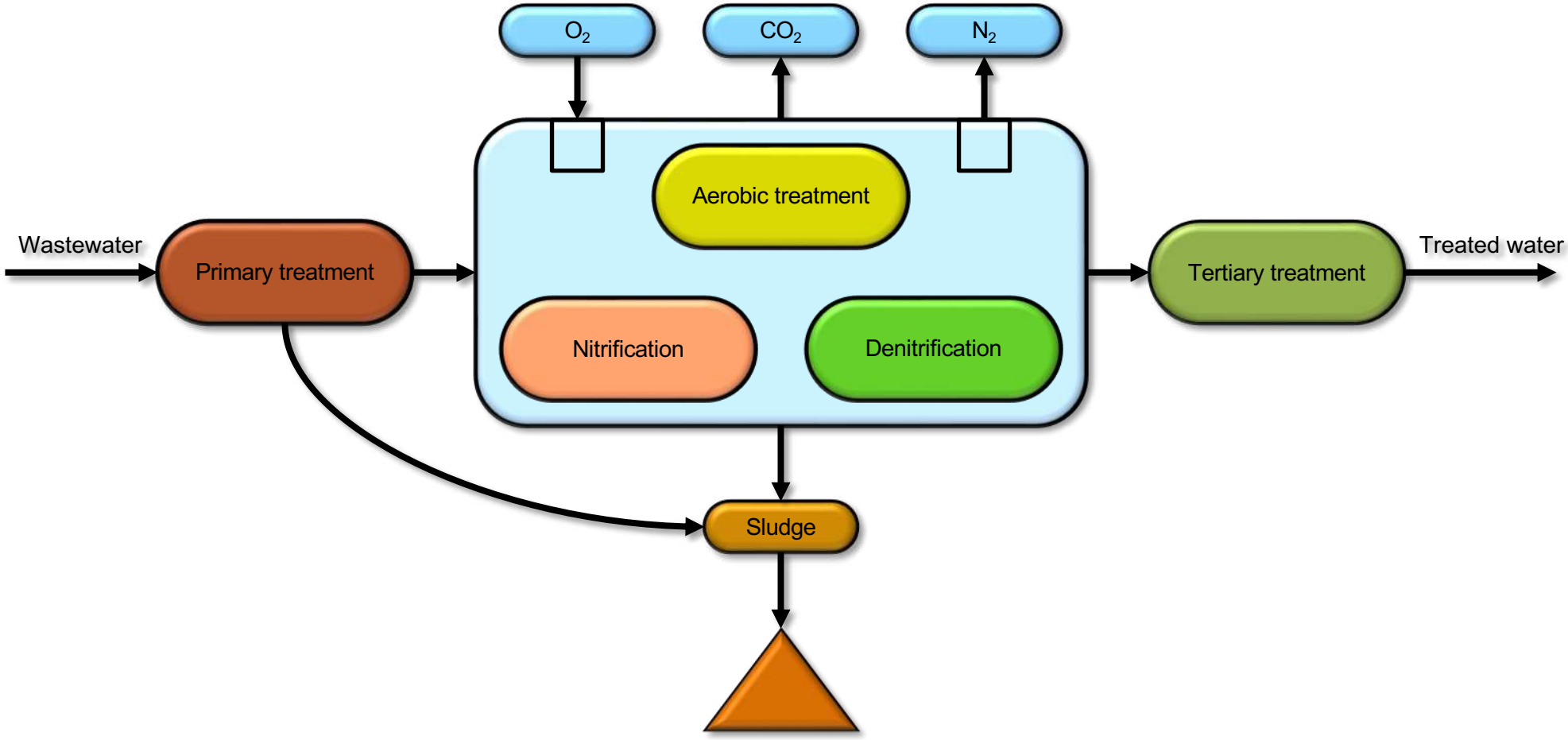
- Anaerobic digestion
- Fermentation
- Extraction
- Biorefineries ...

Wastewater is a neglected source of energy and nutrients

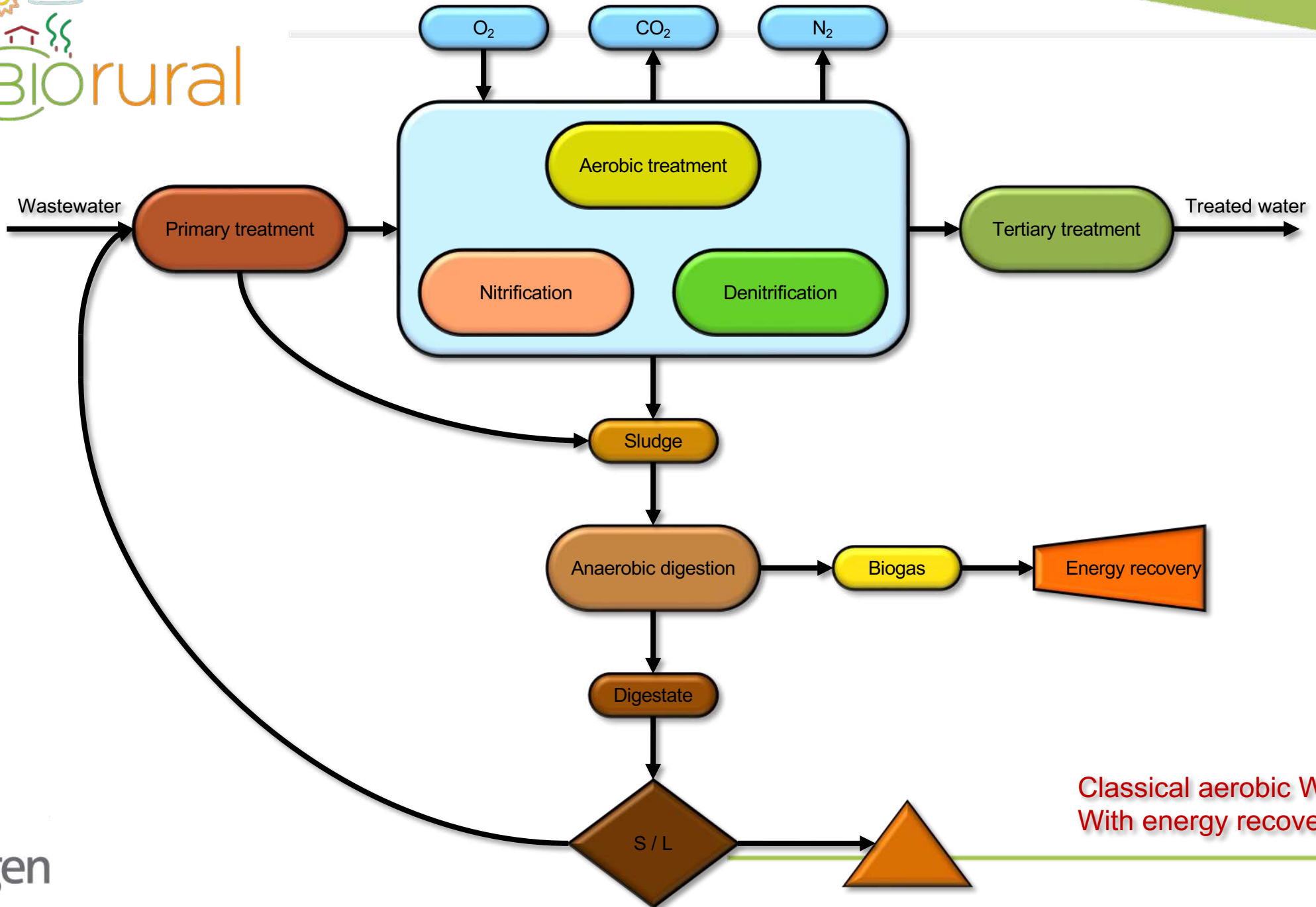
So let‘s use it as a resource.

Producing algae on wastewater

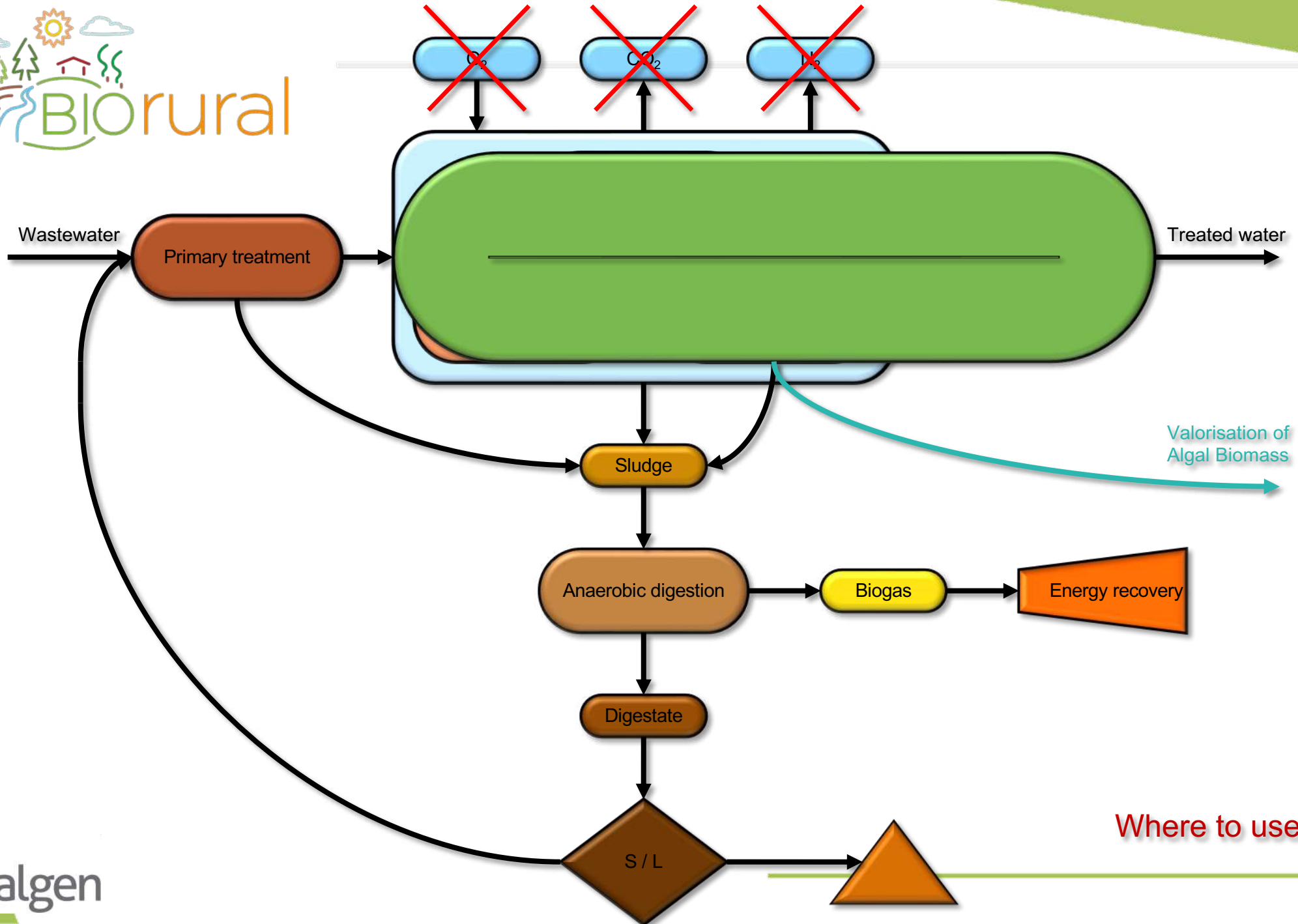
- Produced on wastewater
- Produced on non-arable land
- Recycle nutrients
- Recycle, reuse CO_2
- Water treatment:
  - Reduced treatment cost
  - Improved treatment quality
  - Remove pathogens, odours



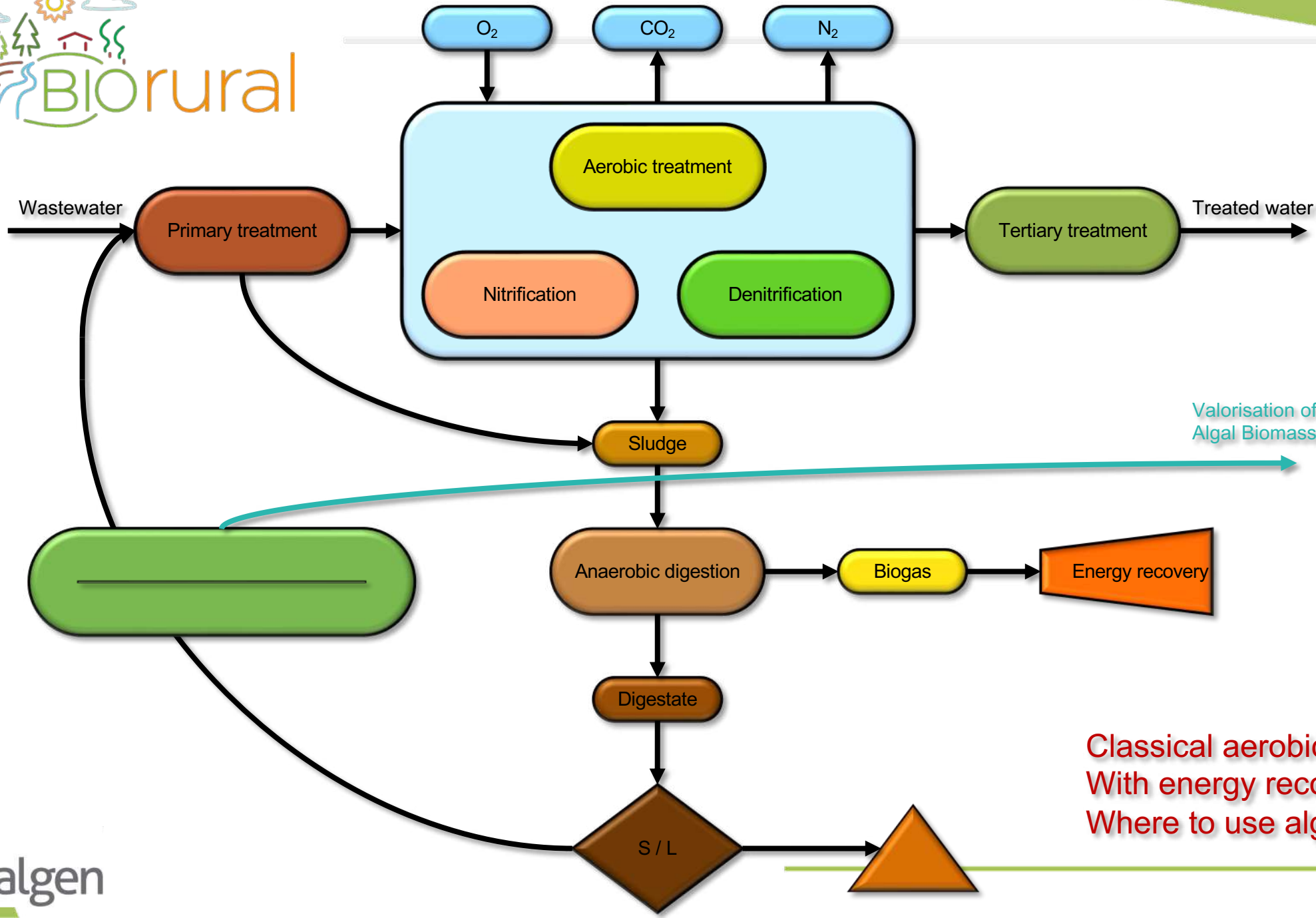
Classical aerobic WWT



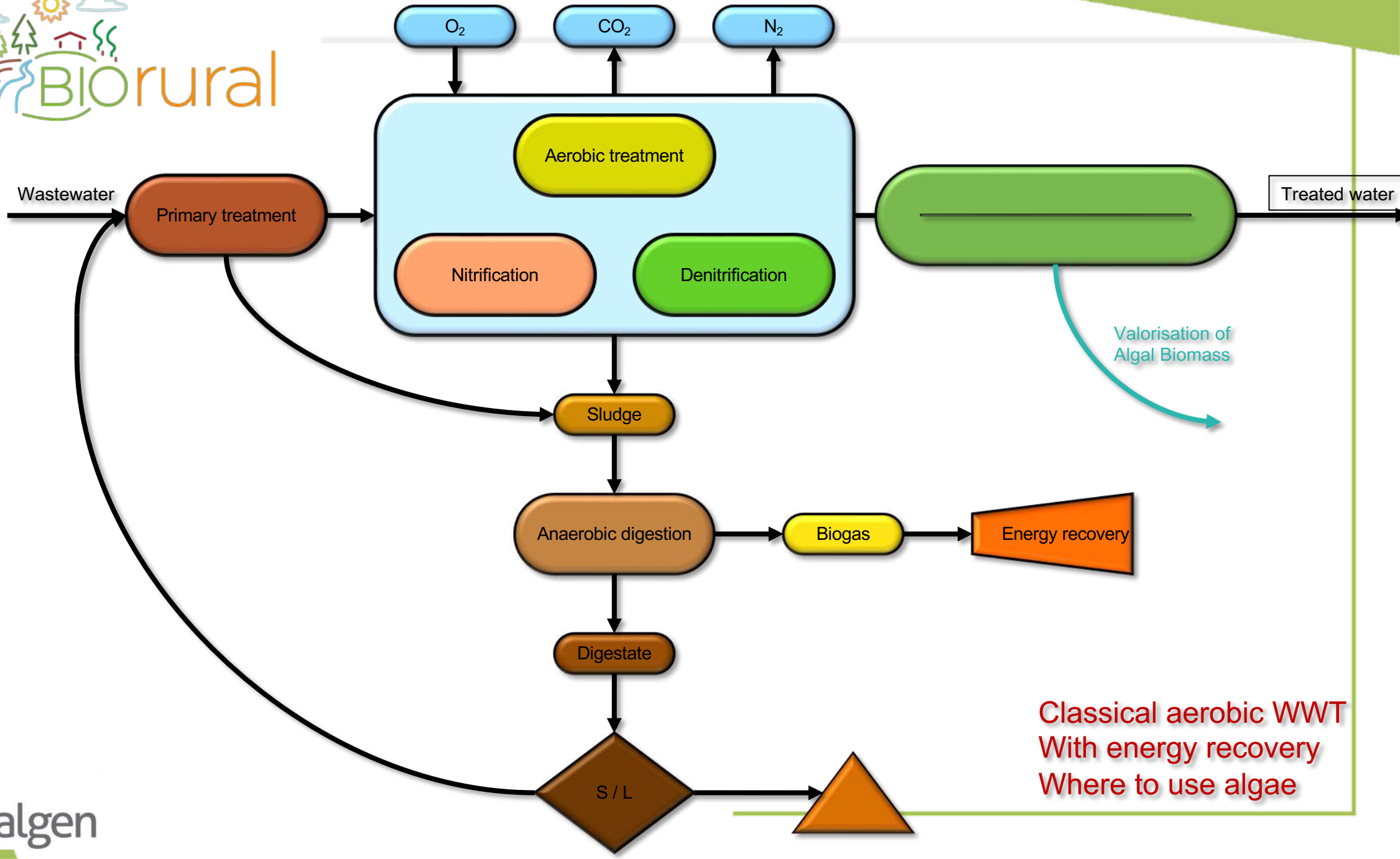
Classical aerobic WWT
With energy recovery



Where to use algae



Classical aerobic WWT
With energy recovery
Where to use algae



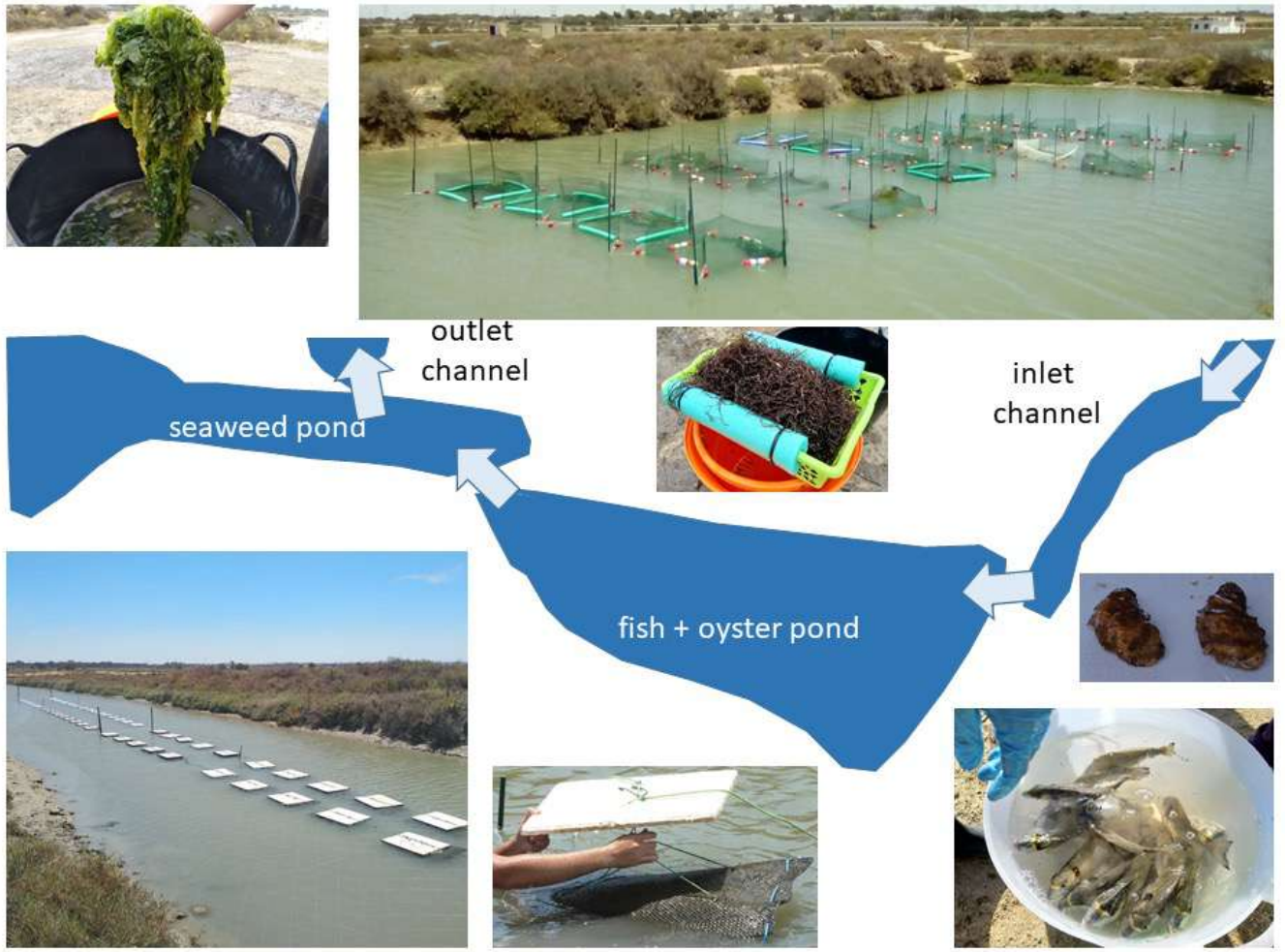
Classical aerobic WWT
With energy recovery
Where to use algae

Producing macroalgae in WWT system

Townsville, Australia (photo courtesy of Andrew J. Cole)

Producing microalgae in WWT system

Integrated Multi-Trophic Aquaculture

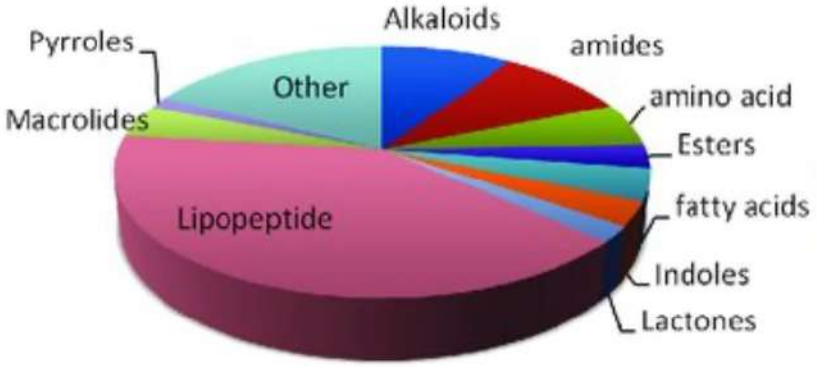


CTAQUA's pilot IMTA installation operating during the INTEGRATE project (Photos: CTAQUA)

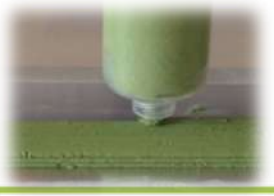
What to do with the produced algal biomass?

Microalgae species	Carbohydrates (% dry weight biomass)	Proteins (% dry weight biomass)	Lipids (% dryweight biomass)	Pigments
Amphora sp.	–	–	26.4–81.5	–
Aphanothece microscopica Nägeli	13.4–17.6	41.3–49.3	7.1–7.9	–
Arthrospira (spirulina) Platensis	15.0–26.97	45.0–62.2	8.04–13.79	–
Botryococcus braunii	2.38	39.61	33	13.05
Chlamydomonas reinhardtii	17	48	21	–
Chlorella vulgaris	16.74	40.95	9.95	12.41
Dunaliella tertiolecta	13.95	29.41	11.44	7.61
Nannochloropsis sp.	8–14	33–44	22–31	–
Porphyridium cruentum	22.8–39.3	27.7–40.8	5.78–7.55	–
Scenedesmus obliquus	10–17	50–56	12–14	–
Spirulina platensis	11	42.33	11	16.12
Synechococcus sp.	15	63	11	–

Example: Compounds isolated from cyanobacteria



Products from algae



Biofuels

All-gas

Bio-fuel

DEMO: 2 ha

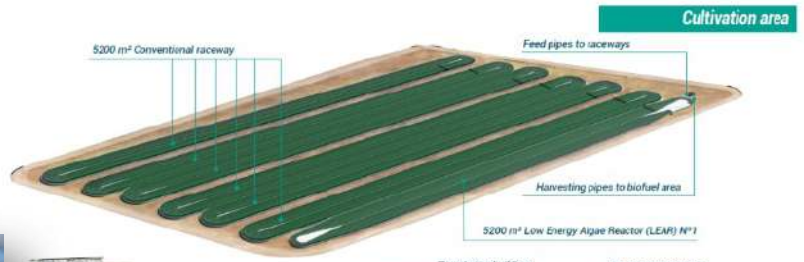
2017

2016

Pilot plant
200 m²

2014

Prototype
1000 m²



2011

Basic
research

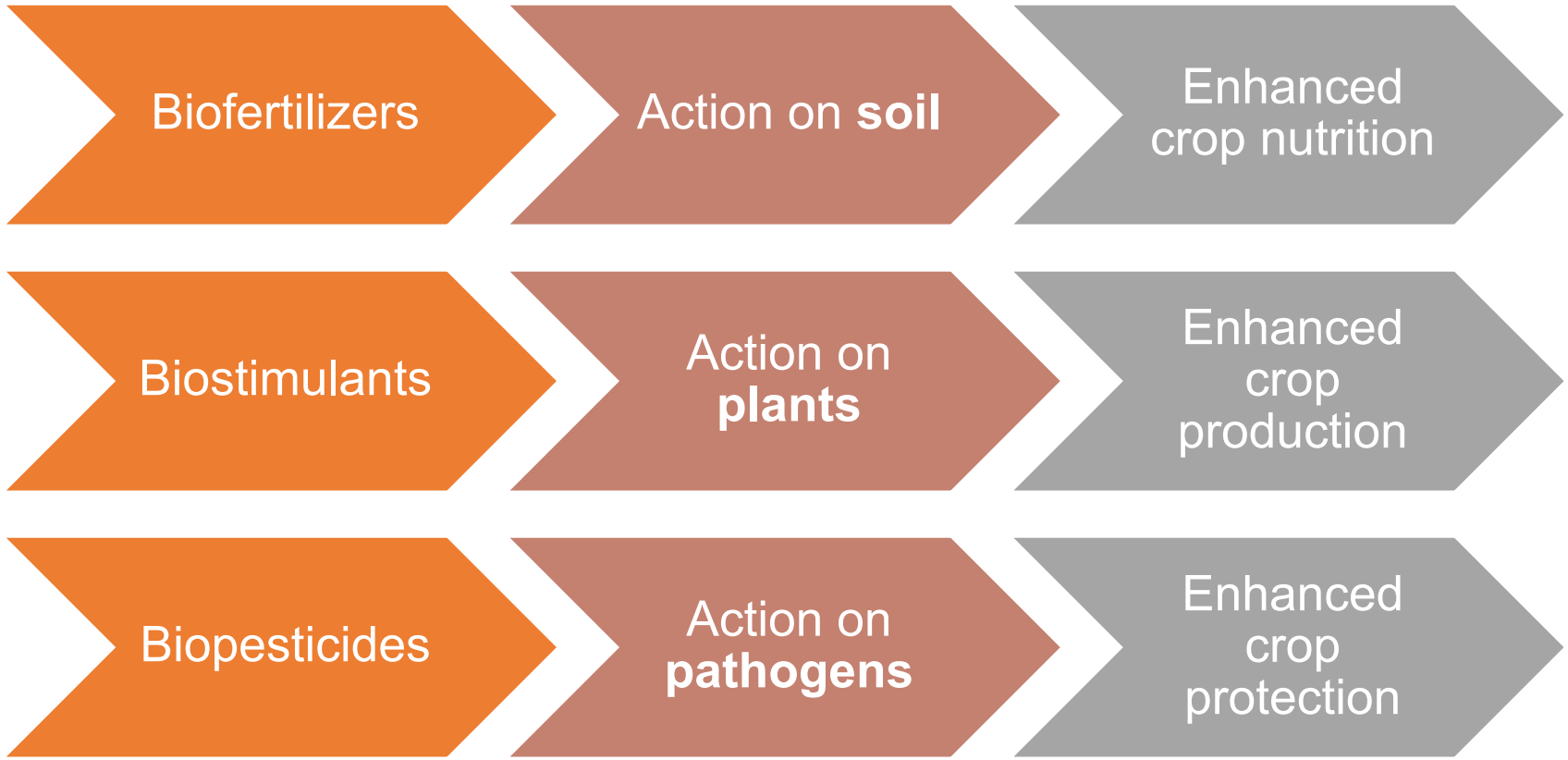
2010

algen

Algae and agriculture

- Macroalgae are used in agriculture for millenia
- Macroalgal agricultural products are popular in last decades
- Microalgae agricultural products are entering the market

Activity of algal & cyanobacterial biomass in crop production



Algae value chain in agriculture

Compost tea

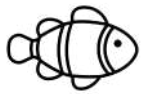
Pre-treated digestate

Biofertilisers
Biostimulants
Biopesticides

Treated water

Agricultural crops

Food

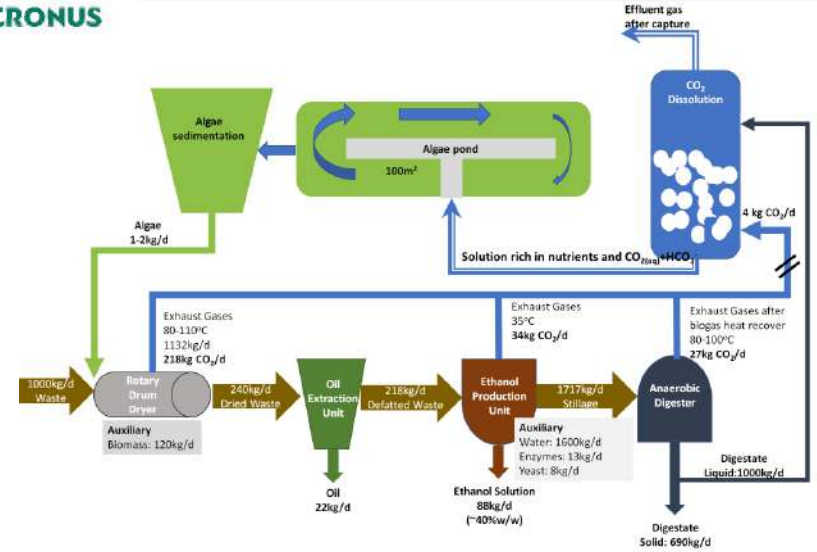


Animal feed

CRONUS

Capture and reuse of biogenic gases: 400 m² ponds, carbonic anhydrase

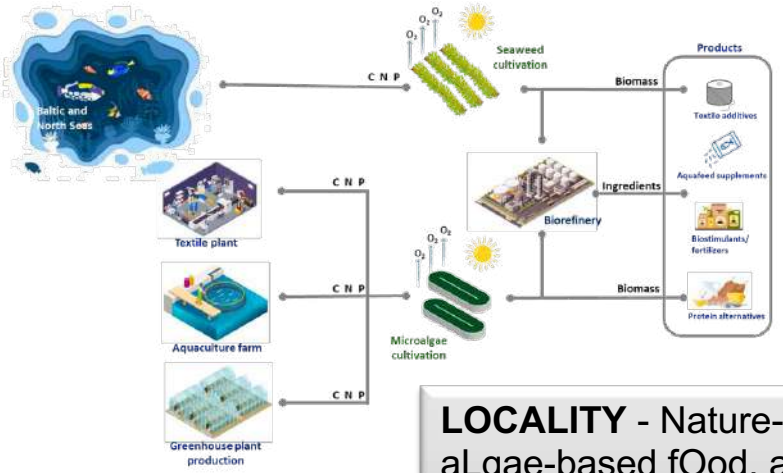
algen algal technology centre



modrozelena

Establishing national spirulina production and processing

Feed and food processing with lactic fermentation



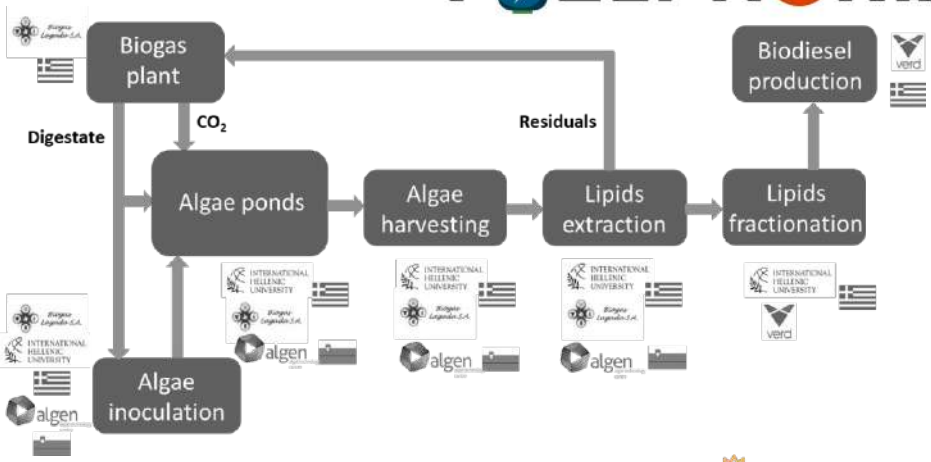
LOCALITY - Nature-positive aLgae-based fOod, agriCulture, AquacuLture and textIle producTs made in North and Baltic Sea ecosYstems

algen

PARAQUA

1000 m² ponds for sustainable production of advanced biofuels from WW

FUELPHORIA



Create pan-European Rural Bioeconomy Network

Biorural

NETWORK

1 European Rural Bioeconomy Network
4 Regional Rural Bioeconomy Platforms
>400 members
20 Rural Bioeconomy Success Stories
42 capacity building workshops
4 regional workshops
1 European Bioeconomy Challenge

KNOWLEDGE

EU Bioeconomy current status
440 interviews with end-users/experts
5 knowledge exchange workshops
5 Bioeconomy business models
Bioeconomy growth guidelines

BioRural TOOLKIT

>400 Bioeconomy material
Filmed workshops
8 success stories videos
Integration with EU's Knowledge **Centre for Bioeconomy**

WHY BioRural SHOULD BE FUNDED?

Holistic framework
...to develop a rural Circular Bioeconomy network
Multi-actor consortium
19 partners
8 success stories
14 countries
Tailored support
...for rural bio-based value chains and new biotechnologies

Thank You!

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