LIFE17 ENV/LT/000407

AlgaeService for LIFE in the light of the European Green Deal

transforming economy for a sustainable future

Project coordinator ***Judita Koreivienė***
Nature Research Centre

Algae Service for Life
LIFE17 ENV/LT/000407

EUROPEAN COMMISSION

Brussels, 11.12.2019
COM(2019) 640 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

The European Green Deal

The European Green Deal for the European Union demonstrates the Commission's commitment to tackling climate and environmental problems. It is a new growth strategy aimed at transforming the EU into a fair and prosperous society with a modern, resource-efficient and competitive economy.

It also aims to protect, preserve and enhance the EU's natural capital and protect the health and well-being of citizens from environment-related risks and impacts. And it contains several elements, which are shown in the diagram.

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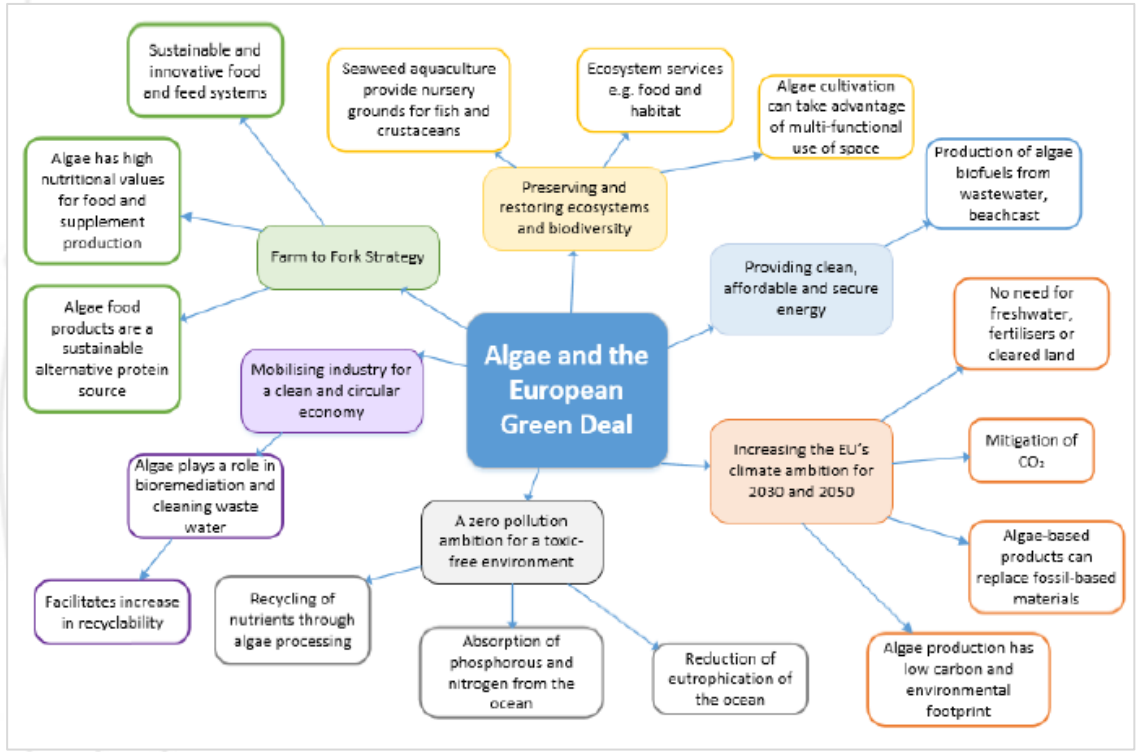
EUROPEAN COMMISSION

Brussels, 15.11.2022
SWD(2022) 361 final

COMMISSION STAFF WORKING DOCUMENT

BLUE BIOECONOMY – TOWARDS A STRONG AND SUSTAINABLE EU ALGAE SECTOR



European Commission

Producers, production systems, species, biomass uses, other steps in the value chain and socio-economic data

An overview of the algae industry in Europe

The European Commission's Knowledge Centre for Bioeconomy

The **,,EU Algae Initiative**" aims to unlock the potential of algae in Europe by increasing sustainable production, ensuring safe consumption and promoting the innovative use of algae and algae-based products. This will contribute to achieving the objectives of the European Green Deal.

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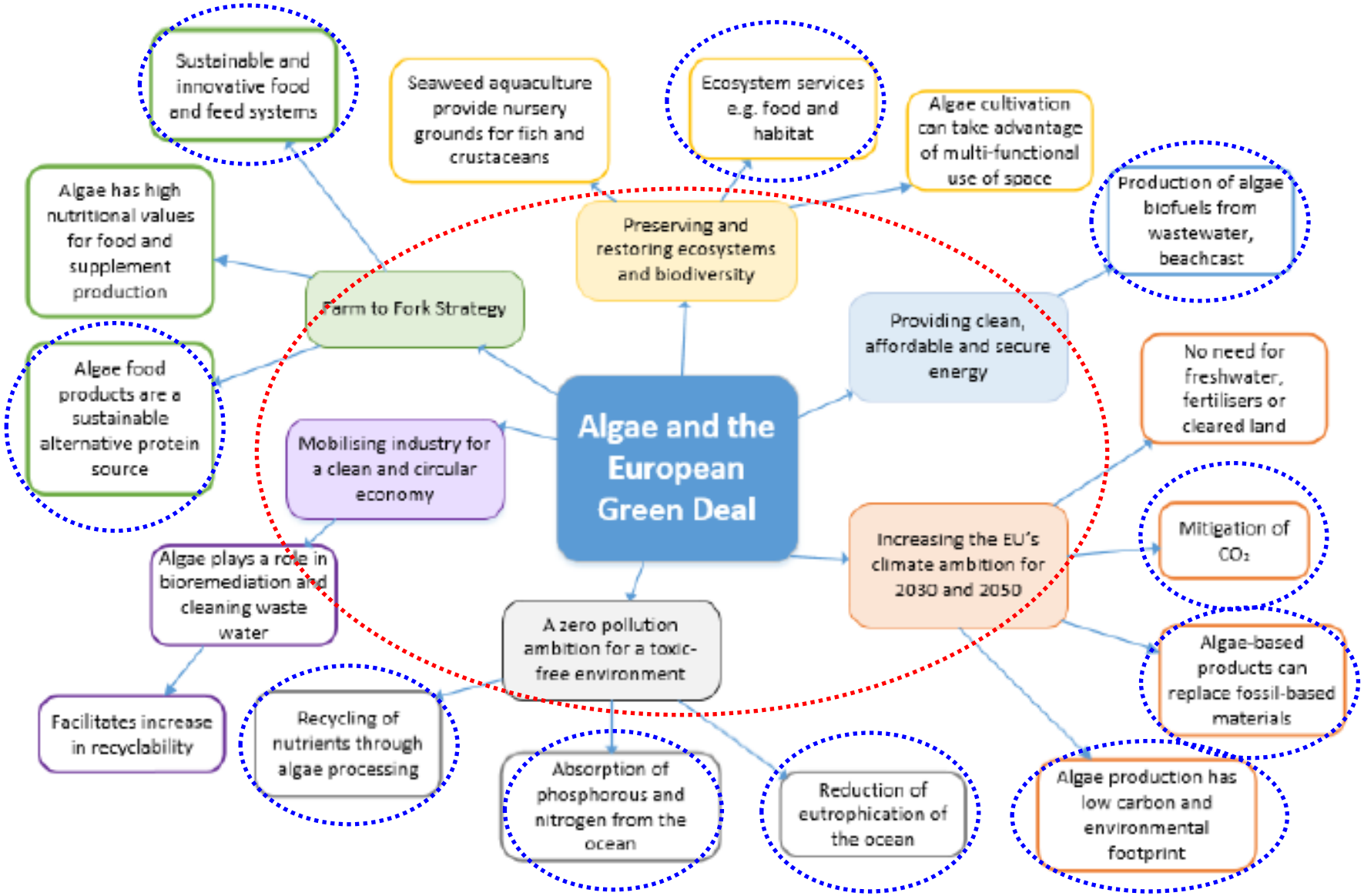

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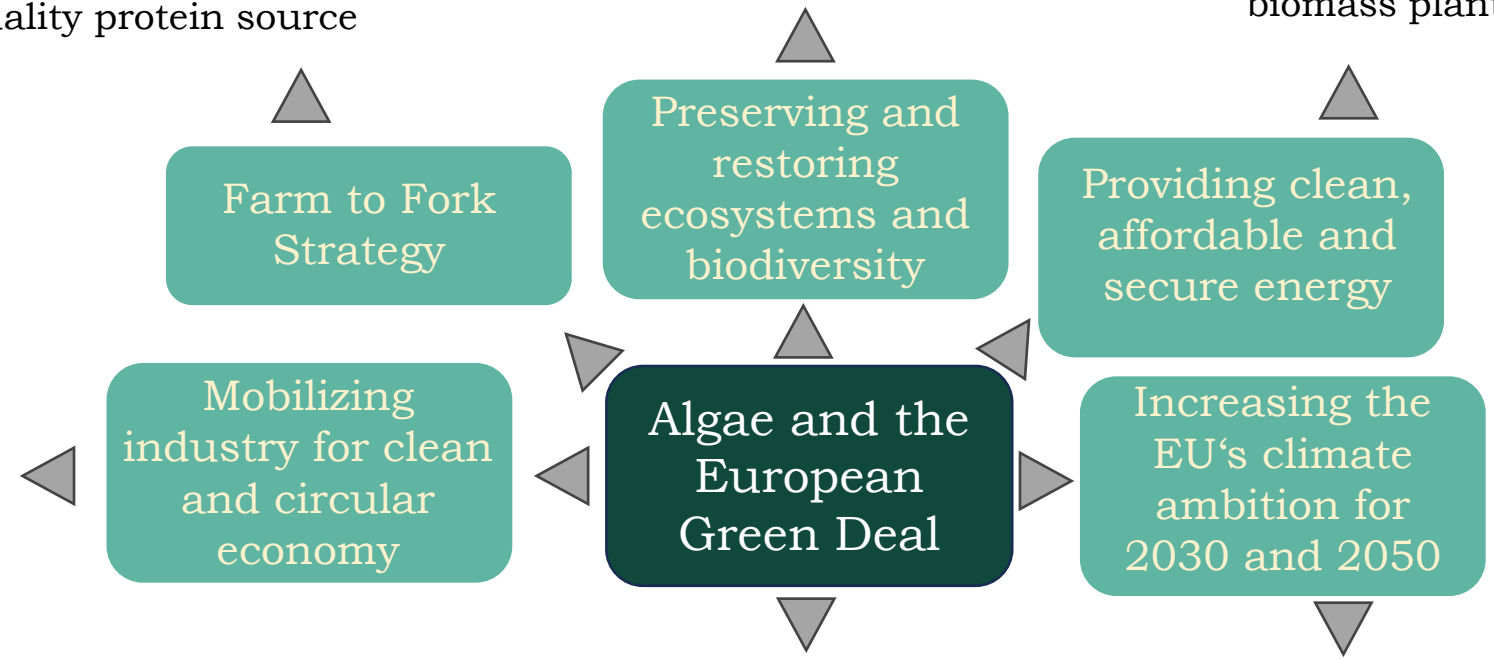
- Algal biomass as slow-release organic fertiliser, soil improvers
- Sustainable and innovative feed - better quality protein source

- Wild algal biomass from blooms – a threat & recourse
- Harvesting biomass - clean and safe environment

- Biogas from algal biomass
- Biogas upgrading using algae
- Algae used as fertilisers for biomass plantations



- Excess biomass if harvested is a cheep recourse for various valuable products
- Facilitate increase in recyclability and sustainable use of the renewable recourses

- Mitigation of CO_2 by temporal sequestration into biomass of plants

- Algae absorbs nutrients (natural filters) released to freshwaters from agriculture
- Eliminated excess algal biomass reduce eutrophication of inland water bodies and nutrient flow to the Baltic Sea

- Elimination cyanotoxins with biomass – reduce risk of contamination
- Recycling nutrients through algae processing

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Two ,,Our Baltic“ Conferences

27-28 September 2020

29 September 2023

RECOGNISING that the legal objective to reach Good Environmental Status by 2020 as required by the Marine Strategy Framework Directive will not be achieved for the whole Baltic Sea and therefore **urgent additional efforts are needed**.

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Baltic Sea Action Plan
2021 update

The **Baltic Sea Action Plan (BSAP) updated** in 2021 maintains all previously agreed measures and adds new measures to reinforce existing efforts.

Eutrophication remains the major environmental threat to the Baltic Sea. It leads to **strong algae growth** and anoxic or hypoxic conditions that affect the entire ecosystem.

Policies and legislation of the European Union supporting the implementation of the Baltic Sea Action Plan

The objectives and actions of the BSAP are in line with the main European policies and in particular the European Green Deal, which includes notably the EU Biodiversity Strategy, the EU Farm to Fork Strategy, the Zero Pollution Action Plan, the EU Offshore energy strategy, the Circular Economy Action Plan and the EU Sustainable and Smart Mobility package.

- ✓ **Eutrophication** is caused by an **excessive input of nutrients** from natural sources and by various **human activities**.
- ✓ **Riverine inputs** are the main source of N and P, with **diffuse sources** (35% from agriculture) accounting for a large proportion.
- ✓ The **historical** loads in **bottom sediments** contributes to the main stock of nutrient and eutrophication.

A significant reduction of nutrient inputs **from diffuse sources** (mainly agriculture) **has not been observed**.

- ✓ BSAP provide Maximum Allowable Inputs (MAI) and Nutrient Input Ceilings (NIC) for all countries in order to achieve good environmental status regarding eutrophication.
- ✓ The annual **NIC for Lithuania** are 35 752 t N and 878 t P, **for Poland** –157 923 t N and 4 291 t P.

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Algae Service for Life

ALGAE – ECONOMY BASED ECOLOGICAL SERVICE OF AQUATIC ECOSYSTEMS

Acronym: AlgaeService for LIFE
Project No: LIFE17 ENV/LT/000407

Project duration: 01/08/2018 – 30/11/2023
Budget: 3 674 830 Eur (EU contribution 59.7%)

Nature Research Centre: ***Judita Koreivienė, Jūratė Karosienė, Jūratė Kasperovičienė,*** *Ričardas Paškauskas, Olga Narkevičienė, Eugenija Bakšienė, Dmitrij Morudov, Kornelija Buzytė*
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Institute of Nature Conservation PAS: ***Elżbieta Wilk-Woźniak,*** *Wojciech Krztoń, Edward Walusiak, Martyna Budziak, Małgorzata Łaciak*
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JSC SPILA: *Vytas Rimkus,* ***Daiva Semėnienė,*** *Andra Rimkuvienė*

COORDINATING BENEFICIARY

Nature Research Centre

ASSOCIATED BENEFICIARIES

Adam Mickiewicz University Poznań

Institute of Nature Conservation PAS

NHF

Spila Baltic Environment

CO-FINANCED BY

Ministry of Environment Republic of Lithuania

Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej

Algae Service for Life
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The goal of the project is to promote best practices in ecological services and the circular economy approach by implementing an innovative complex system.

Objectives

- To demonstrate integrated efficient management of nutrients and algal blooms through the harvesting of macroalgae mats and cyanobacteria scums
- To test and demonstrate the redesigning of harvested biomass into potentially valuable products
- To raise awareness to environmental, water quality and health hazard issues

	Actions
A1	Overview of algae harvesting instruments, technical sketches, permits
B1	Construction, testing and demonstration of harvesting devices
B2	Testing biomass agglomerations and water quality based on traditional and distant methods
B3	Testing algae biomass for low and high value bioproducts
C1	Monitoring impact of the project actions on ecological and economic benefits
D1	Raising awareness and dissemination project results
D2	Replication and transfer of the project results
E1	Project management and monitoring

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Algae and the European Green Deal

- Preserving and restoring ecosystems and biodiversity
- A zero pollution ambition for a toxic free environment
- Leave no one behind
- Farm to Fork Strategy
- Providing clean, affordable and secure energy
- Mobilising industry for clean and circular economy

Algal blooms in standing and floating water ecosystems
CYANOBACTERIA

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Algae and the European Green Deal

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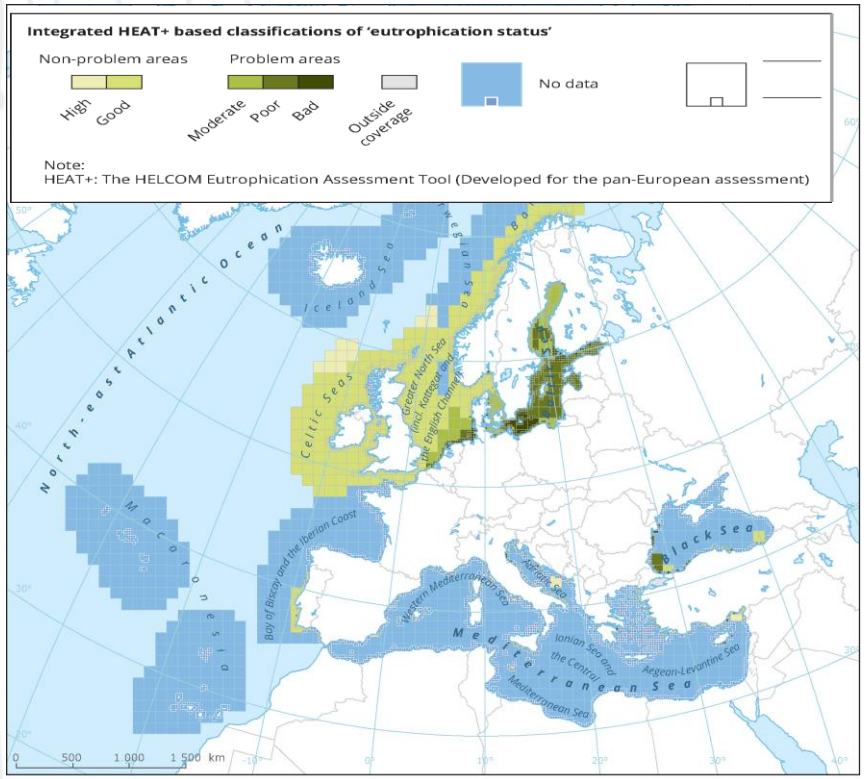
Algal blooms in standing and floating water ecosystems

European Environment Agency



https://www.eea.europa.eu/highlights/eutrophication-remains-a-major-problem

According to the European Environment Agency, **~23%** (563,000 km^2) **of the seas** and oceans around Europe are **affected by eutrophication**.

The situation is the worst in the **Baltic Sea** - **up to 99%** of the area is **affected by eutrophication**. Vulnerable because it is closed sea - the water turnover time is ~30 years (Stigebrandt 2001)

The Baltic Sea **basin is four times the size of the sea area** (~1.7 million km2) and has a **population of 85 million people**. Agricultural areas in the west and east account for 60-70% of the basin's area

Blooms cover ~200,000 km^2

Cyanobacteria bloom in the Baltic Sea, 2005.
Satellite image from NASA' s Terra satellite, MODIS instrument.

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Algae and the European Green Deal

Preserving and restoring ecosystems and biodiversity

A zero pollution ambition for a toxic free environment

Leave no one behind

Farm to Fork Strategy

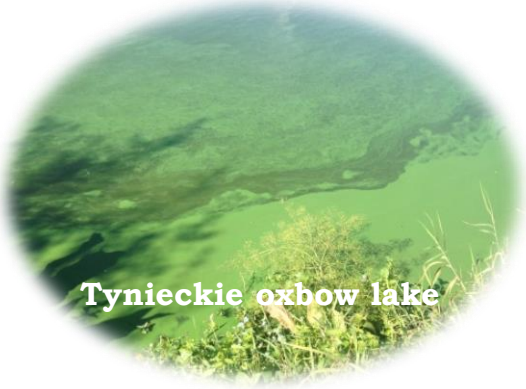
Providing clean, affordable and secure energy

Mobilising industry for clean and circular economy


Simnas

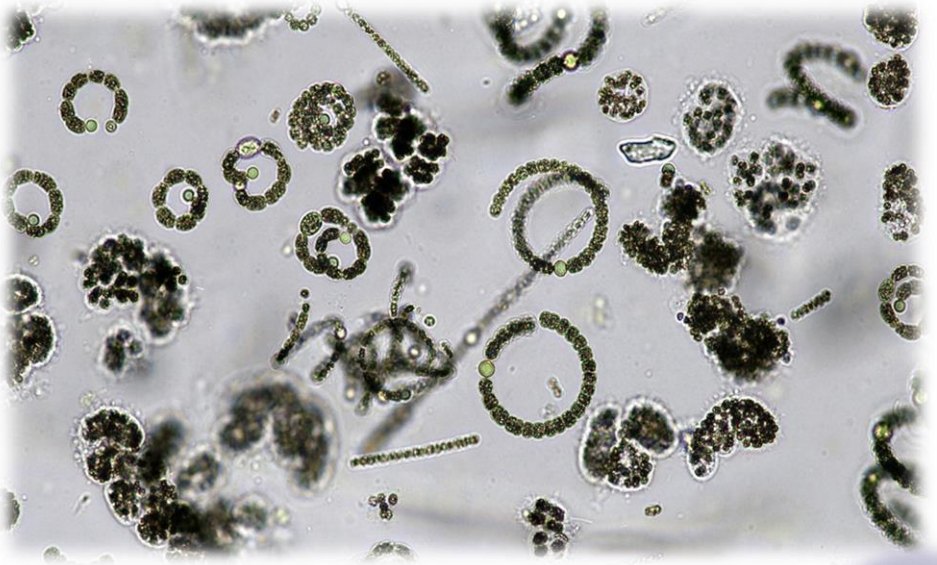

Curonian Lagoon

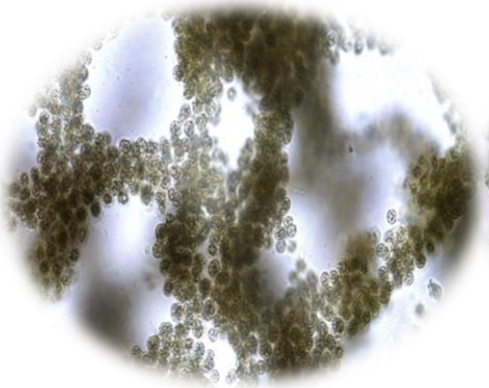

Podkamycze

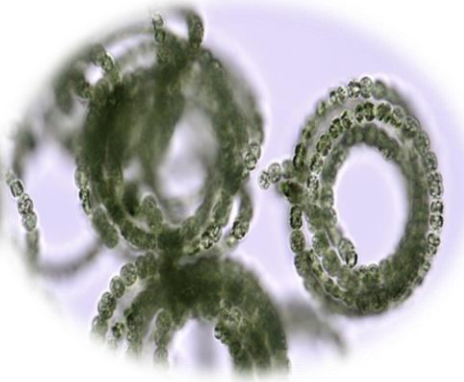

Tynieckie oxbow lake

- Cyanobacteria blooms are usual in inland aquatic ecosystems.

Cyanobacteria




Microcystis


Dolichospermum


Aphanizomenon

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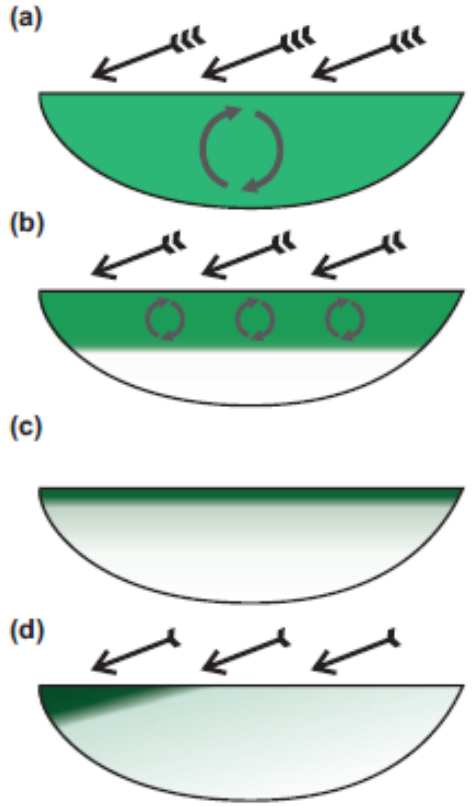
Algal blooms in standing and floating water ecosystems

- Decrease in water clarity and biodiversity
- Increase in sedimentation of organic matter
- Oxygen is consumed during the decomposition
- Dangerous cyanotoxins are produced

SCUM FORMATION



Schematic illustration of the formation of a surface bloom and scum of buoyant planktonic cyanobacteria like *Microcystis* spp. (Chorus & Welker 2021).

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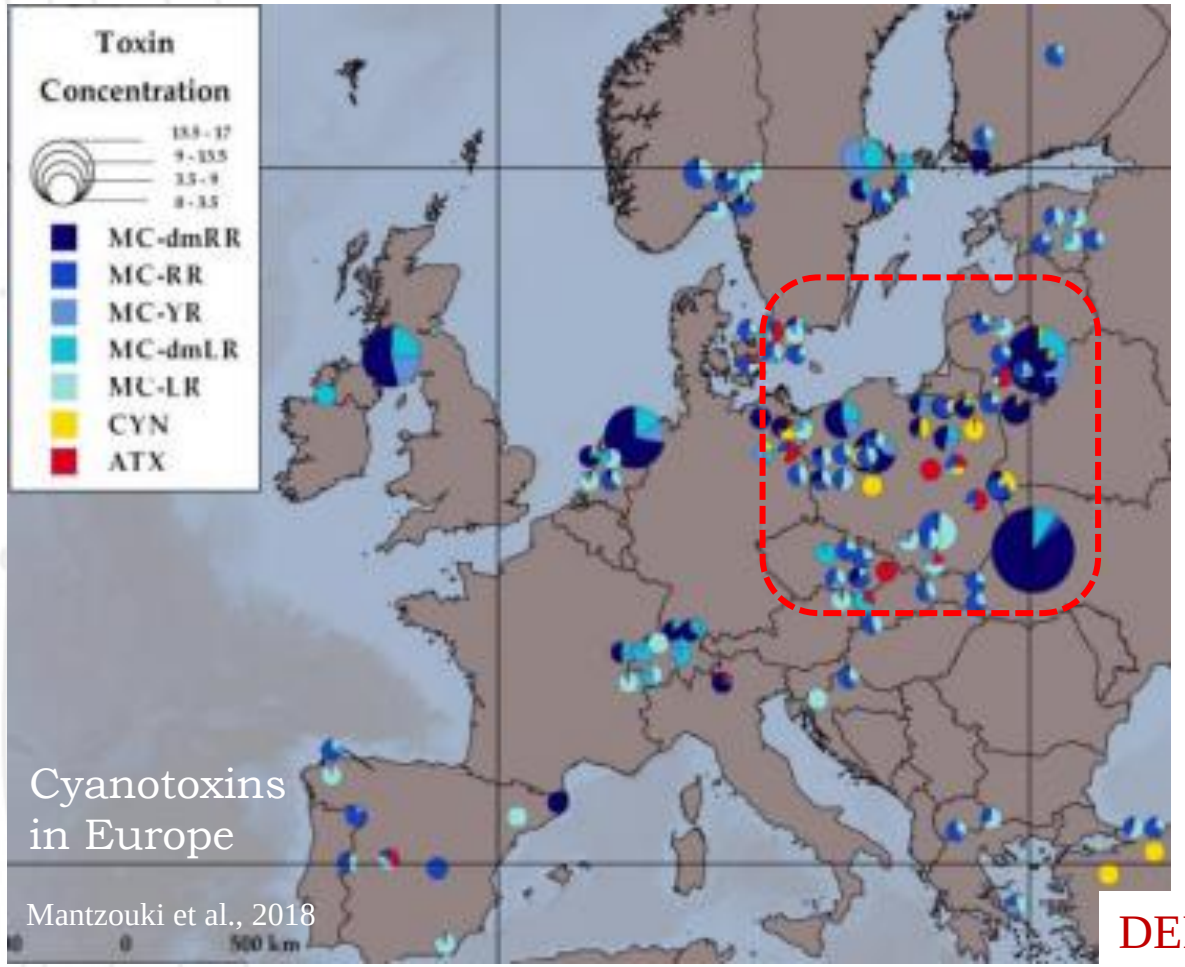
Algal blooms in standing and floating water ecosystems

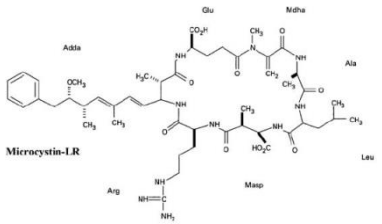


Cyanotoxins in Europe

Mantzouki et al., 2018

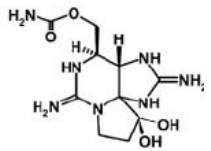
➢ Cyanotoxin groups and their effect

HEPATOTOXINS



- Widest distribution, highest concentrations
- Remains in the water for up to 4 months.
- The effect can be seen after days or weeks
- Acts on the liver and digestive system
- Accumulates in the organisms
- Causes chronic diseases

NEUROTOXINS



Saxitoxin

- Effect on the nervous system
- The effect occurs within one hour
- It manifests itself as dispnea, tingling in the limbs
- The group contains rapidly degradable and long-lasting toxins

DERMATOTOXINS

- After contact with cyanobacteria biomass irritation of skin, wounds

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Algal blooms and REMOTE SENSING

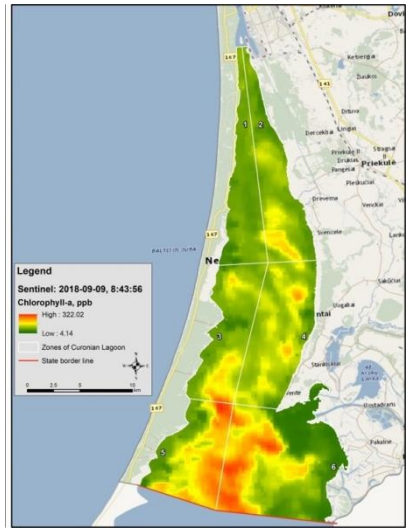
HOW much cyanobacteria biomass can be accumulated in blooming aquatic ecosystems?

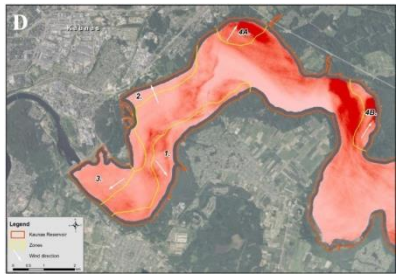
Partners involved:

Networking with:

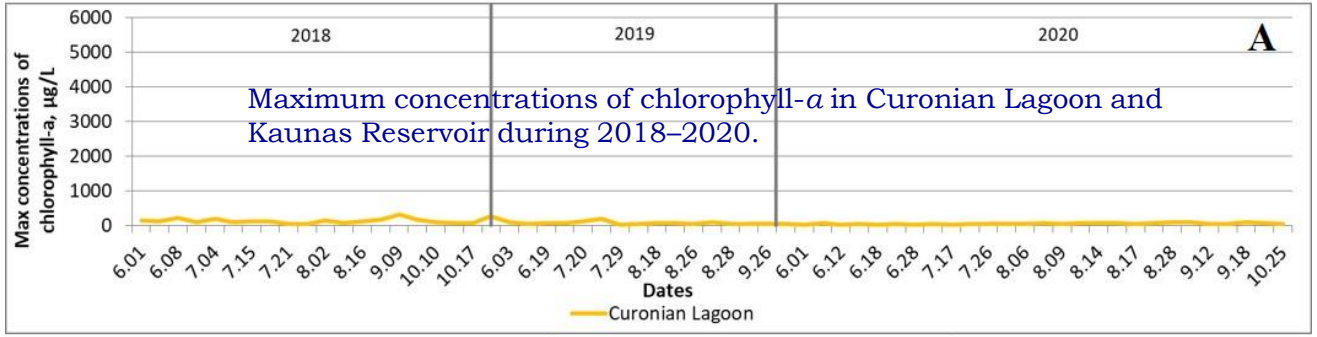
KLAIPĖDA UNIVERSITY

The methodology for selecting water bodies and determining hot spots of blooms on the basis of remote sensing was developed as part of the project.

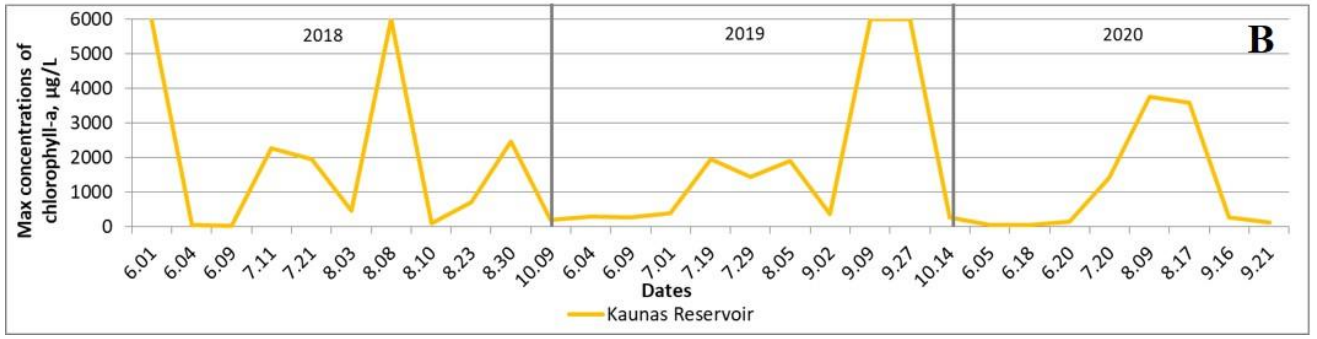




The tools developed as part of the networking projects - Horizon 2020 EOMORES and TODAY (No. 4000122960/18/NL/SC) - were used to analyse satellite images of the Curonian Lagoon and the Kaunas Reservoir.



Maximum concentrations of chlorophyll-*a* in Curonian Lagoon and Kaunas Reservoir during 2018–2020.



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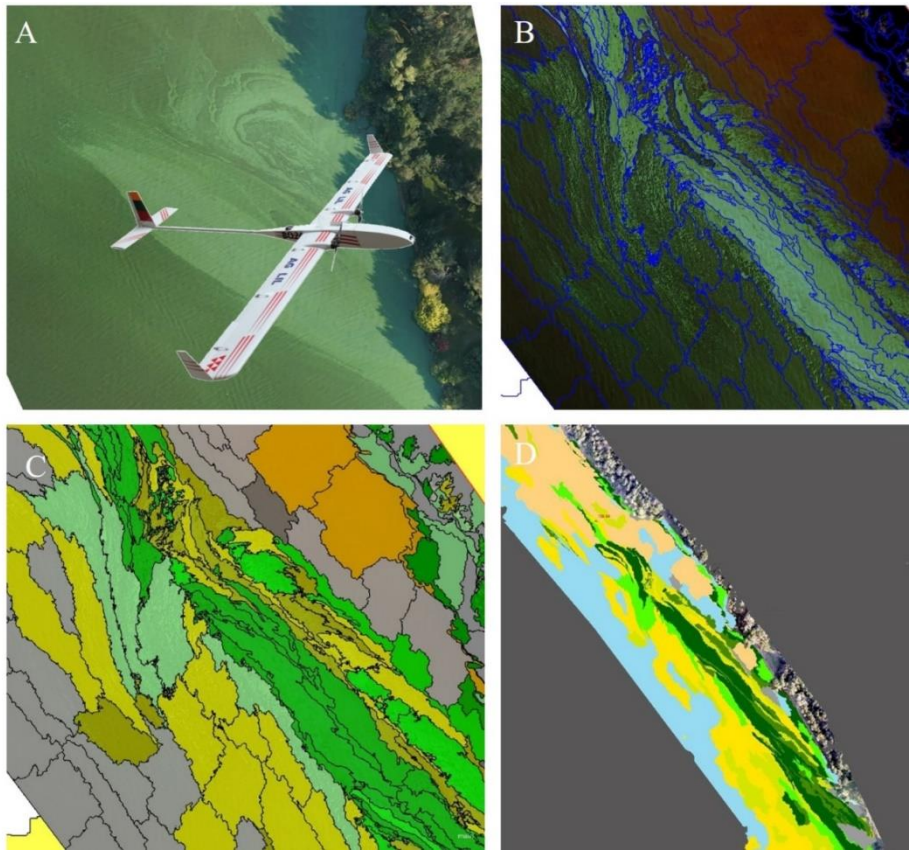
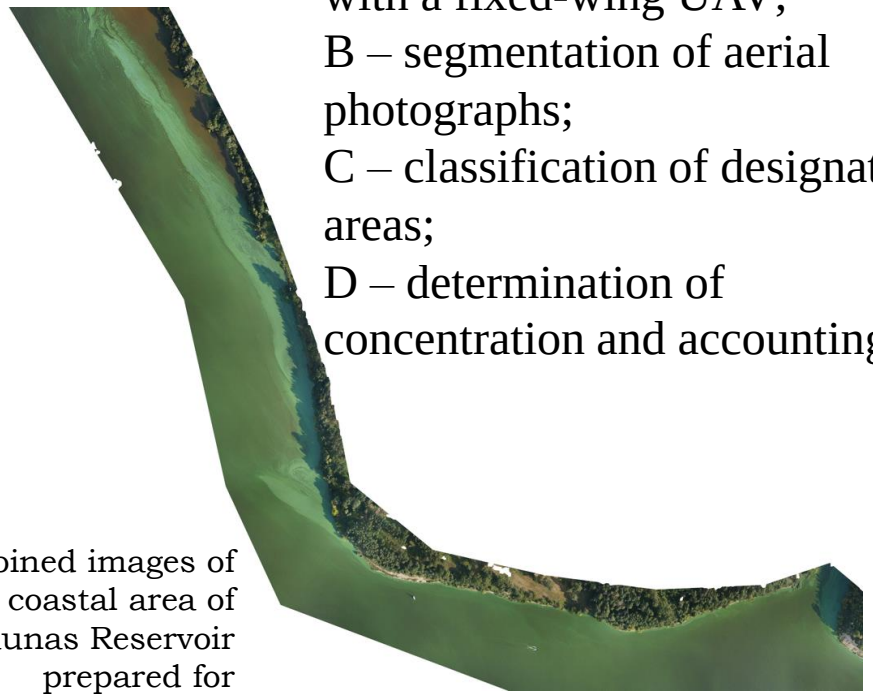
Algal blooms and REMOTE SENSING

A methodology was developed to identify hotspots of blooms and assess biomass based on images taken by unmanned aerial vehicles (UAV).



Stages of orthophoto analysis:

A – taking aerial photographs with a fixed-wing UAV;
B – segmentation of aerial photographs;
C – classification of designated areas;
D – determination of concentration and accounting



Joined images of the coastal area of Kaunas Reservoir prepared for analysis

Partners involved:

External experts:
A. Gedvilas
R.Skorupskas

Networking with:

KLAIPĖDA UNIVERSITY

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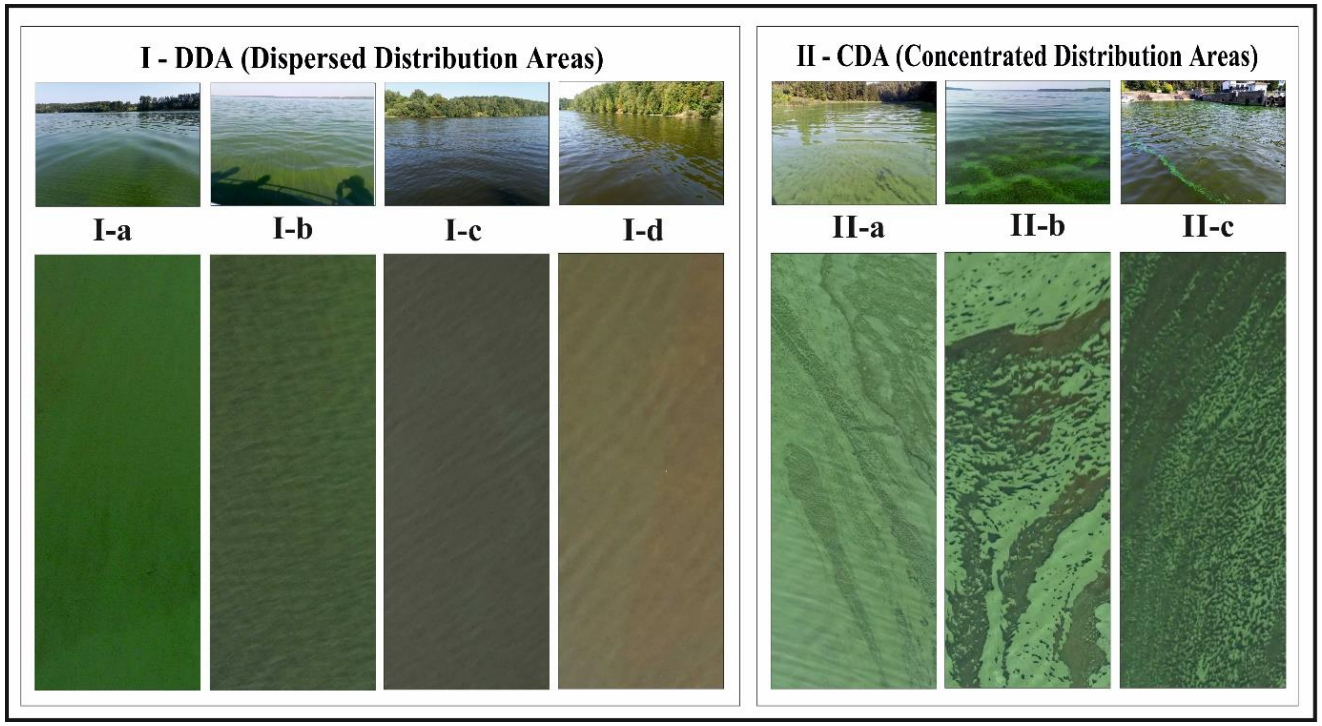
Algal blooms and REMOTE SENSING

Types of cyanobacteria accumulations on the surface of the Kaunas Reservoir based on UAV images.



Dispersed Distribution Areas **(DDA)**: **I-a** – high density areas; **I-b** – low density areas; **I-c** – deep water areas with extremely low density; **I-d** – shallow areas with extremely low density;
Concentrated Distribution Areas **(CDA)**: **II-a** – continuous cover; **II-b** – honey-comb-like cover; **II-c** – fragmentary cover.

Partners involved:

External experts:
A. Gedvilas
R.Skorupskas

Networking with:

KLAIPĖDA UNIVERSITY

- In the 1 km^2 littoral zone of the Kaunas reservoir, a total of **33 278 tons** wet biomass of cyanobacteria was estimated.
- Over 98% of the biomass was accumulated in the DDA areas, which covered 0.724 km^2.
- **578 tons** of harvestable biomass with an **average density of 20–28 kg/m^2** were accumulated in the CDA areas (0.286 km^2).

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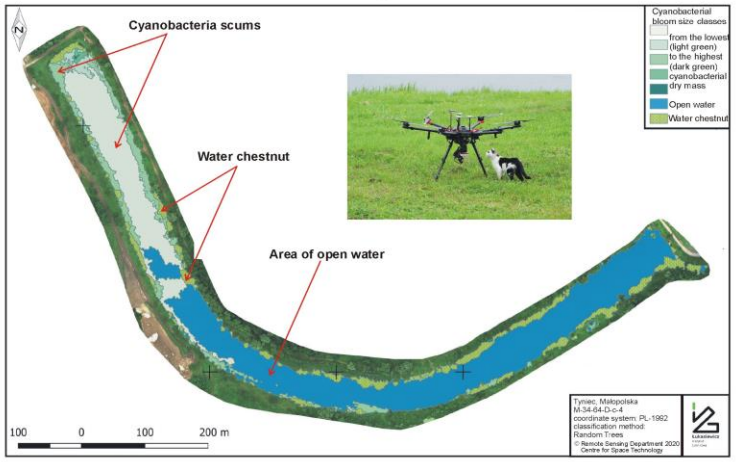
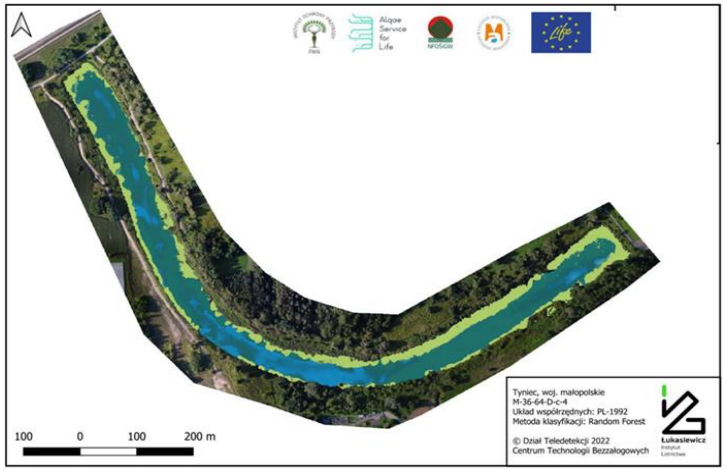
Algal blooms and REMOTE SENSING

Visualisation of the estimated dry mass of cyanobacteria in the Vistula River oxbow lake using the Random Tree method

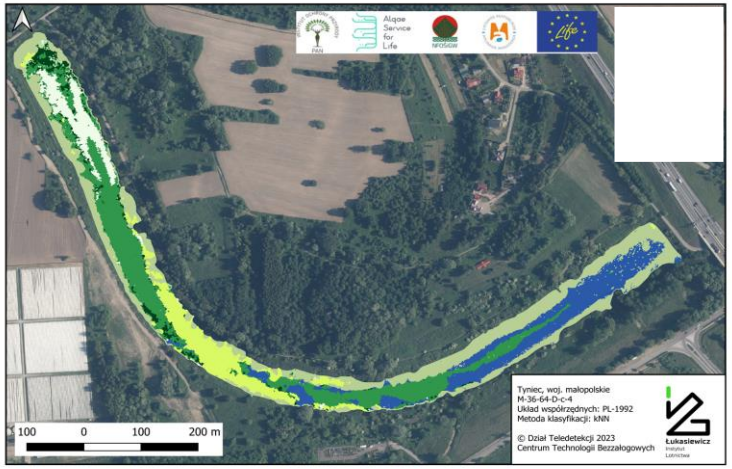
2020



2022



2023



Partner involved:

INSTITUTE OF NATURE CONSERVATION PAS

Networking with:

Łukasiewicz Institute of Aviation

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Algal blooms and REMOTE SENSING

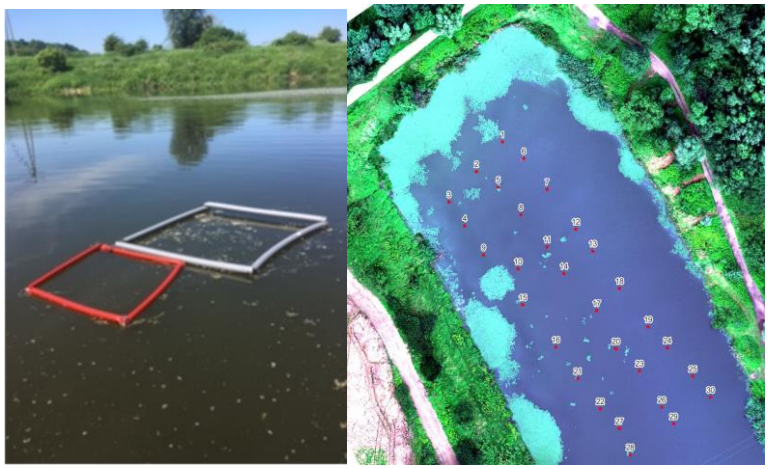
Development of remote sensing index designed for cyanobacterial blooms identification

Partner involved:

Networking with:

Łukasiewicz Institute of Aviation

1. 30 styrofoam frames (60 x 60 cm)



2. Measurement of chlorophyll *a* and phycocyanin concentration:

a) *In situ* – inside of each frame

b) Densed material

3. UAV multispectral measurment

Chlorophyll *a*
In situ – correlation +75%
Densed – correlation + 54%

Phycocyanin
In situ – correlation +70%
Densed – correlation + 59%

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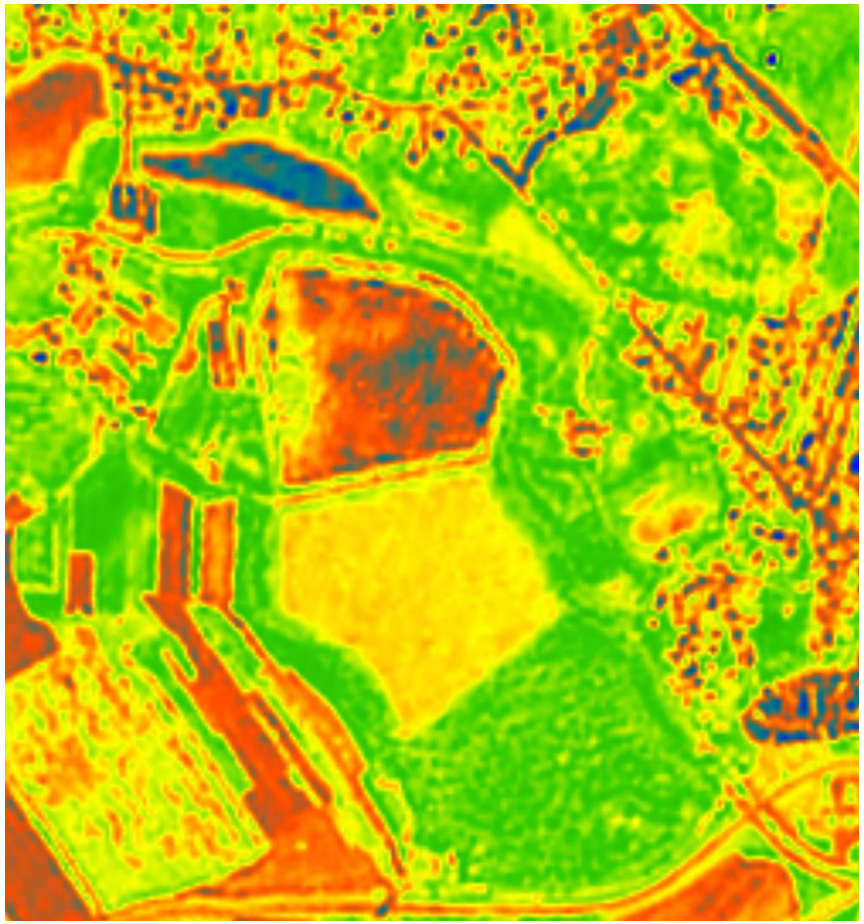
Algal blooms and REMOTE SENSING

Next step: application of developed indexes to Sentinel



Partner involved:

INSTITUTE OF NATURE CONSERVATION PAS

Networking with:

Łukasiewicz Institute of Aviation

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Algal blooms in standing and floating water ecosystems
MACROALGAE

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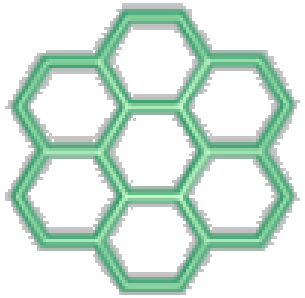
Algal blooms in standing and floating water ecosystems

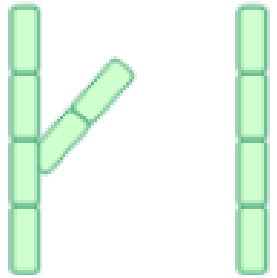
Partner involved:

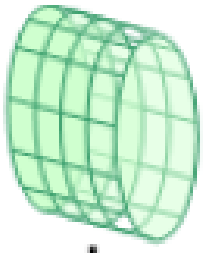
Adam Mickiewicz University Poznań

MORPHOLOGICAL STRUCTURE

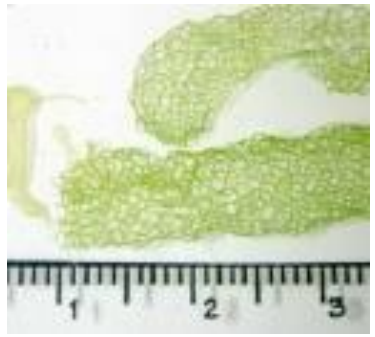
CRUSTY THALLUS	NET THALLUS	FILAMENTOUS	TUBULAR







Hildenbrandtia



Hydrodictyon

Cladophora

Ulva

Algae Service for Life
LIFE17 ENV/LT/000407

Algae and the European Green Deal

Preserving and restoring ecosystems and biodiversity | A zero pollution ambition for a toxic free environment | Leave no one behind | Farm to Fork Strategy | Providing clean, affordable and secure energy | Mobilising industry for clean and circular economy

Algal blooms in standing and floating water ecosystems

Partners involved:

Adam Mickiewicz University Poznań

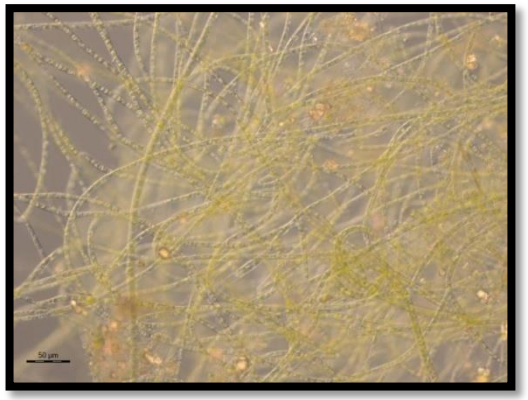
Name „MAT” applies to filamentous algae - floating on the surface or attached to the macroscopic surface (Saunders i in. 2012).

MAT

TAXONOMIC DIVERSITY

STRUCTURE

OCCUPIED SPACE



Algae Service for Life
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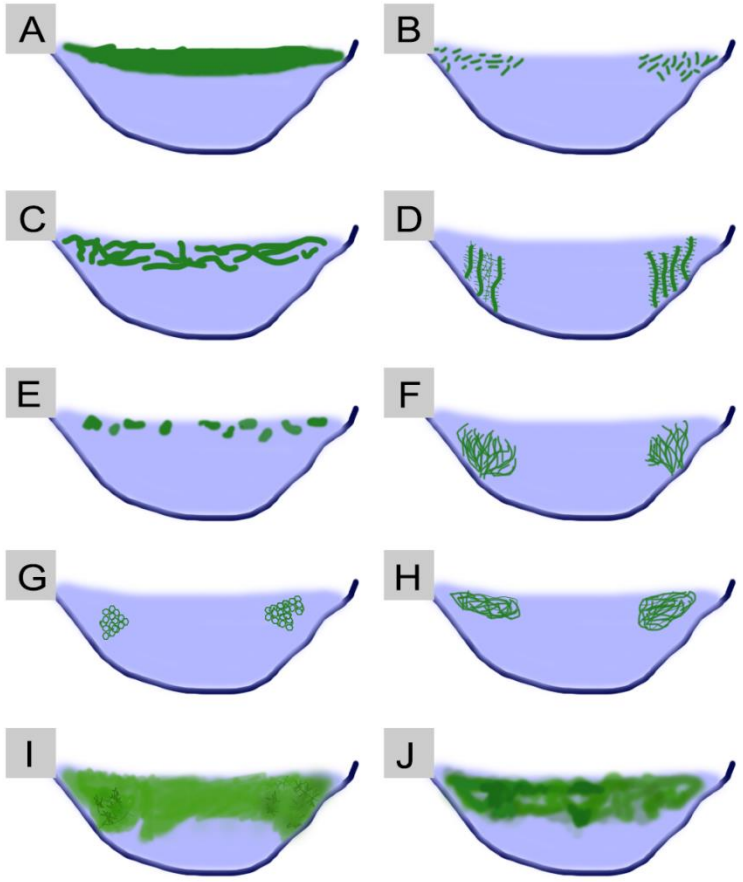
Algal blooms in standing and floating water ecosystems

Partner involved:

Adam Mickiewicz University Poznań



MACROALGAE MAT FORMATIONS CAN BE DEVIDED INTO:

- **free-floating mats** – taking shapes of flocs (B), mats or felts, tufts, clouds (E), net-like structures (G);

- **attached to the bottom** - upright growth forms (aligned), bush-like structures (F), solitary thalloid growth forms (D – stonworts);

- **overgrowing the entire water column** – includes both free floating and attached forms, also the forms that overgrow each element that can serve as a pillar e.g. submerged water plants.

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Algal blooms in standing and floating water ecosystems

Partner involved:

Adam Mickiewicz University Poznań

SECRETION OF SUBSTANCES INHIBITING THE GROWTH OF THE COMPETITOR

PRODUCTION OF SURVIVAL STRUCTURES

NUTRIENTS INTAKE FROM WATER

EARLY DEVELOPMENT IN SPRING

ADAPTIVE STRATEGY

CHEMICAL COMPOSITION OF THALLI

CHANGE IN MORPHOLOGICAL FEATURES

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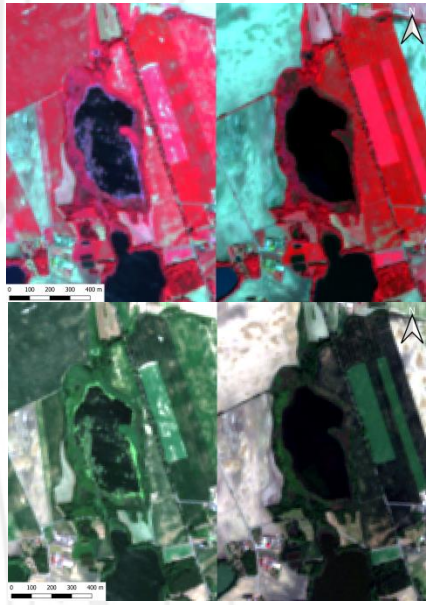
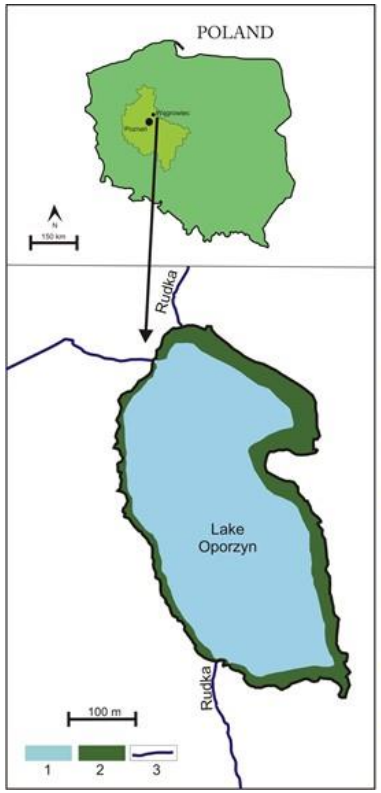
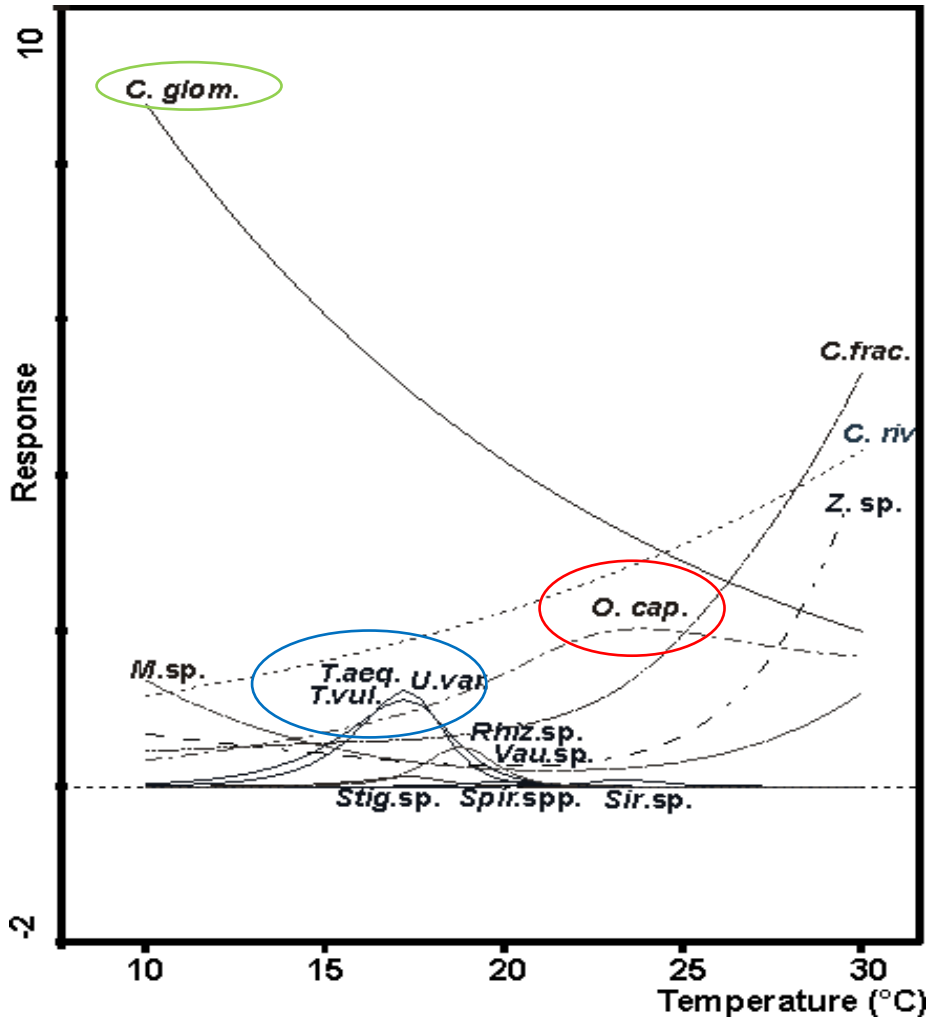
Algal blooms in standing and floating water ecosystems

Partner involved:

ADAM MICKIEWICZ UNIVERSITY POZNAŃ







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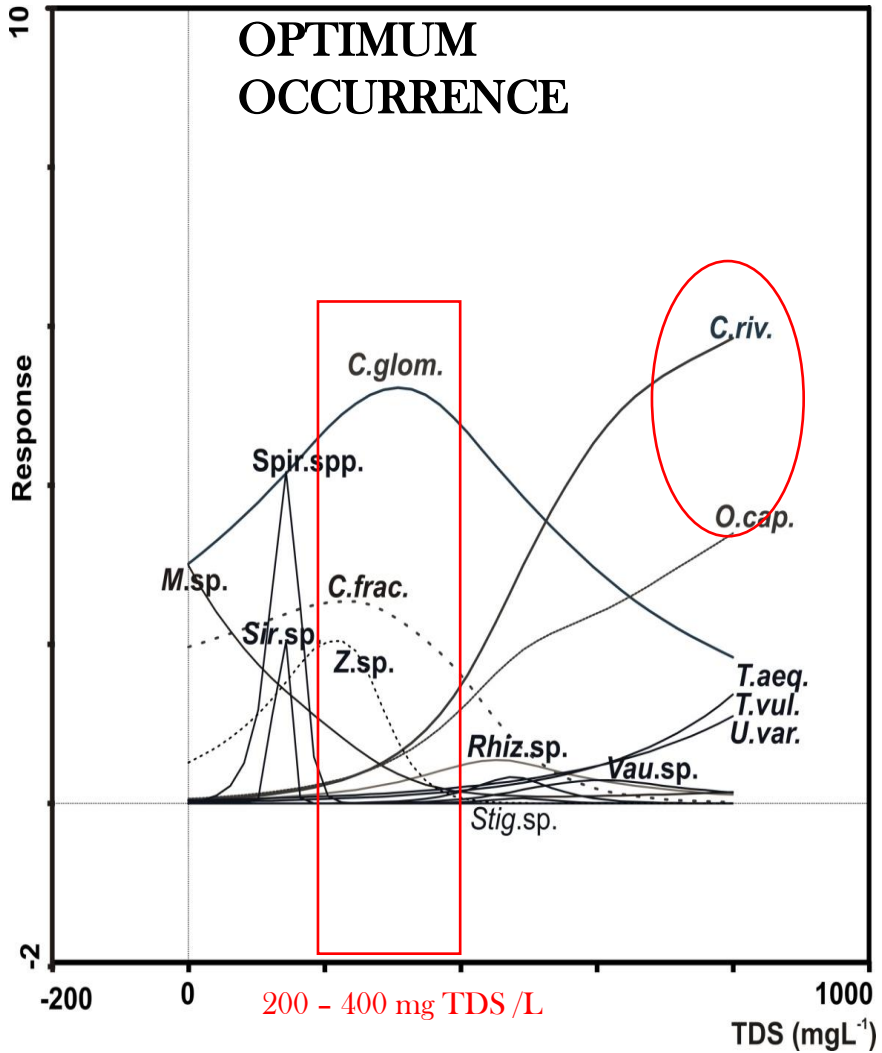
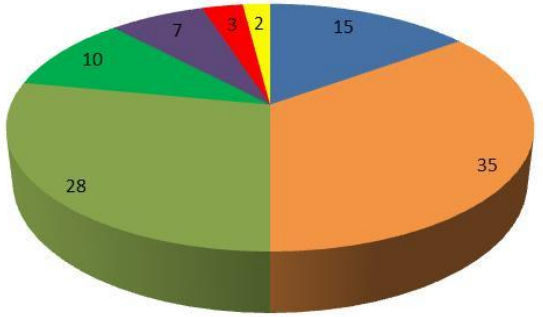
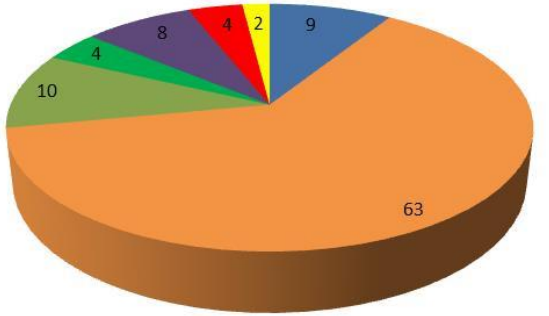


SUMMER



PLANKTONIC ALGAE

AUTUMN



Algae Service for Life
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Algae and the European Green Deal

- Preserving and restoring ecosystems and biodiversity
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- Leave no one behind
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Algal blooms in standing and floating water ecosystems

Partner involved:

External experts:
A. Gedvilas
R.Skorupskas

- ✓ Destroys aquatic vegetation
- ✓ Reduces habitat heterogeneity
- ✓ Reduces flow rate
- ✓ Covering the bottom - negatively affects fish populations

Algae Service for Life
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Algae and the European Green Deal

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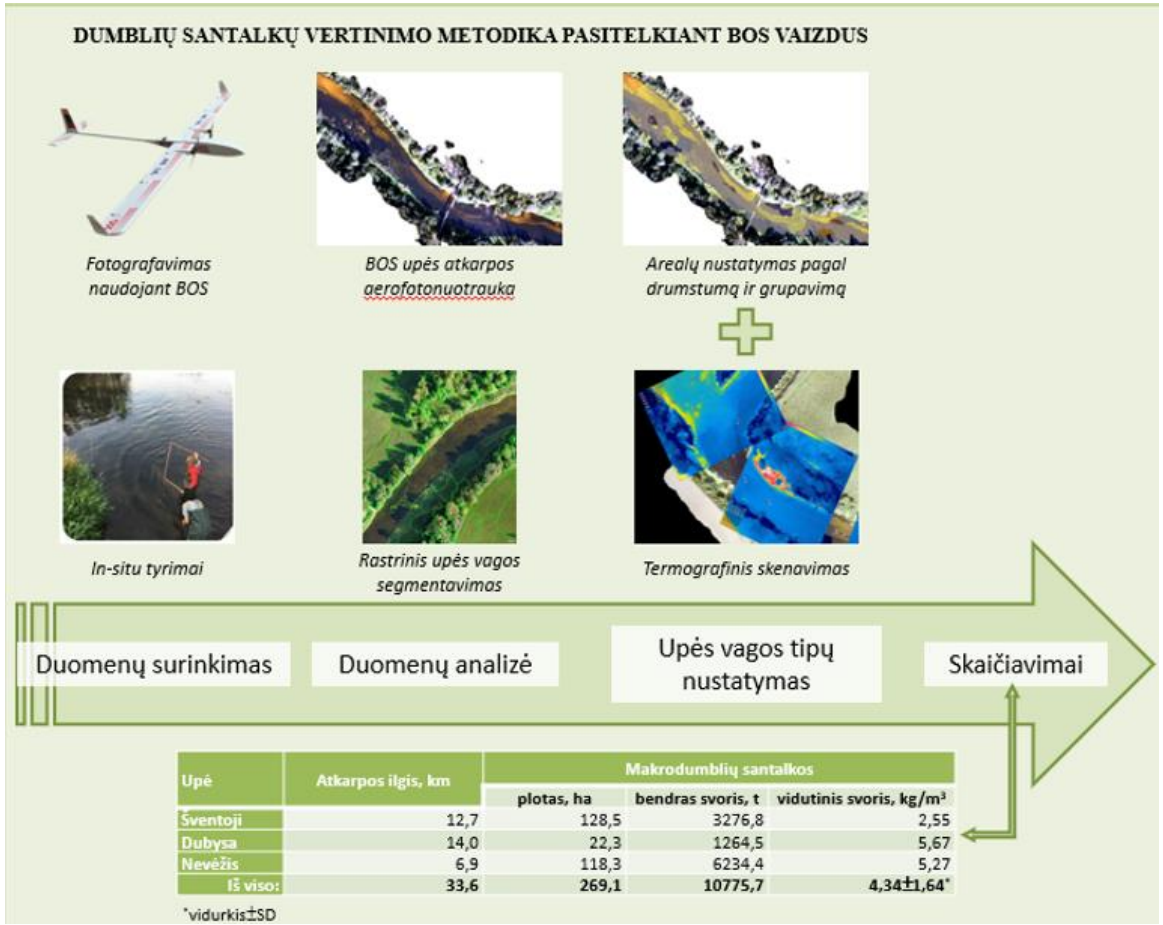
Algal blooms and REMOTE SENSING

The methodology to assess *Cladophora* macroalgae agglomerations in inland aquatic ecosystems by remote sensing was prepared and validated.

Partner involved:

External experts:
A. Gedvilas
R.Skorupskas



Upė	Atkarpos ilgis, km	Makrodumblių santalkos		
		plotas, ha	bendras svoris, t	vidutinis svoris, kg/m²
Šventoji	12,7	128,5	3276,8	2,55
Dubysa	14,0	22,3	1264,5	5,67
Nevėžis	6,9	118,3	6234,4	5,27
Iš viso:	33,6	269,1	10775,7	4,34±1,64*

*vidurkis±SD

- On the analysed UAV images of 140 km of Lithuanian rivers, *Cladophora* macroalgae cover an area of more than 270 ha with a calculated total amount of over **10776 tones**.
- The amount of biomass depends on seasonal characteristics (precipitation, temperature) and varies between **40 and 904 t/km** on different river sections.

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Algal blooms and REMOTE SENSING

The advantages and limitations of the UAV method for the assessment of macroalgae and cyanobacteria agglomerations in inland aquatic ecosystems.

Partners involved:

External experts:
A. Gedvilas
R.Skorupskas

ADVANTAGES

- Faster than conventional monitoring of macroalgal and cyanobacterial agglomerations
- Provides an approximate estimate of macroalgae and cyanobacteria biomass
- Can be used to increase efficiency in harvesting algal biomass by determining hot spots of agglomeration
- More cost-effective survey compared to traditional *in situ* monitoring

LIMITATIONS

- Assessment requires advanced techniques and a high level of expertise for image analysis

For the assessment of macroalgae

- Clouds, solar radiation, water transparency, shadows from trees and shoreline
- Similarity of macroalgae to some aquatic plants

For the assessment of cyanobacteria

- wind mixing, surface layer instability, thickness of scum layer

Algae Service for Life

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Algae and the European Green Deal

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- Mobilising industry for clean and circular economy

Harvesting of algal biomass – specialised prototypes

Algae Service for Life
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Algae and the European Green Deal

Preserving and restoring ecosystems and biodiversity

A zero pollution ambition for a toxic free environment

Leave no one behind

Farm to Fork Strategy

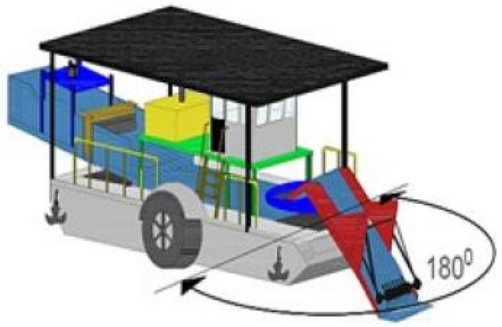
Providing clean, affordable and secure energy

Mobilising industry for clean and circular economy

Harvesting of algal biomass – specialised prototypes

Partner involved:

Baltic Environment



AS-S PROPOSAL for LIFE

Microfiltration system

AS-S PROTOTYPE V1

Macroalgae harvesting system

Algae Service for Life
LIFE17 ENV/LT/000407

Algae and the European Green Deal

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Harvesting of algal biomass – specialised prototypes

Partner involved: Baltic Environment

AS-S PROTOTYPE V2

Macroalgae harvesting system


Microfiltration

Algae Service for Life
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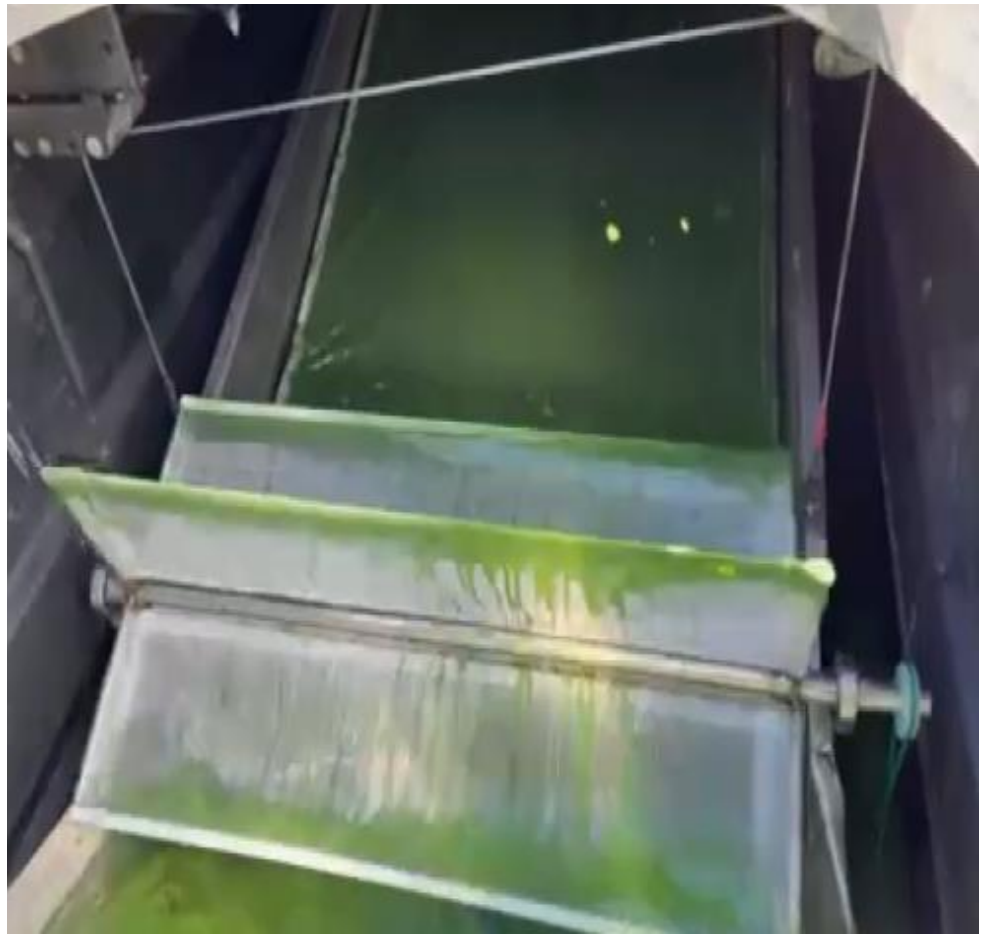
Harvesting of algal biomass – specialised prototypes

Partner involved: Baltic Environment

AS-S PROTOTYPE V3



Algae Service for Life
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Harvesting of algal biomass – specialised prototypes

AS-S PROTOTYPE SPECIFICATION:

Partner involved: Baltic Environment

Water bodies: inland water bodies-rivers, lakes and ponds

Mobility: towing a car (SUV) on a trailer

Target biomass: macroalgae and cyanobacteria

Collected amount: 60 tons of macroalgae; up to 1 tones cyanobacteria

Characteristics: fully electrical, renewable energy, gentle collection, lightweight, transformer

Size of floating collecting device: length- 4 m, width- 2.45 m, height - 2.2 m, weight - 1.5 t, filter mesh area for cyanobacteria – 3.38 m^2

Water filtered: 1068 l/hour for cyanobacteria, for macroalgae n/a

Collection rate: up to 2000 kg/hour macroalgae; 30-80 liters/hour of cyanobacteria

Biomass density: wet macroalgae n/a; up to 4 % of dry weight of cyanobacteria (up to 8% with additional concentration)

Water column filtered for cyanobacteria: 1.2 m

Algae Service for Life
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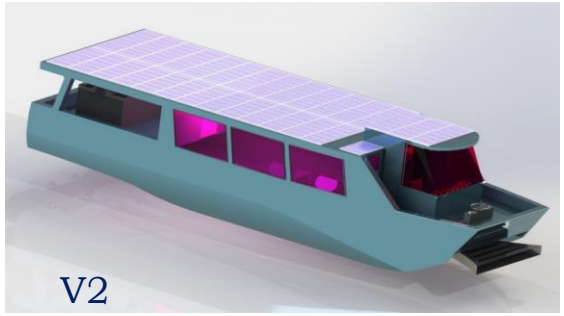
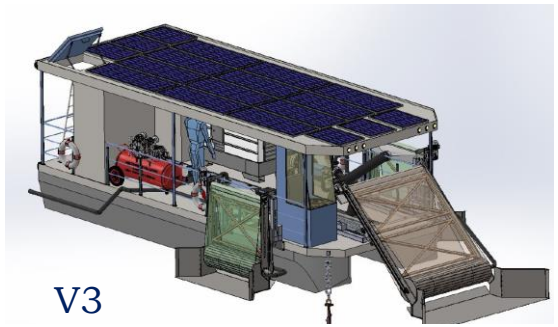
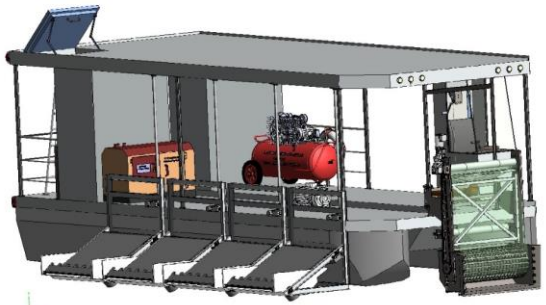
Harvesting of algal biomass – specialised prototypes

Partner involved: Baltic Environment


V2


V3


AS-L PROPOSAL for LIFE


V4


FINAL AS-L PROTOTYPE (V5)

Algae Service for Life
LIFE17 ENV/LT/000407

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Harvesting of algal biomass – specialised prototypes

AS-L PROTOTYPE SPECIFICATION:

Partner involved:

Baltic Environment

Target biomass: cyanobacteria near and off shore

Water bodies: inland water bodies-rivers, lakes and ponds

Mobility: special trailer with manipulator

Collected amount: 8 tones

Characteristics: trimaran, biomass storage tank inside, renewable energy, non-chemical biomass collection, gentle collection in column

Size of floating collecting device: length - 9 m, max width- 4.8 m, height – 3.8 m, weight - 4 t, filter mesh area for cyanobacteria- 13.52 m2

Water filtered: 4272 l/hour

Collection rate: 120-350 liters/hour of cyanobacteria

Biomass density: up to 4 % of dry weight of cyanobacteria (up to 8% with additional concentration)

Water column filtered for cyanobacteria: 1.2 m

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Harvesting of algal biomass – specialised prototypes

PATENTS AND PERMITS (READY TO MARKET):

AS-S prototype patent: The State Patent Bureau of Republic Lithuania: Patent No. 6681 ,,Dumblių surinkimo kombainas“ (AS-S prototype)

AS-L prototype patent: The State Patent Bureau of Republic Lithuania: Patent No. 6844 ,,Mikrodumblių surinkimo kombainas“ (AS-L prototype)

AS-S permit to operate: Lithuanian transport safety administration Certificate on inland watercraft registration Nr. LT-PI-756

AS-L permit to operate: Lithuanian transport safety administration Certificate on inland watercraft registration Nr. LT-PI-767

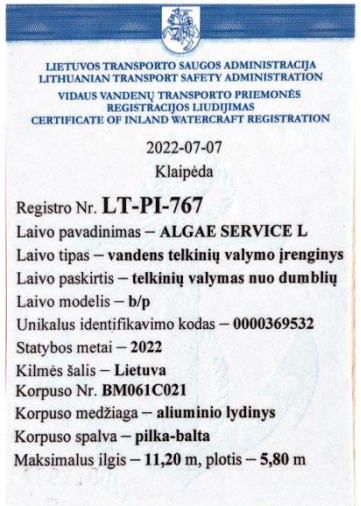
Other documents:

- First technical inspections
- Annual technical inspections
- AS-S and AS-L manual instructions


LIETUVOS TRANSPORTO SAUGOS ADMINISTRACIJA
LITHUANIAN TRANSPORT SAFETY ADMINISTRATION
VIDAUS VANDENŲ TRANSPORTO PRIEMONĖS REGISTRACIJOS LIUDIJIMAS
CERTIFICATE OF INLAND WATERCRAFT REGISTRATION

2020-06-11
Kaunas

Registro Nr. **LT-PI-756**
Laivo pavadinimas – **AS-S**
Laivo tipas – **plūduriuojantis įrenginys**
Laivo paskirtis – **paviršinių vandens telkinių valymas**
Laivo modelis – **b/p**
Unikalus identifikavimo kodas – **0000366499**
Statybos metai – **2020**
Kilmės šalis – **Lietuva**
Korpuso Nr. **AS-S-2020**
Korpuso medžiaga – **aliuminis**
Korpuso spalva – **pilka**
Maksimalus ilgis – **7,69** m, plotis – **2,45** m


LIETUVOS TRANSPORTO SAUGOS ADMINISTRACIJA
LITHUANIAN TRANSPORT SAFETY ADMINISTRATION
VIDAUS VANDENŲ TRANSPORTO PRIEMONĖS REGISTRACIJOS LIUDIJIMAS
CERTIFICATE OF INLAND WATERCRAFT REGISTRATION

2022-07-07
Klaipėda

Registro Nr. **LT-PI-767**
Laivo pavadinimas – **ALGAE SERVICE L**
Laivo tipas – **vandens telkinių valymo įrenginys**
Laivo paskirtis – **telkinių valymas nuo dumblių**
Laivo modelis – **b/p**
Unikalus identifikavimo kodas – **0000369532**
Statybos metai – **2022**
Kilmės šalis – **Lietuva**
Korpuso Nr. **BM061C021**
Korpuso medžiaga – **aliuminio lydinys**
Korpuso spalva – **pilka-balta**
Maksimalus ilgis – **11,20** m, plotis – **5,80** m


LIETUVOS RESPUBLIKOS VALSTYBINIS PATENTŲ BIURAS
STATE PATENT BUREAU OF THE REPUBLIC OF LITHUANIA

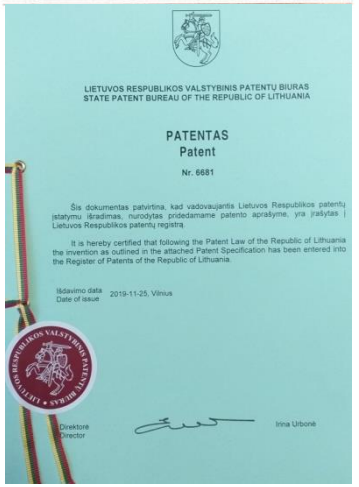
PATENTAS
Patent
Nr. 6681

Šis dokumentas patvirtina, kad vadovaujantis Lietuvos Respublikos patentų įstatymu išradimas, nurodytas pridedamame patento aprašyme, yra įrašytas į Lietuvos Respublikos patentų registrą.

It is hereby certified that following the Patent Law of the Republic of Lithuania the invention as outlined in the attached Patent Specification has been entered into the Register of Patents of the Republic of Lithuania.

Išdavimo data / Date of issue 2019-11-25, Vilnius

Direktorė / Director Irina Urbonė


LIETUVOS RESPUBLIKOS VALSTYBINIS PATENTŲ BIURAS
STATE PATENT BUREAU OF THE REPUBLIC OF LITHUANIA

PATENTAS
Patent
Nr. 6681

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Išdavimo data / Date of issue 2019-11-25, Vilnius

Direktorė / Director Irina Urbonė

Partner involved:

Baltic Environment

Algae Service for Life
LIFE17 ENV/LT/000407

Algae and the European Green Deal

Preserving and restoring ecosystems and biodiversity | A zero pollution ambition for a toxic free environment | Leave no one behind | Farm to Fork Strategy | Providing clean, affordable and secure energy | Mobilising industry for clean and circular economy

Harvesting of algal biomass – specialised prototypes

ENVIRONMENTAL, SOCIAL AND ECONOMICAL IMPACT:

Partner involved:

Baltic Environment

Prototypes AS-S and AS-L for cyanobacteria and macroalgae biomass harvesting -**is a tool to improve water quality and provide ecosystem service**

Algae collection from water bodies can lead to various benefits: **Water Quality Improvement, Biodiversity Conservation, Human Health Protection, Wildlife Habitat Enhancement, Recreational Opportunities, Economic Benefits**

Application of biomass for bioproducts - tool for restitution of harvesting costs by **redesign of waste into valuable products**

Algae collection helps to **reduce greenhouse gas emissions** (GHG) (CO2 assimilated with harvested macroalgae); **reduces of dangerous substances (cyanotoxins)** in water bodies; **reduced N and P** concentrations in water bodies;

Suggested technologies supports **the EU Algae Initiative towards Green Deal and unlock algae potentiality in Europe to use collected biomass for algae-based products**.

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Harvesting of algal biomass – specialised prototypes

WHAT NEXT? MILESTONES FOR THE FUTURE

Partner involved:

Baltic Environment

Value proposition: Providing innovative, eco-friendly, and adaptable algae collection technology and services with ecological and economic benefits.

Offered products and services: Micro and macro algae collection technologies (AS-S, AS-L prototypes), technology support, biomass application know-how (especially for biogas production), and algae harvesting services.

Potential clients: Governmental institutions (ministries, municipalities, agencies), private companies (agriculture, biotechnology, renewable energy firms), and others.

Full cycle business model: Covers algae collection from start to end-of-use.

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Harvesting of algal biomass – specialised prototypes

AS-LAND prototype: Under patenting at The State Patent Bureau of Republic Lithuania

Target biomass: cyanobacteria scums near the shore

Type of water: littoral zone of lakes & ponds

Mobility: easy transportable on trailer, weight ~100 kg

Two parts:

Floating collecting device 1.3 x 1.7 m

Concentration on-land device 4.6 x 1 m

Area of filtration: 4 m^2

Concentration rate: up to 136 kg/hour

Biomass elimination efficiency: up to 96%

Biomass density: up to 5.8 (average 4.8) % of dry weight

Collected biomass per project: 4.14 t

Partners involved:

External experts:
,,Baltic UAV Services“

Algae Service for Life

LIFE17 ENV/LT/000407

Algae and the European Green Deal

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A zero pollution ambition for a toxic free environment

Leave no one behind

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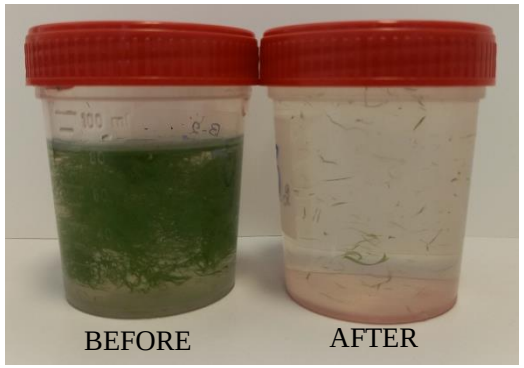
Harvesting of algal biomass – specialised prototypes

Simnas fish pond

Water of Simnas fish pond



Kaunas Reservoir

Partner involved:

External experts:
,,Baltic UAV Services“

Algae Service for Life

LIFE17 ENV/LT/000407

Algae and the European Green Deal

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Mitigation of nutrients via biomass harvesting

Algae Service for Life
LIFE17 ENV/LT/000407

Algae and the European Green Deal

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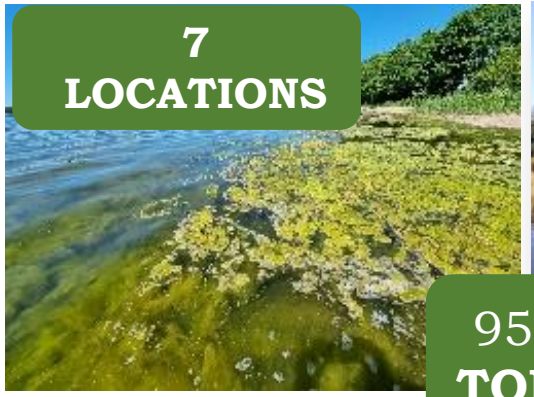
Mitigation of nutrients via biomass harvesting

Cyanobacteria harvesting

13.3
TONS

Macroalgae harvesting



95.4
TONS

Partners involved:

Baltic Environment

Nature Research Centre

Adam Mickiewicz University Poznań

Institute of Nature Conservation PAS

Cyanobacteria
Kaunas Reservoir 12.67 t
Lakes Podkamycze & Tynec 0.53 t
Other (Lake Gineitiškės, Curonian Lagoon, Lake Simnas, Simnas fish pond) 0.12 t

Macroalgae:
Lake Oporzynskie 25.5 t
River Nevėžis 21,5 t
River Šventoji 20.4 t
Kaunas Reservoir 19.0 t
River Nielba 6.5 t
River Jūra 2.0 t
Lake Rgielskie 0.5 t

Algae Service for Life

LIFE17 ENV/LT/000407

Algae and the European Green Deal

- Preserving and restoring ecosystems and biodiversity
- A zero pollution ambition for a toxic free environment
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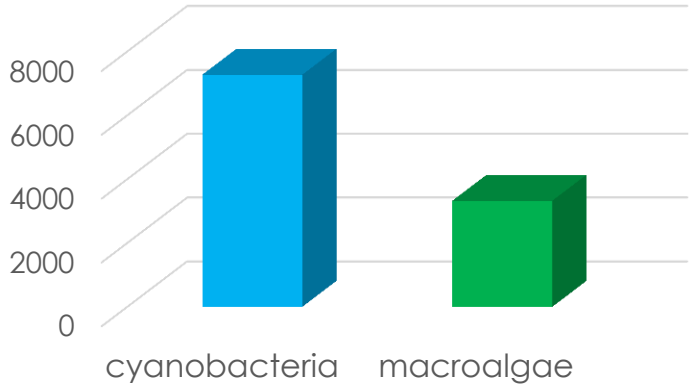
- Providing clean, affordable and secure energy
- Mobilising industry for clean and circular economy

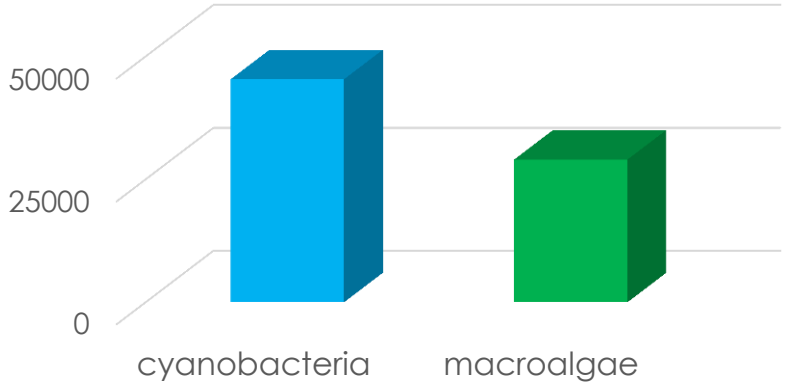
Mitigation of nutrients via biomass harvesting

Poland

Phosphorus P mg/1 kg dry mass

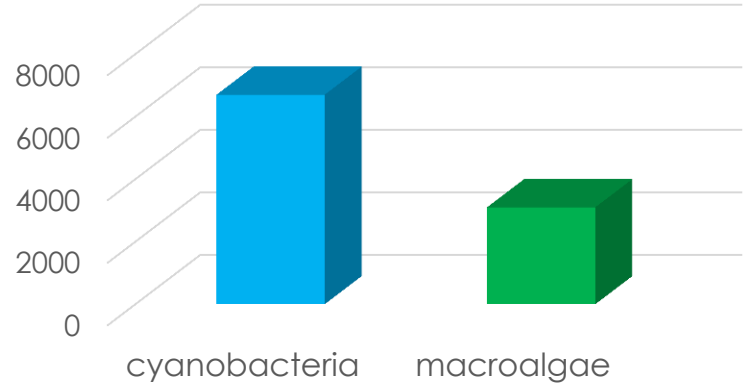


Nitrogen N mg/1kg dry mass

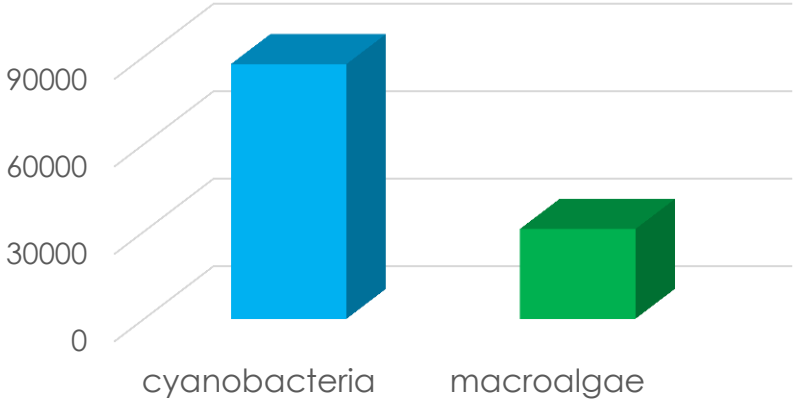


Lithuania

Phosporus P mg/1 kg dry mass



Nitrogen N mg/1kg dry mass



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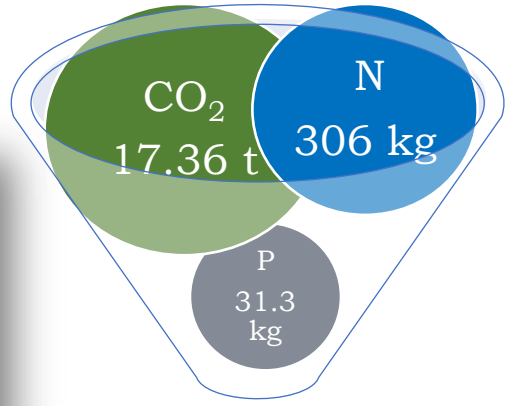
Mitigation of nutrients via biomass harvesting

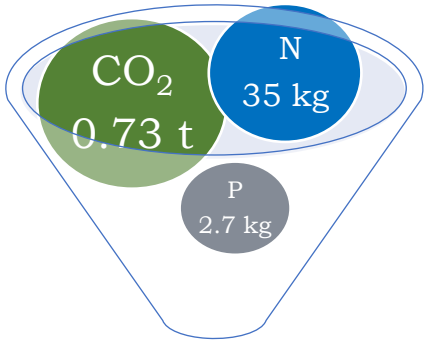
Partners involved:

Nature Research Centre
Adam Mickiewicz University Poznań
Institute of Nature Conservation PAS
Baltic Environment

During project implementation



Macroalgae 95.44 tons



Cyanobacteria 13.32 tons

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Managing cyanotoxins risks

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Managing cyanotoxins risks

KAUNAS RESERVOIR (Lithuania)

IN WATER				IN SCUMS
Cyanotoxins (µg/L)	Grabučiškės 2019-2021	Pažaislis 2019-2021	*Profile* 2021.09.09	Grabučiškės 2019-2020
HEPATOTOXINS **Microcystins**	1.6-202.9 (80.1±91.5)	0.1-74.4 (19.1±26.4)	59.8-5291.6 (1230.6±1687.8)	922.5-1247.5 (1085.0±229.8)
NEUROTOXINS				
Anatoxin-a	0.0-0.3 (0.0±0.1)	0.2	0.1-1.1 (0.5±0.4)	0.1-0.2 (0.2±0.02)
Saxitoxin	0.00	0.00	0.00-0.08 (0.03±0.03)	0.00

Cyanotoxins concentrations in the water and biomass

Table 5.1 Guideline values and health-based reference values for selected cyanotoxins and exposure scenarios (WHO, 2020)

Toxin	*Exposure*[a]	*Value (µg/L)*	*Value type* [b]
Microcystin-LR	Drinking-water, lifetime	1	Provisional guideline value
Microcystin-LR	Drinking-water, short term	12	Provisional guideline value
Microcystin-LR	Recreational	24	Provisional guideline value

Polish lakes

Cyanotoxins (µg/L)		**Podkamycze 1**	**Podkamycze 2**	**Tynieckie ox. lake**
HEPATOTOXINS **Microcystins**	**IN BIOMASS** (2018-2022)	0.2-0.9 (0.1±0.4)	0.1-7.49 (0.8±1.6)	0.4-12.07 (1.5±2.66)
Microcystins	**SCUMS** (av. 2021-2022)	1.41	13.4	11.52
NEUROTOXINS **Anatoxin-a/ Saxitoxin**		0.00	0.00	0.00

Partners involved:

NATURE RESEARCH CENTRE

INSTITUTE OF NATURE CONSERVATION PAS

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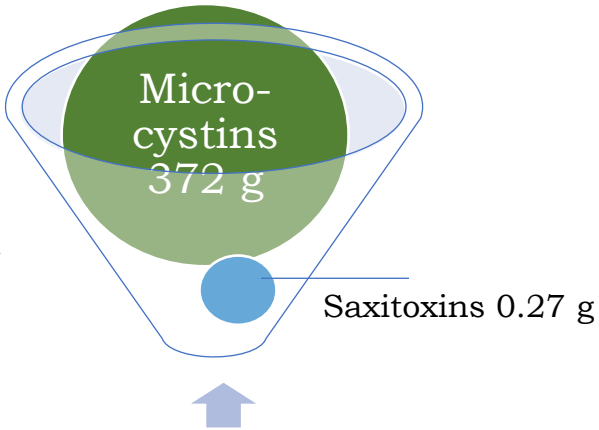
Managing cyanotoxins risks

Partners involved:

MICROCYSTINS
(hepatotoxins)

- Remains in the water for up to 4 months.
- The effect can be seen after days or weeks
- Acts on the liver and digestive system
- Accumulates in the organisms
- Causes chronic diseases



Cyanobacteria 13.32 tons

Baltic Environment

LIFE17 ENV/LT/000407

Algae Service for Life

ALGAE – ECONOMY BASED ECOLOGICAL SERVICE OF AQUATIC ECOSYSTEMS

Acronym: AlgaeService for LIFE
Project No: LIFE17 ENV/LT/000407

Project duration: 01/08/2018 – 30/11/2023
Budget: 3 674 830 Eur (EU contribution 59.7%)

Nature Research Centre: ***Judita Koreivienė, Jūratė Karosienė, Jūratė Kasperovičienė,*** *Ričardas Paškauskas, Olga Narkevičienė, Eugenija Bakšienė, Dmitrij Morudov, Kornelija Buzytė*
Adam Mickiewicz University: ***Beata Messyasz, Bogusława Łęska,*** *Radosław Pankiewicz, Łukasz Tabisz*
JSC Baltic Environment: ***Loreta Drazdienė,*** *Jokūbas Drazdas,* ***Alvydas Zagorskis,*** *Balys Rutkauskas, Kristina Vitkutė, Leonardas Chotkevičius, Danguolė Tamkevičienė, Karolis Inčiura, Mantas Vyšniauskas*
Institute of Nature Conservation PAS: ***Elżbieta Wilk-Woźniak,*** *Wojciech Krztoń, Edward Walusiak, Martyna Budziak, Małgorzata Łaciak*
Nature Heritage Fund: ***Zenonas Gulbinas, Vaidotas Valskys,*** *Raminta Mikalauskienė, Argaudas Stoškus*
JSC SPILA: *Vytas Rimkus,* ***Daiva Semėnienė,*** *Andra Rimkuvienė*

COORDINATING BENEFICIARY

Nature Research Centre

ASSOCIATED BENEFICIARIES

Adam Mickiewicz University Poznań

Institute of Nature Conservation PAS

NPF

Spila Baltic Environment

CO-FINANCED BY

Ministry of Environment Republic of Lithuania

Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej

Algae Service for Life

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Algae and the European Green Deal

- Preserving and restoring ecosystems and biodiversity
- A zero pollution ambition for a toxic free environment
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Raising awareness
Interactive map of algal blooms

Algae Service for Life
LIFE17 ENV/LT/000407

Algae and the European Green Deal

Preserving and restoring ecosystems and biodiversity | A zero pollution ambition for a toxic free environment | **Leave no one behind** | Farm to Fork Strategy | Providing clean, affordable and secure energy | Mobilising industry for clean and circular economy

Raising awareness

- **Popular papers >20** — >8000
- **Interview to media >20** — >9000
- **Communication events with:**
  - Society >25
  - Key stakeholders >15
  - Scientific community >10 — >5000
- **Training seminars and demonstration events – 5** — >400
- **Scientific conferences >25** — >3000
- **Research articles – 4** — >1000
- **Project proposals – 8** — N.A.
- **Networking – 14** — N.A.

>26 000

Target groups reached

Practitioners and businessmen
Nature conservationists
NGOs
General public
Scientists
Tourism sector
Governmental institutions
Municipalities
Administrations of Pas

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Interactive map of algal blooms

Partners involved:

Pažymėk žydintį vandens telkinį / Oznacz zbiorniki wodne z zak…

Žemėlapis skirtas vandens telkinių žydėjimo vietų žymėjimui. Informacija bus skirta duomenų analizei pagal vandens telkinių žydėjimo vietų pasiskirstymą.

Mapa została zaprojektowana w celu oznaczenia lokalizacji zbiorników wodnych, w których stwierdzono zakwit wody. Informacje zostaną wykorzystane do analizy danych zgodnie z rozkładem lokalizacji zbiorników z zakwitami.

ArcGIS application - Mark a blooming water body. The map is designed to mark locations of blooming water bodies. The information will be used for data analysis according to the distribution of locations of blooming water bodies.

Data / Data*

Data fiksuojama automatiškai. Prašome patikrinti datą.
Data jest ustalana automatycznie. Prosimy sprawdzić czy data jest właściwa.

07/11/23

Laikas / Czas*

Laikas fiksuojama automatiškai. Prašome patikrinti laiką.
Czas jest ustalany automatycznie. Prosimy sprawdzić czy czas jest właściwy.

11:30

Žydėjimo vieta / Lokalizacja zakwitu*

Žydėjimo vieta fiksuojama automatiškai, tačiau galite koreguoti žymeklio vietą.
Lokalizacja zbiornika w którym stwierdzono zakwit jest ustalana automatycznie, ale można dostosować położenie za pomocą kursora.

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Algae and the European Green Deal

Preserving and restoring ecosystems and biodiversity

A zero pollution ambition for a toxic free environment

Leave no one behind

Farm to Fork Strategy

Providing clean, affordable and secure energy

Mobilising industry for clean and circular economy

Interactive map of algal blooms

Partners involved:

IPF

Nature Research Centre

UAM Adam Mickiewicz University Poznań

Institute of Nature Conservation PAS

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Algae and the European Green Deal

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Questionnaire ,,Water blooms“

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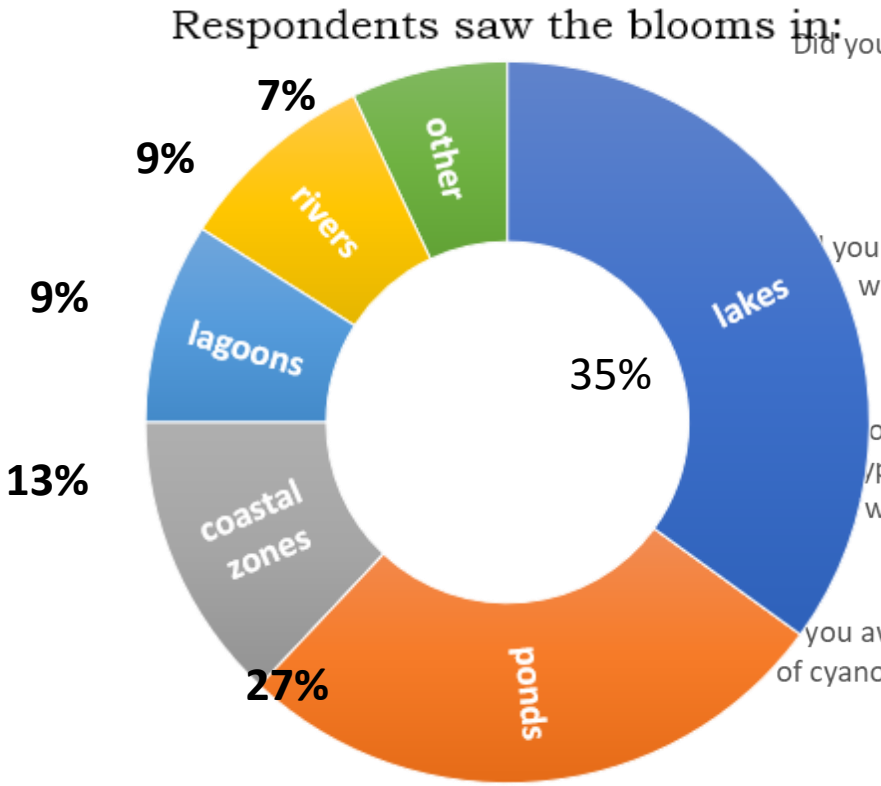
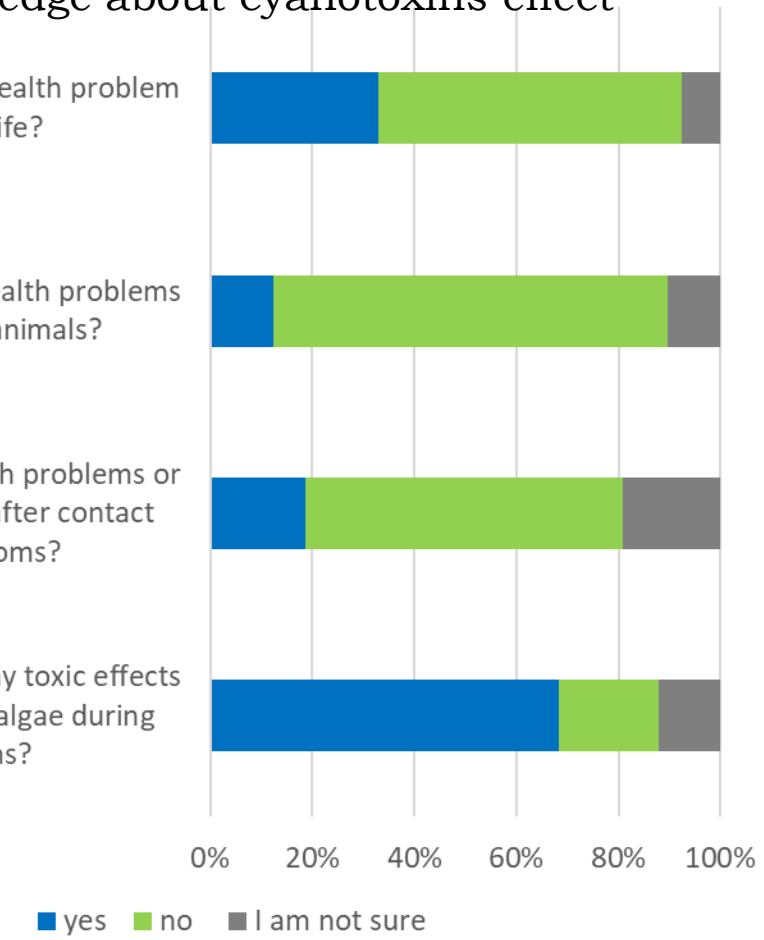
Questionnaire ,,Water blooms“

Partners involved:

Respondents saw the blooms in:



Knowledge about cyanotoxins effect



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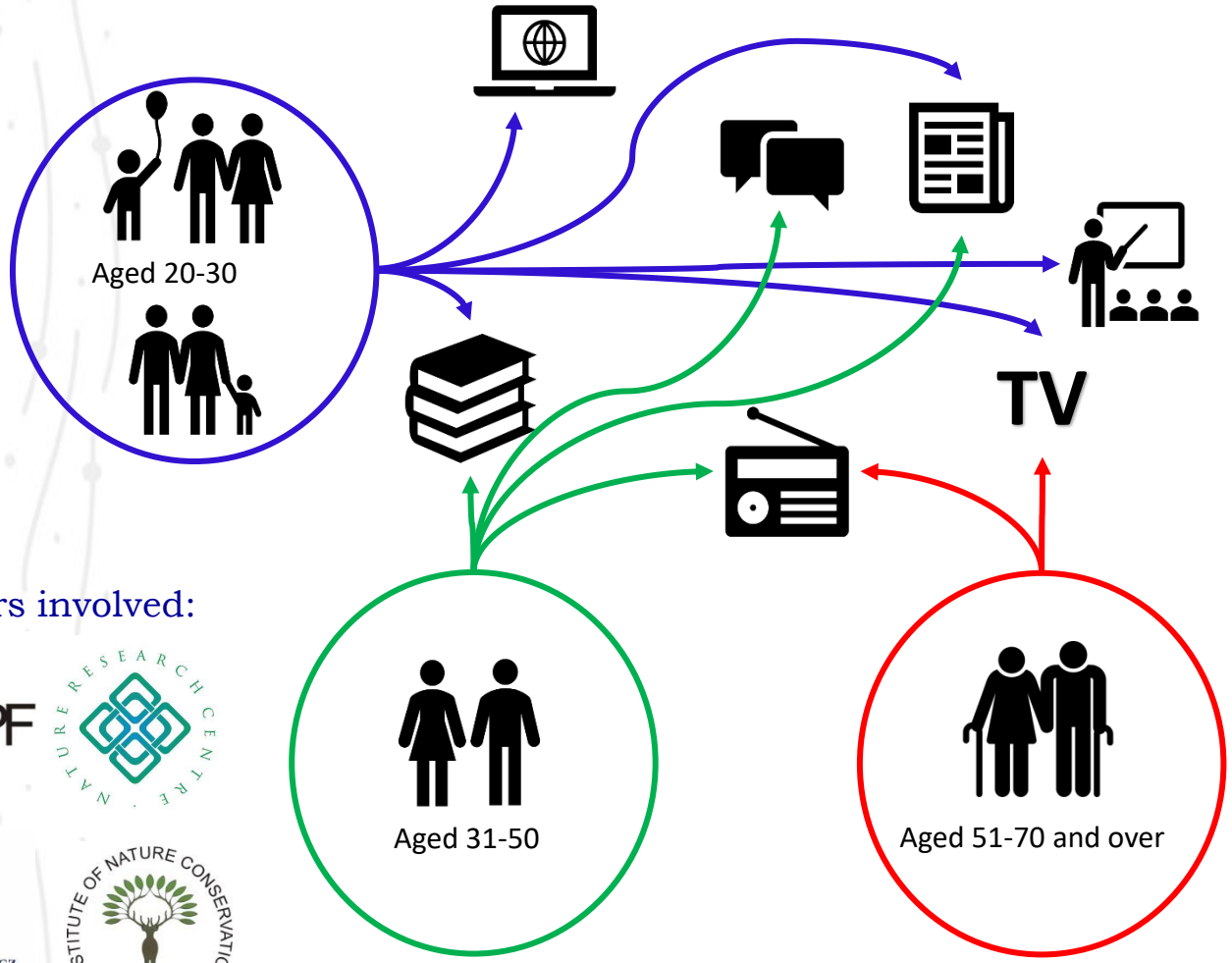
Questionnaire ,,Water blooms“



Partners involved:

Age and preferences of information Sources (VosViewer):

- People aged 20-30 preferred as sources of information – social networks, meetings and scientific publications, newspapers, TV
- People aged 31-50 preferred – scientific publications, meetings, websites, traditional media (radio, TV)
- People ages 51-70 and over preferred traditional media (radio, TV) and especially TV

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Willingness to pay for increased water quality

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Willingness to pay

Partner involved:

Spila

Why?

- ✓ Socio-economic impact assessment of the AlgaeService for Life Project
- ✓ Monetisation of nature (ecosystem services) allows assessing impact the improvement of water quality makes to society
- ✓ Knowing pros and cons of the biomass harvesting makes decisions on its usage easier
- ✓ Allows comparing all benefits (i.e., social impacts, human health and environment) and costs of the water quality improvement

Where, when, how and who?

- ✓ Kaunas Reservoir
- ✓ Contingent valuation method - *capable of estimating economic values that include use and non-use components and reveal respondents' true preferences and values*
- ✓ Questionnaire tested by focus group
- ✓ Online representative survey, November – December 2022
- ✓ 1000 respondents from Lithuania

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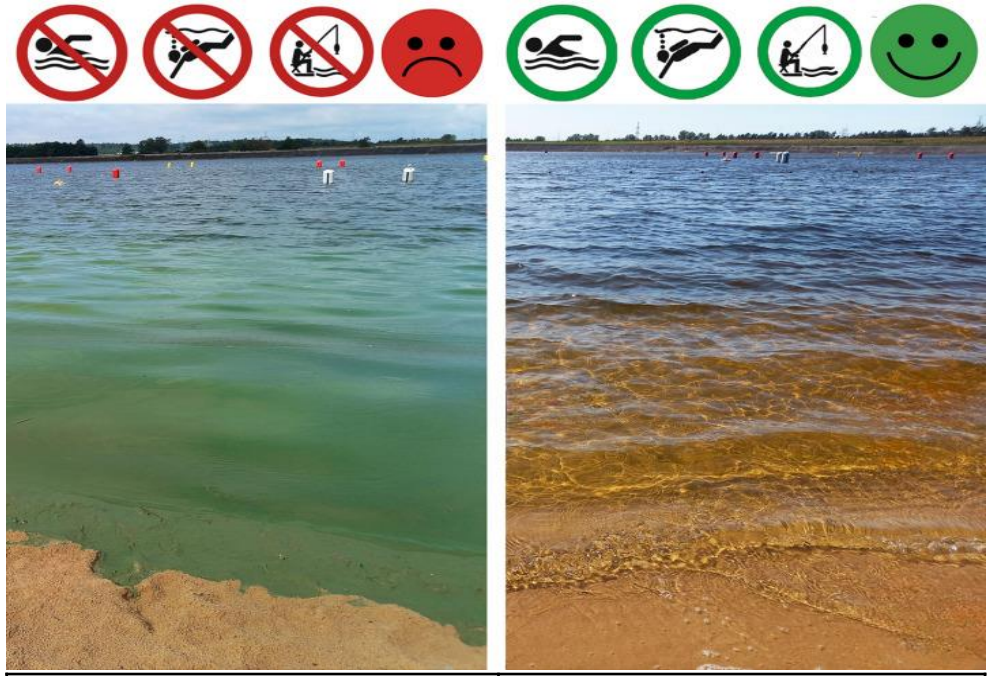

Current status	Good status
The water is turbid, there are blue-green sediments, and there is a water bloom	The water is clear, there is no water bloom
High concentration of toxic substances in the biomass of cyanobacteria. Bathing in water or eating fish can pose a threat to people and pets. A person may suffer from indigestion, general weakness, dizziness, difficulty to breath, tingling in the limbs. Pets can get sick or die.	There are no toxic substances. It is safe for humans and pets.
Low diversity of species and habitats (predominantly small fish – roach, cried, white bream, crucian carp and similar)	High diversity of species and habitats (high diversity of predatory valuable fish – pike, common perch, sander and similar)

Willingness to pay for increased water quality

The questionnaire consisted of the following sections:

1) Perception of the area and environmental issues, connection to the Kaunas Reservoir
2) Experience / the use of the Kaunas Reservoir
3) Current status of the Kaunas Reservoir
4) Preferred status of the Kaunas Reservoir
5) Willingness to Pay for improved water quality (how much, why/why not, certainty)
6) Socio-economic profile of a respondent
7) Other debriefing questions, feedback from respondents (e.g., difficulties in answering), environmental friendliness)

Partner involved:

Spila

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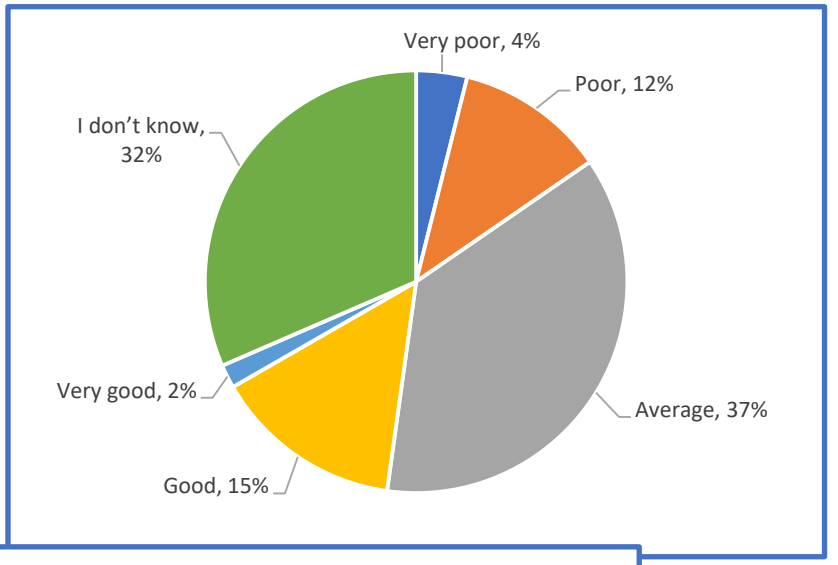
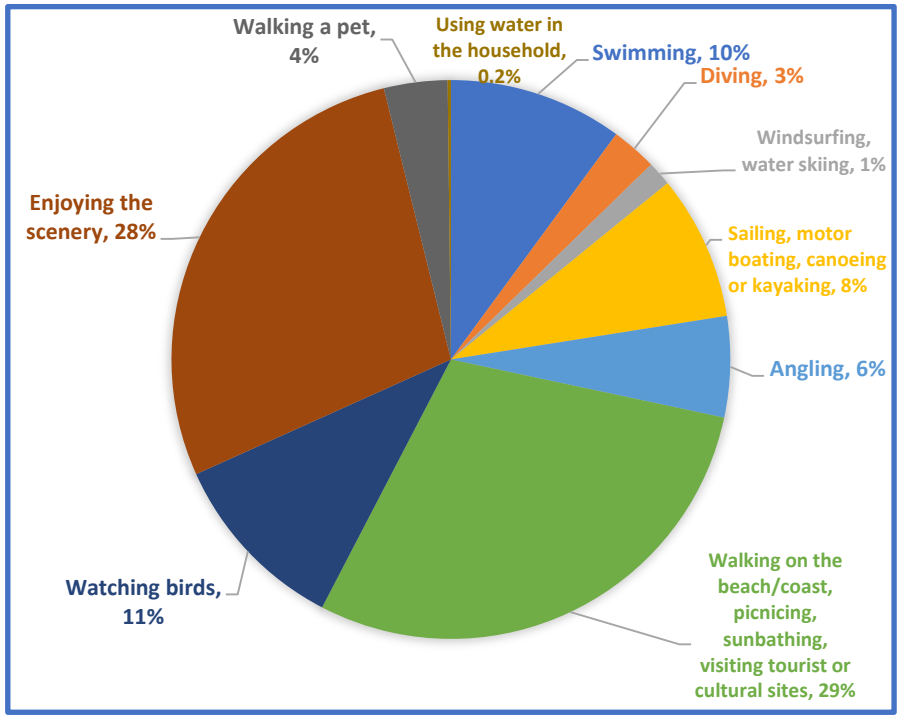
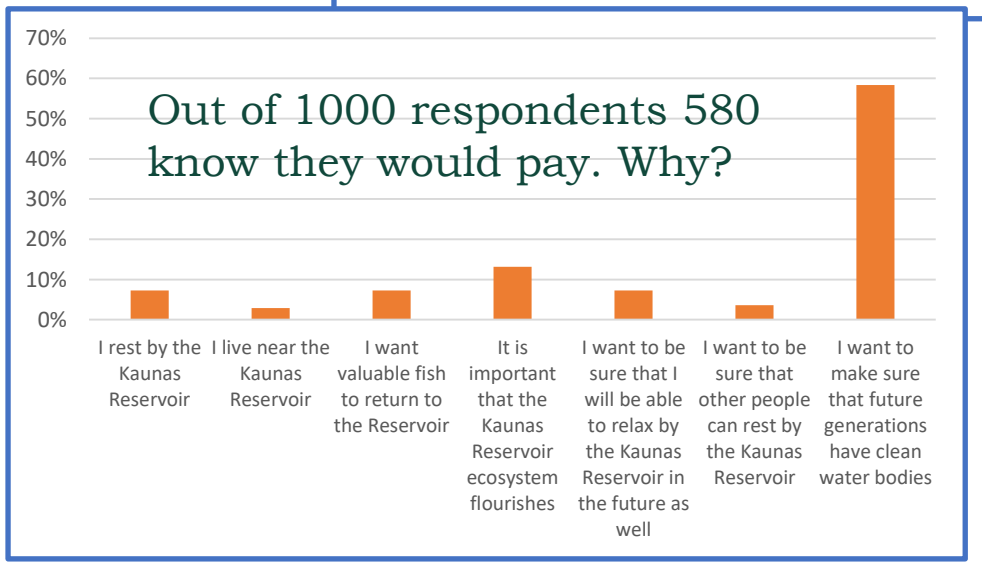
Willingness to pay

Respondents' assessment of water quality of the Kaunas Reservoir



Most common activities when visiting the Kaunas Reservoir





Partner involved:

Spila

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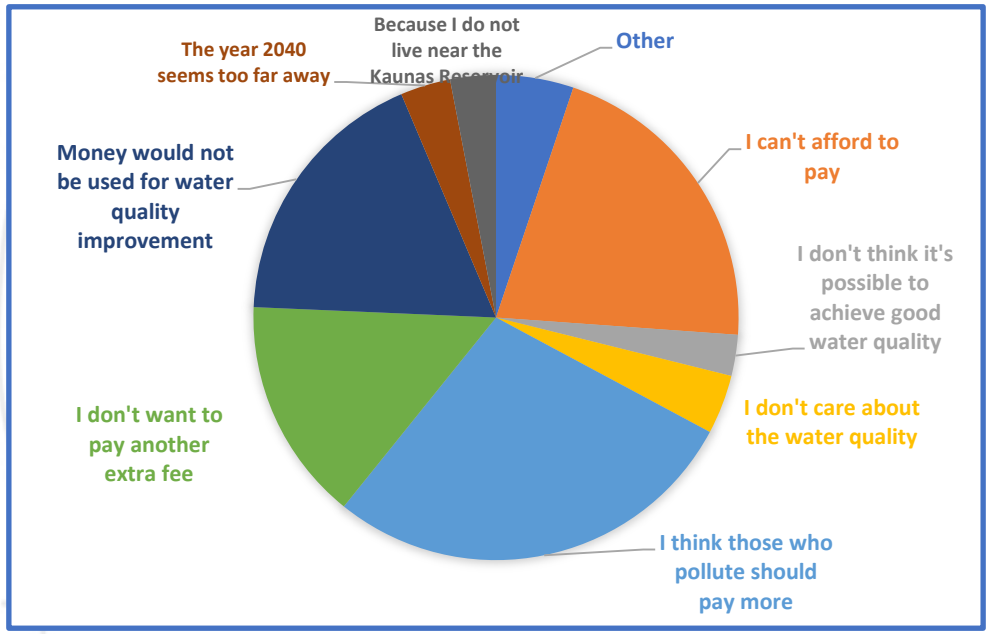
Willingness to pay

Partner involved:

Spila

Reasons not to pay (for 329 out of 1000)



Results – willingness to pay for the increase of water quality in the Kaunas Reservoir

Statistical analysis of the data shows that

- non-parametric lower-bound is **7.59 Eur/person/year** (standard error of 1.44, resulting in a 95% confidence interval of 4.76 to 10.42)
- the best parametric estimate is **9.16 Eur/person/year** (standard error of 0.92, resulting in a 95% confidence interval of 7.35 to 10.97)
- this aggregates to **18.5 - 22.3 million Eur / year** in Lithuania

The consistency of willingness to pay results across the best-fitting distributions suggests robustness in the findings regardless of the model specification

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Macroalgae biomass as a slow-release fertilizer:
experimental scale

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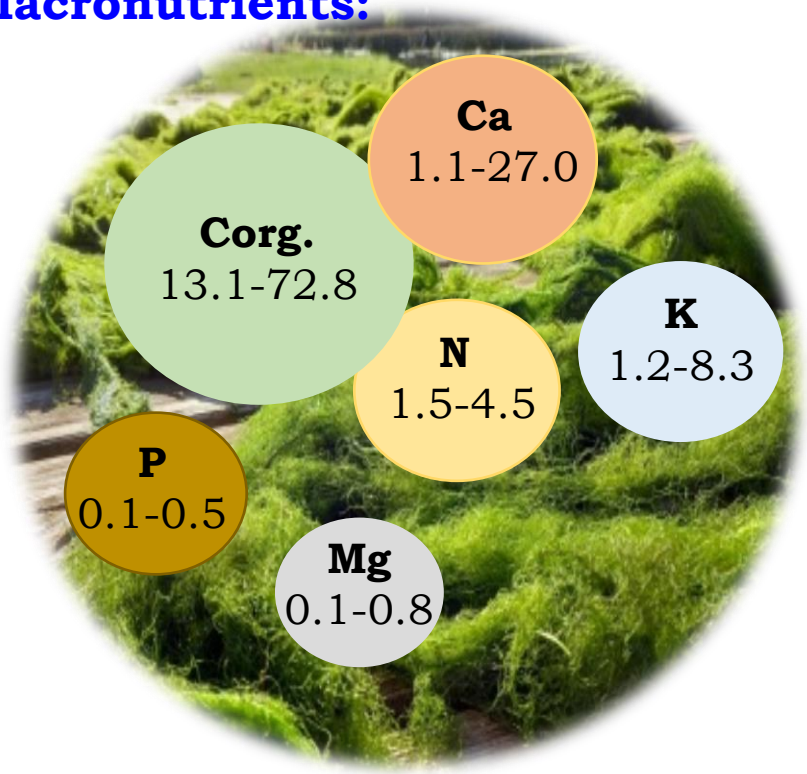
Partner involved:

Slow-release fertilizer:
experimental scale

Chemical composition of *Cladophora glomerata* (% in dry biomass)

Macronutrients:



Micronutrients (mg/kg):
Fe 867-8786, B 34-195, Mn 803-23896, Zn 4-61, Cu 4-10, Ni 1-28

Heavy metals:
amount below safe limits

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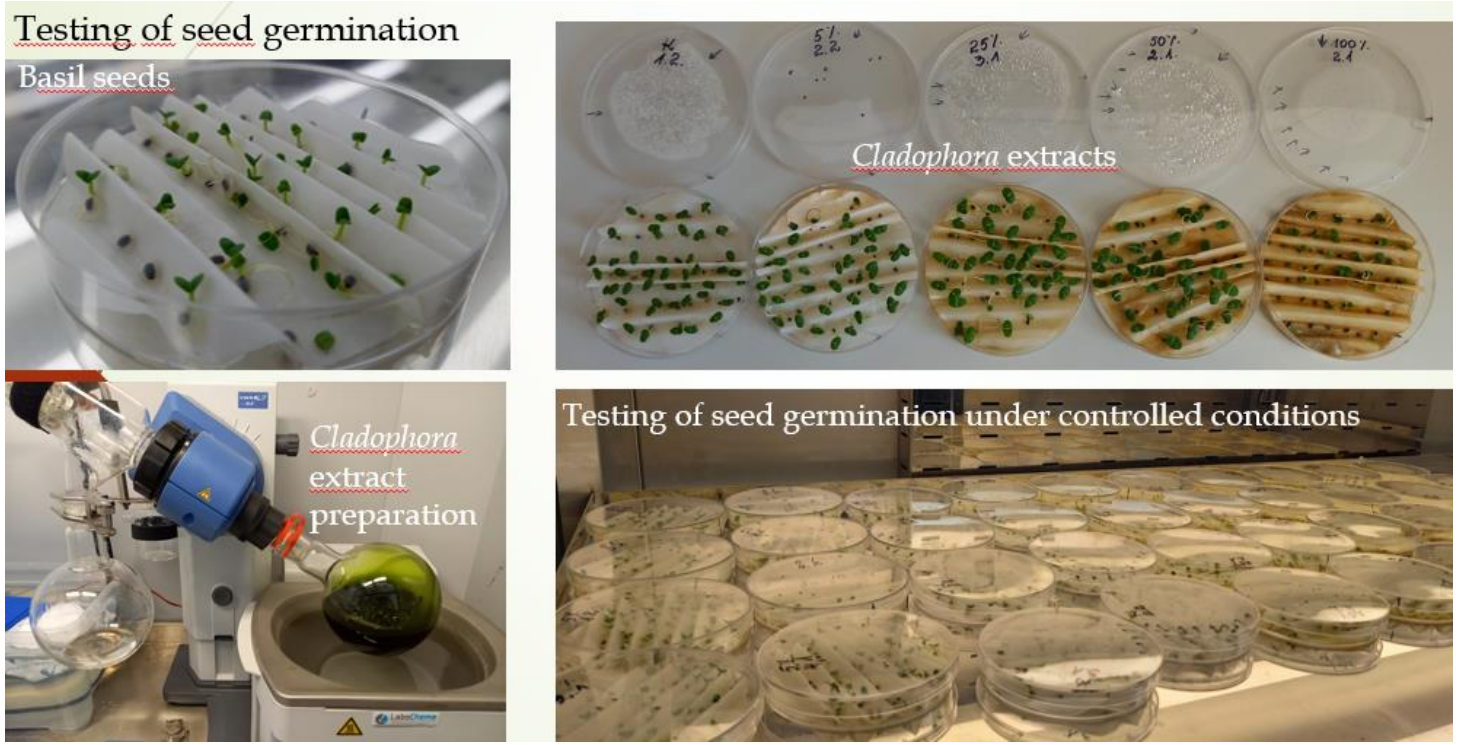
Partner involved:

Laboratory testing

Slow-release fertilizer: experimental scale



Aqueous macroalgae extracts (5 % and 25 % concentration) had a **positive effect** on the germination of tomato, basil, spring wheat and cucumber seeds, whereas they had **no effect** or a negative effect on pea seeds.

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Slow-release fertilizer: experimental scale

Partner involved:

Corn 2020

Barley 2021

Oats 2022

Experimental fields 0.25 m^2

A positive effect on yield was observed in all treatments with macroalgae biomass:

- the green mass of the corn increased by **14-31%**;
- the grain yield of barley increased up to **60%** and the straw yield up to **90%**
- the grain yield of oats increased by **20%** and the straw yield by **82%**.

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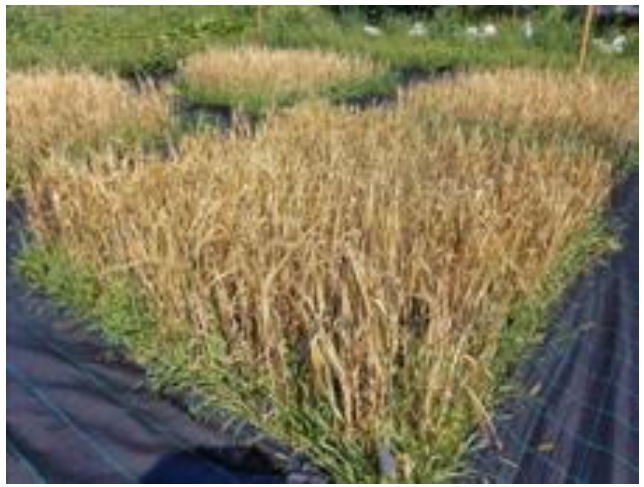
Partner involved:

Slow-release fertilizer: experimental scale



Barley 2021

Oats 2022

Potatoes 2023

Experimental fields 4 m^2

- Differently prepared macroalgal biomass applied as fertilizer to infertile soils increased the yield of cereals and storage crops by **47-104 %**.
- The application of biomass as fertilizer in spring was **50 %** more effective.

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Slow-release fertilizer: experimental scale

Partner involved:

Improvement of soil quality

- Algal biomass has the same fertilizing effect as conventional organic fertilizers and increases the proportion of organic carbon in the soil.
- The nitrogen from the algal biomass was used efficiently to increase plant production.
- The amount of soluble phosphorus and potassium increased and accumulated in the soil up to **30%** and **90%** respectively.
- After harvest humic content of the soil increased by up to **10%.**

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Slow-release fertilizer: experimental scale

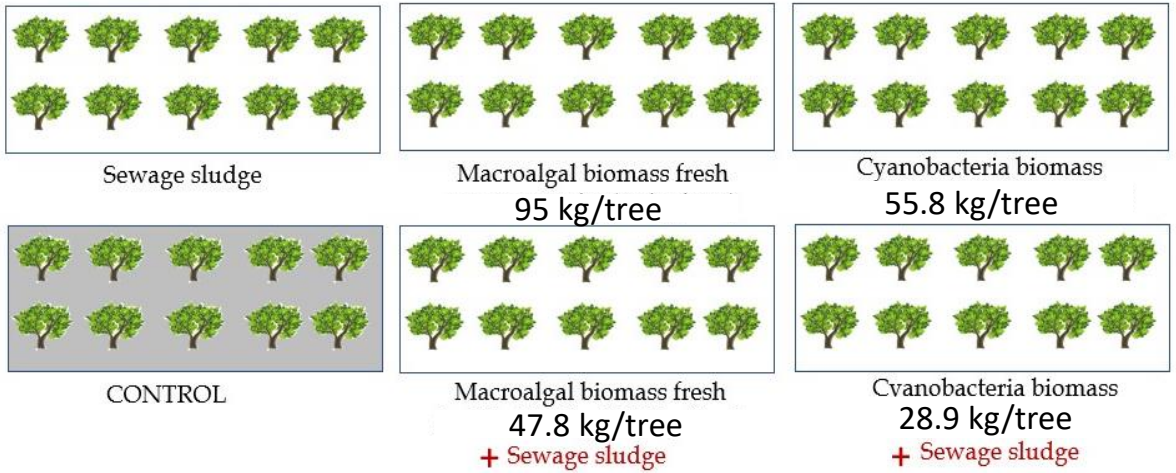
AFTER-LIFE PLAN

Partner involved:

Networking with:

NutriBiomass 4LiFE

Populus plantations



Salix plantations

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Algae and the European Green Deal

- Preserving and restoring ecosystems and biodiversity
- A zero pollution ambition for a toxic free environment
- Leave no one behind
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Macroalgae biomass as a slow-release fertilizer: field scale

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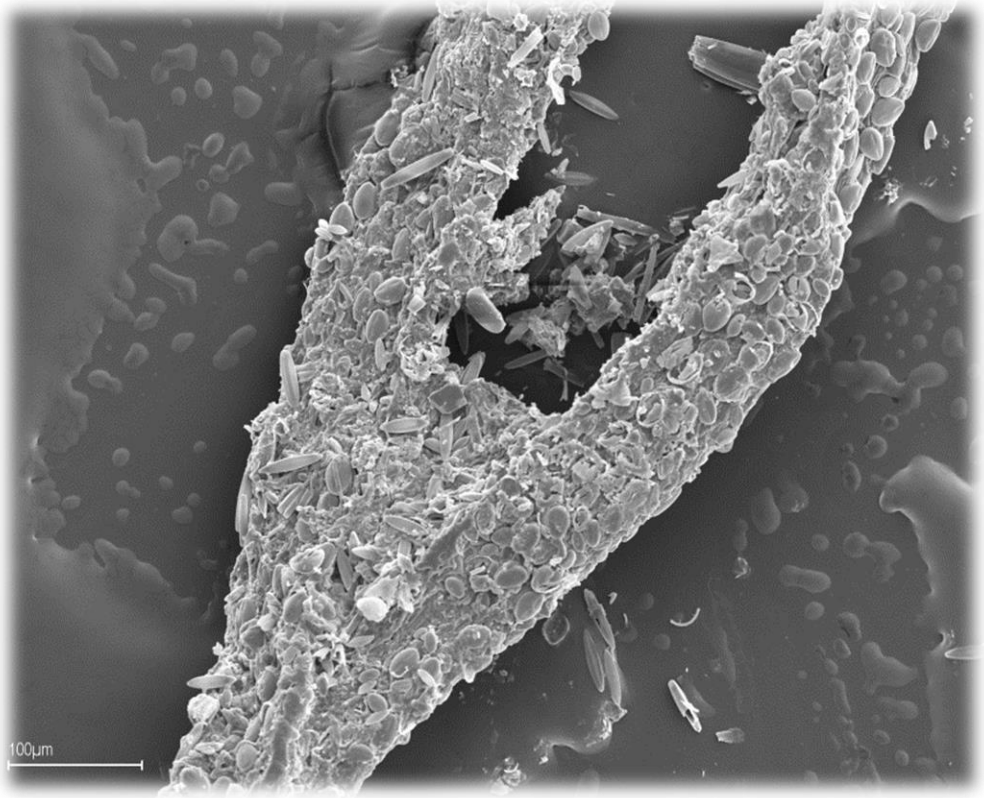
Slow-release fertilizer: field scale

Partner involved:

Adam Mickiewicz University Poznań

Chemical components	MANURE* [%]	ALGAE [%]
water	ca. 77	ca. 80
Organic substances	20-27	20-30
Nitrogen	0,4-0,7	0,3-0,7
Phosphate	0,2-0,9	0,3-0,8
Magnezium	0,1-0,3	0,2
Potassium	0,5-0,7	0,2-0,6
Sodium	0,1	0,1
Calcium	0,4-0,8	0,5-1,0
Silicon	0	0,3-1,0
pH	7,5	7,9

*Maćkowiak i Żebrowski 2000



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Slow-release fertilizer: field scale

Partner involved:

UAM Adam Mickiewicz University Poznań



K – control
OB – animal manure
OB+G – animal manure&algal biomass
MI – mineral fertilizer;
MI+G – mineral fertilizer& algal biomass
G – algal biomass

	K	OB	OB+G	MI	MI+G	G
Crop [t]	0.8	4.5	4.7	3.5	3.9	4.6
Starch	15.8	18.9	19.8	16.4	16.9	18.8

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Slow-release fertilizer: field scale

Partner involved:

Adam Mickiewicz University Poznań

10% ADDITION

Algae biomass added in 10% w/w ratio to (fertilizer) was the most successful composite biofertilizer among those tested

20% YIELD INCREASE

Potato crop yields have increased significantly, along with their starch content, when grown in soil fortified with algae

P.438 915

Index numer of patent application granted, describing the use of algae-based biofertilizer for enhancing potato crops

The Patent Office in Poland: patent No P.438915 “Bio-fertilizer for increasing the starch content in potato tubers” [„Bionawóz do zwiększania zawartości skrobi w bulwach ziemniaków”]”, aplication date 09/2021.

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Slow-release fertilizer: field scale

Partner involved:

Adam Mickiewicz University Poznań

K – control
OB – animal manure
OB+G – animal manure&algal biomass
MI – mineral fertilizer;
MI+G – mineral fertilizer& algal biomass
G – algal biomass

	K	OB	OB+G	MI	MI+G	G
Crop [t]	0.9	1.2	1.5	1.0	1.4	1.5
Germination [%]	86	98	99	93	98	96

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Slow-release fertilizer: field scale

Partner involved:

Adam Mickiewicz University Poznań

Key benefits of macroalgae as bio-fertelizer

(1) Ultra-fast nutritional effect - quick and easy absorption of macronutrients

(2) Very high concentration of nutrients - up to 55% more nutrients compared to standard chelates

(3) High performance

(4) Biodegradability

(5) Excellent solubility and miscibility with agrochemicals

(A) Wet biomass - increase in moisture content of dried manure; immediate availability of all bioactive substances; longer storage = homogeneity of the material (humidity, penetration of layers)

(B) Dry biomass – extracts (easy to store, can be used in doses during spraying)

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Innovative feed products from algal biomass

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Algae and the European Green Deal

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Innovative feed products

Partner involved:

PHYCOCIANIN

A blue-colored pigment-protein complex responsible for the light-harvesting in cyanobacteria.

- **Application according to purity**
  - Food grade:
    - in food as a colorant or a dietary supplement
    - in cosmetics as a colorant
  - Reagent grade:
    - in diagnostic as biomarker
  - Analytic grade:
    - pharmaceutical industries as a potential drug for cancer, inflammatory treatment, platelet aggregation inhibitor

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Innovative feed products

PHYCOCIANIN

Partner involved:

Non-toxic wild cyanobacteria biomass was applied for phycocyanin purification.

- The method for extraction and purification of phycocyanin from wild cyanobacteria biomass was optimised.
- Phycocyanin purity varied from food grade used for food and cosmetic to analytic grade.

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Algae and the European Green Deal

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Innovative feed products

TRANSFER of the LIFE project results

Partner involved:

Networking with:

LITHUANIAN UNIVERSITY OF HEALTH SCIENCES
Medical Academy
Prof. Nijolė Savickienė
Daiva Dranskienė

eureka

Project
E! 13474 **ECO-AQUA-RECYCLE** 2021-2023
(Results under patenting)

Algae Service for Life

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Algae and the European Green Deal

Preserving and restoring ecosystems and biodiversity

A zero pollution ambition for a toxic free environment

Leave no one behind

Farm to Fork Strategy

Providing clean, affordable and secure energy

Mobilising industry for clean and circular economy

Innovative feed products

TRANSFER of the LIFE project results

water MDPI

Article

Evaluation of Phenolic Compounds and Pigments in Freshwater *Cladophora glomerata* Biomass from Various Lithuanian Rivers as a Potential Future Raw Material for Biotechnology

Monika Nutautaitė [1,*], Asta Racevičiūtė-Stupelienė [1], Saulius Bliznikas [2], Ilona Jonuškienė [3], Jūratė Karosienė [4], Judita Koreivienė [4] and Vilma Vilienė [1]

agriculture MDPI

Article

Freshwater *Cladophora glomerata* Biomass as Promising Protein and Other Essential Nutrients Source for High Quality and More Sustainable Feed Production

Monika Nutautaitė [1,*], Vilma Vilienė [1], Asta Racevičiūtė-Stupelienė [1], Saulius Bliznikas [2], Jūratė Karosienė [3] and Judita Koreivienė [3]

animals MDPI

Article

Sensory Evaluation of Rabbit Meat from Individuals Fed Functional and More Sustainable Diets Enriched with Freshwater *Cladophora glomerata* Macroalgal Biomass

Monika Nutautaitė [1,*], Asta Racevičiūtė-Stupelienė [1], Alius Pockevičius [2] and Vilma Vilienė [1]

foods MDPI

Article

Enhancement of Rabbit Meat Functionality by Replacing Traditional Feed Raw Materials with Alternative and More Sustainable Freshwater *Cladophora glomerata* Macroalgal Biomass in Their Diets

Monika Nutautaitė [1,*], Asta Racevičiūtė-Stupelienė [1], Saulius Bliznikas [2] and Vilma Vilienė [1]

Partner involved:

Nature Research Centre

Non-project collaboration:

Lithuanian University of Health Sciences

Veterinary Academy

Vilma Vilienė
Monika Nutautaitė
Asta Racevičiūtė-Stupelienė

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Algae and the European Green Deal

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Innovative feed products

TRANSFER of the LIFE project results

Traditional feed raw materials in rabbit feed supplemented with *Cladophora glomerata* biomass:

- increased protein and total amino acid level in muscles
- increased in the length of muscle fibers
- reduced the fat content of muscles
- reduce lipid oxidation levels
- reduce the risk of heart disease

Partner involved:

Nature Research Centre

Non-project collaboration:

Lithuanian University of Health Sciences
Veterinary Academy

The replacement of conventional feed materials in rabbit diet with *Cladophora glomerata* biomass can lead to more sustainable production and improve nutritional value of rabbit meat.

Vilma Vilienė
Monika Nutautaitė
Asta Racevičiūtė-Stupelienė

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Algae and the European Green Deal

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Production of biogas from algal biomass

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Algae and the European Green Deal

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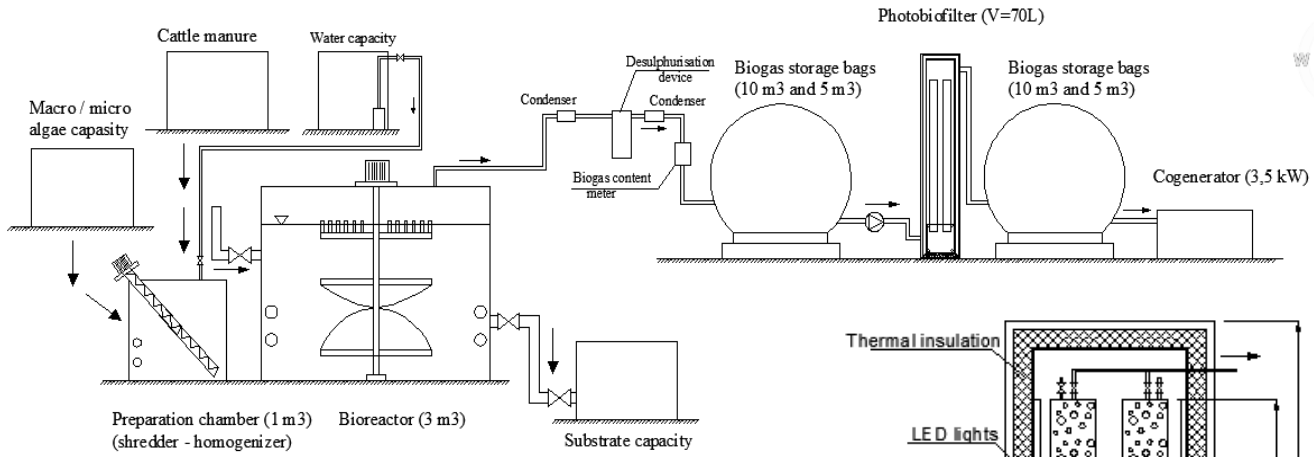
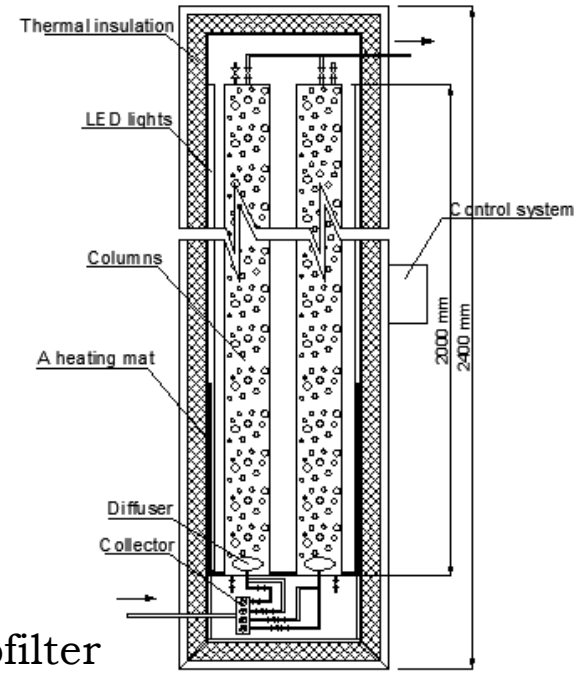
Production of biogas from algal biomass

Partner involved:

Baltic Environment

System of the biogas production and upgrading





Photobiofilter

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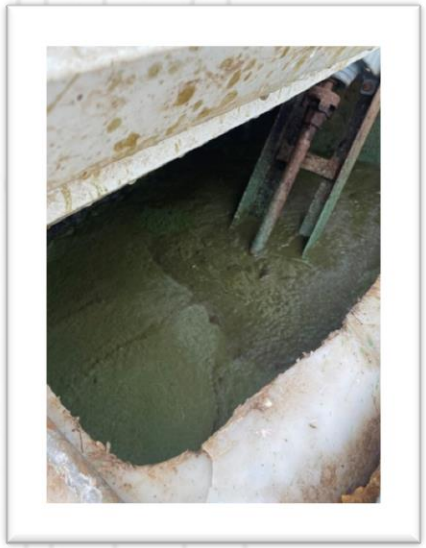
Production of biogas from algal biomass

Partner involved:

Baltic Environment



Year	Period in months	Mixing ratio of wet algae to manure (with wheat straw)	The amount of algae loaded during the period, tons
2020	August – September	50/50	2.50 (macro)
2021	August – November	40/50; 50/50; 55/45	14.14 (macro)
2022	July – December	40/50; 50/50; 60/40	4.50 (macro) 7.50 (micro)
2023	June – November	50/50	14.50 (macro) 1.50 (micro)
		Total:	35.64 (macro) 9.00 (micro)

During the project, the bioreactor operated for 18 months. During this period, 35.64 t wet mass of macroalgae and 9.00 tons of microalgae were digested.

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Production of biogas from algal biomass

Year	Biogas production, m^3	Electric energy, kWh	Heat energy, kWh	Total energy, kWh
2020	45.00	90	153	243
2021	208.8	418	710	1128
2022	303.3	736	1255	1991
2023	275.6	578	985	1563
	832.7	**1822**	**3103**	**4925**

Biogas composition

Partner involved:

Baltic Environment

During the test, 832.7 m3 of biogas was produced from algae. Burning this biogas in the co-generator can produce 4925 kWh of energy (1822 kWh of electricity and 3103 kWh of heat energy).

Biogas yield	0.58-0.80 $m^3/d/m^3$
CH_4	65-85 %
CO_2	8-30 %
O_2	0.1-2.0 %
H_2S	7-70 ppm
H_2	0.01-0.04 %

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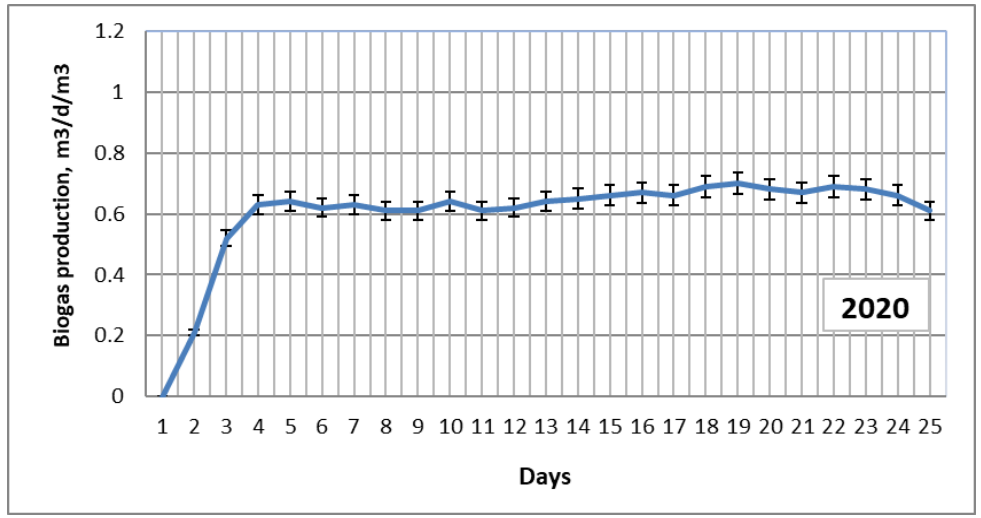
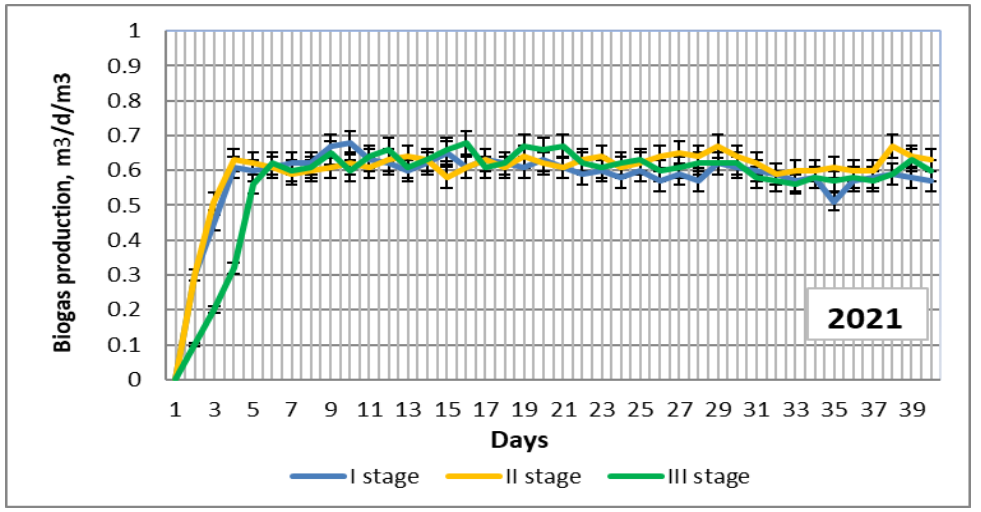
Production of biogas from algal biomass

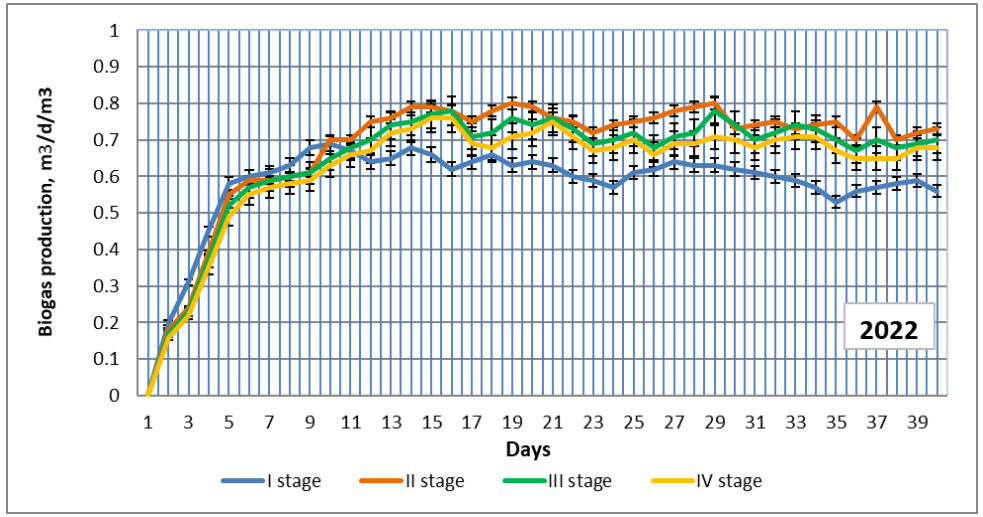
Partner involved:

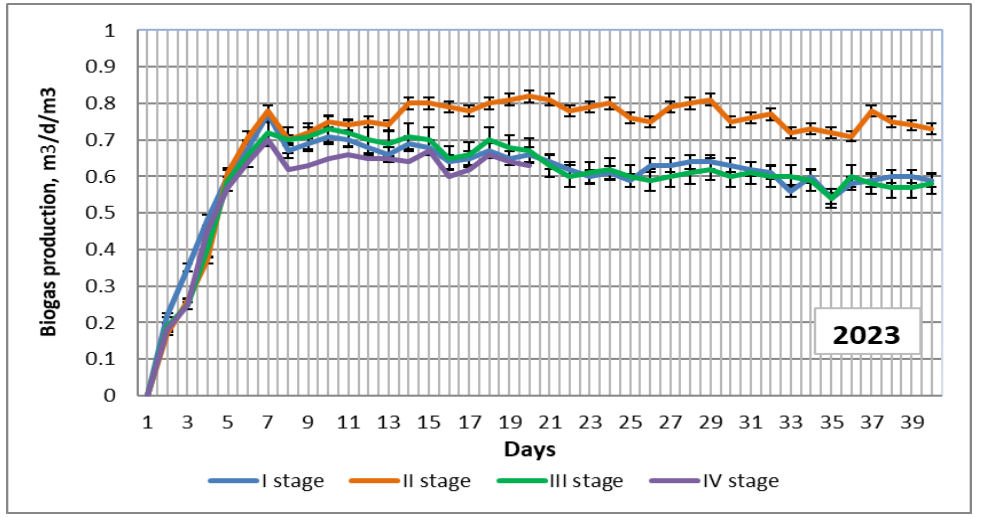
Baltic Environment

Biogas yield during different stages









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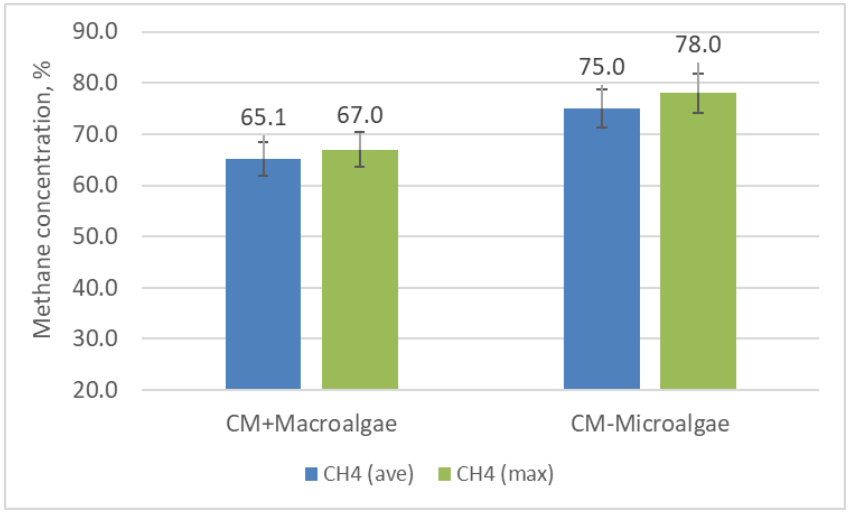
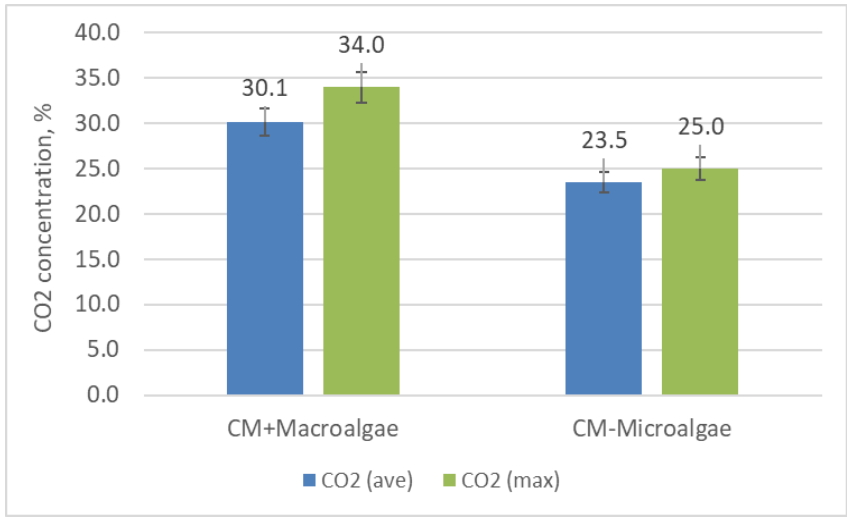
Production of biogas from algal biomass

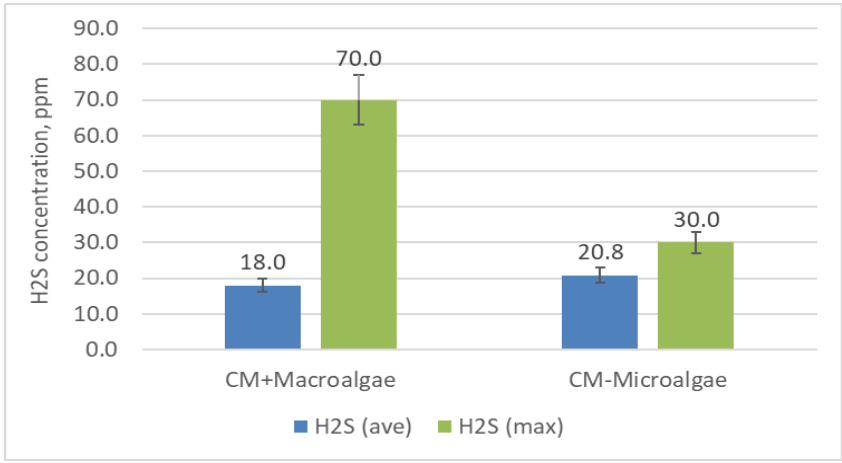
Partner involved:

Baltic Environment

Composition of biogas after the bioreactor







After the process was established, the average concentration of methane in biogas was 65–75%, CO_2 – 23–30%, H_2S – 18-21 ppm. Oxygen concentration was 0.1–2.0%, hydrogen – 0.01–0.04%.

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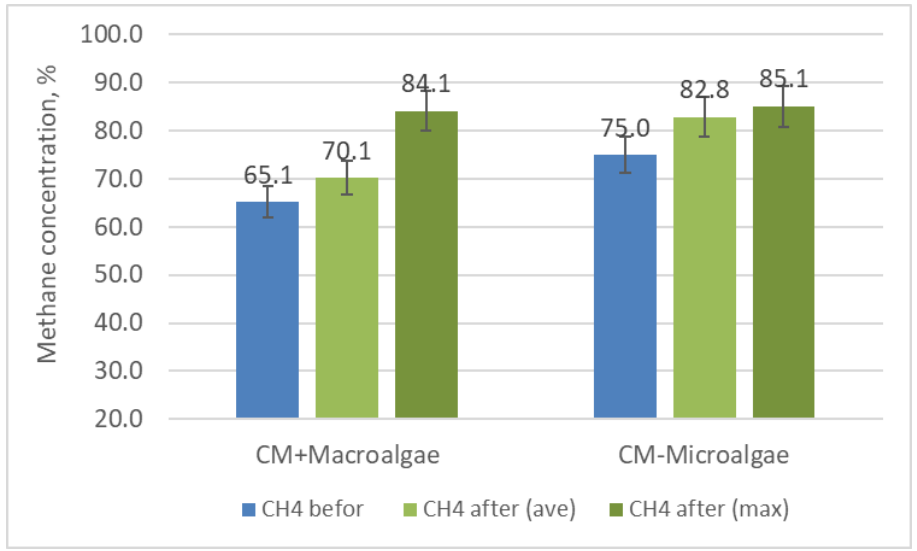
Production of biogas from algal biomass

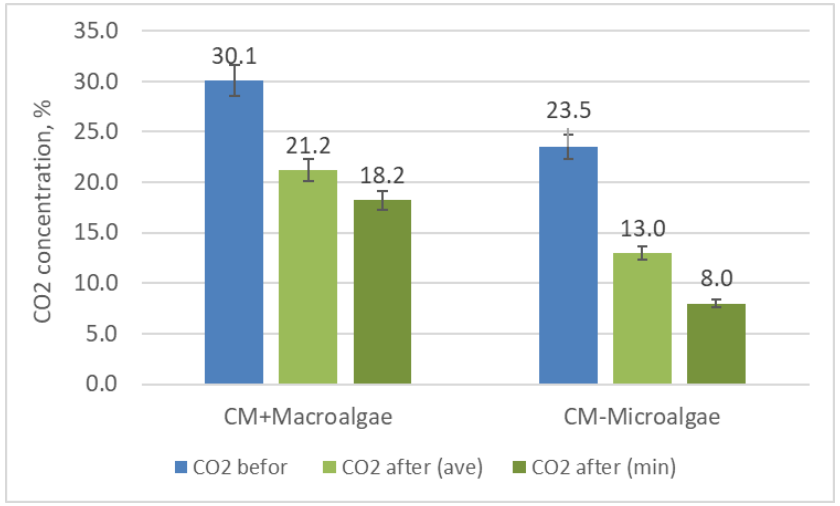
Partner involved:

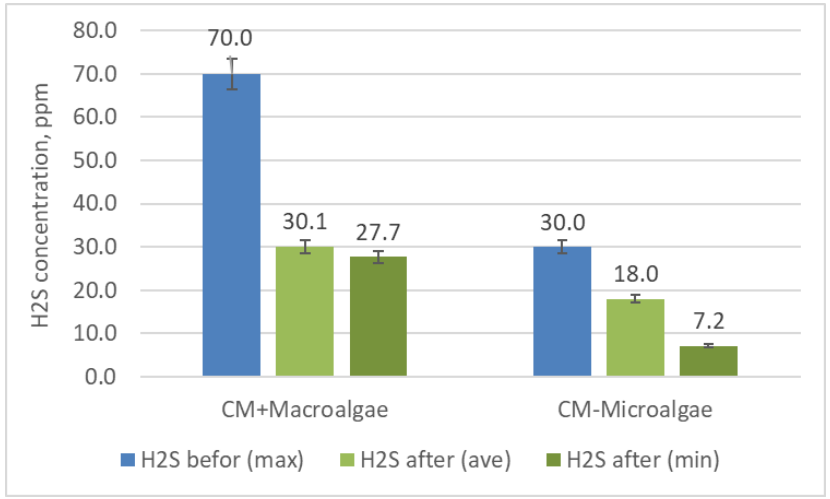
Baltic Environment

Biogas upgrading using a photobiofilter



The installed photobiofilter for biogas upgrading resulted in an increase of methane concentration by 5–8% and reduction of CO_2 by 8–15% and H_2S by 12–40%.





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Production of biogas from algal biomass

Partner involved:

Baltic Environment

Conclusions

For biogas yield testing, macroalgae were collected using harvester prototypes AS-S and AS-L. Biogas was produced by using 35.6 t of macroalgae and 9.0 t of cyanobacteria as wet biomass.

During the project, 832.7 m^3 of biogas was produced. 553 m^3 of biogas was produced using macroalgae and 279.7 m^3 was produced using microalgae.

The average biogas yield from algae reached 0.58–0.80 $m^3/d/m^3$.When the process stabilized, the average concentration of methane in biogas was 65-75%, CO2 - 23-30%, H2S - 18-21 ppm. Oxygen concentration was 0.1-2.0%, hydrogen - 0.01-0.04%.

The installed photobiofilter for biogas upgrading resulted in an increase of methane concentration by 5–8% and reduction of CO2 by 8–15% and H2S by 12–40%.

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Production of biogas from algal biomass

Partner involved:

Baltic Environment

Conclusions

Burning this biogas in the co-generator can produce 4925 kWh of energy: 1822 kWh of electricity and 3103 kWh of heat energy. Up to 5.9 kWh of energy can be produced from 1 m^3 of biogas.

Mixing algae with cattle manure (with straw) can increase the yield of biogas and methane up to 2 times compared to cattle manure. The amount of energy produced increases accordingly.

Cyanobacteria and macroalage can be used as promising biomass source for biogas production with high methane concentration and can be applicable in small-scale bioreactors owned by farmers.

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Algal extracts for cosmetics

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Algal extracts for cosmetics

Partner involved:

Adam Mickiewicz University Poznań

We need to think not only about the environment in which we live, but also about the products we use. Replacing chemical compounds with those derived from natural resources is a „green way“ that is currently receiving more and more attention☺

Since natural products degrade faster compared to chemical products, they also contribute to toxic-free environment and provide human-friendly products.

Algae extracts for cosmetics are an example of such products …

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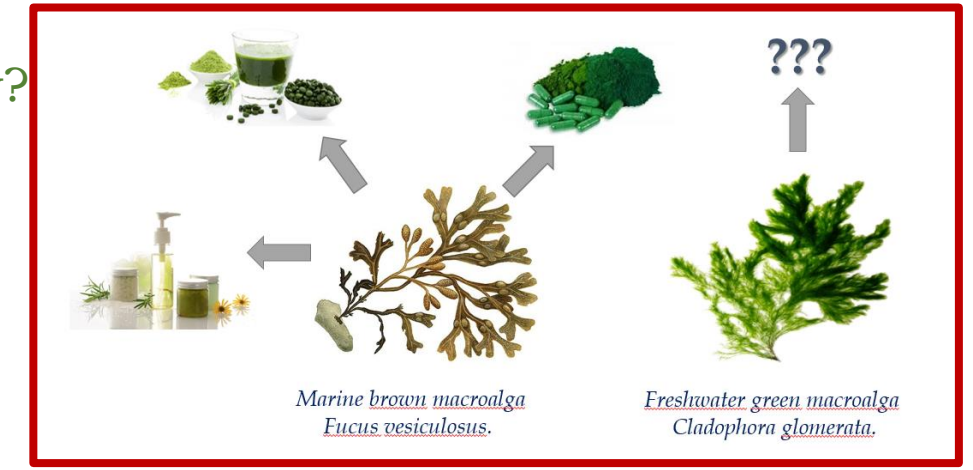
Algal extracts for cosmetics

What type of algae are usually used in the cosmetics industry?

Marine algal biomass (MAB) and their extracts - the rich source of bioactive chemicals:
- their chemical composition allows it to be used in the cosmetics industry;
- the use of them is an important aspect from the point of view of economics and life cycle assessment.

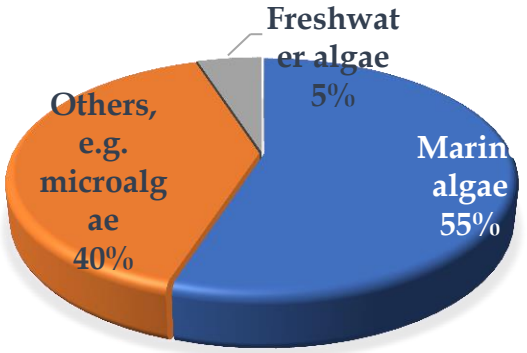


The freshwater macroscopic green algae species (*Chara fragilis, Cladophora glomerata, Ulva flexuosa*) can also be a rich source of macro- and microelements and other bioactive substances (fatty acids, polysaccharides, pigments, polyphenols, etc.).

Freshwater macroalgae - a rare subject of research and practically do not yet appear as ingredients of cosmetic products.

Our research has a chance to change this!

Cladophora glomerata *Cladophora rivularis* *Ulva flexuosa*



The percentage distribution of literature data about bioactive compounds investigation in algae.[1]

[1] *http://apps.webofknowledge.com/ (data from May 2023)*

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Algal extracts for cosmetics

Partner involved:

Adam Mickiewicz University Poznań

Algae are one of the most popular natural cosmetic ingredients on the market. Almost every cosmetics company offers products containing algae.

- more and more popular;
- the increasing consumer awareness towards ecology, safety and quality of cosmetics;
- the natural origin of algae and the diversity of

bioactive agents causing various health effects on skin:
- basic toiletries: body lotions, face masks, shampoos,
- the most advanced cosmetics and cosmeceuticals used in a treatment of acne, psoriasis or eczema.

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Algal extracts for cosmetics

Algae harvesting for cosmetic industry

Partner involved:

Adam Mickiewicz University Poznań

I. from the natural sites:

- botanical identification and verification of the genus and species - the separating of macroalgae from water;
- algal biomass - properly prepared by purification, cellular disruption and drying

SAMPLE COLLECTION
TAXONOMICAL
IDENTIFICATION

CLEANING THALLI

DRYING

The raw materials for the production of cosmetic formulations should be prepared within 4 hours after collection (an important factor in maintaining the effect of bio-active substance)

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Algal extracts for cosmetics

Partner involved:

ADAM MICKIEWICZ UNIVERSITY POZNAŃ

II. from cultures grown under special conditions

Farming technology - algae grow in a system of glass tubes or photo bioreactors

- to receive algae concerns algaculture, which are conducted in the open or in closed systems;

- mainly used for the production of microalgae and includes the culturing under suitable conditions (temperature, pH, nutrients), separating the algae from water (e.g. by filtration), cell disruption and drying.

After drying algae may be micronized or extracted to recover high value products from their biomass and they are added to cosmetics in this form.

The micronized algae and algae extracts are the major forms of algae used in cosmetic industry

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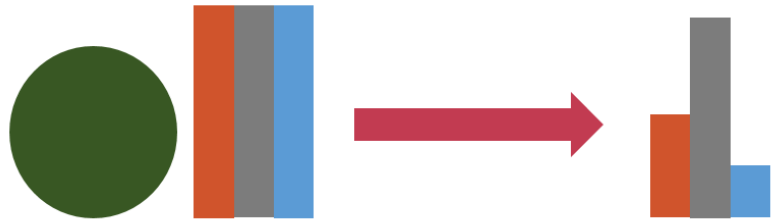
Algal extracts for cosmetics

Partner involved:

Adam Mickiewicz University Poznań

EXTRACTION - a method of separating a component from a mixture of solids or liquids using a solvent selected to dissolve primarily the desired compound. Example: to obtain natural compounds from plant material (leaves, bark …)



EXTRACT - a solution of chemical compounds obtained as a result of the completed extraction process; it may be a finished product itself, or a pure chemical compound may be isolated from it by distillation, freezing or crystallization

1. **What type of extraction should we choose if we want to use the extract in cosmetics?**
SFE or MAE or UAE or Soxhlet's or ……?

2. **What should we remember when determining the parameters (conditions) of extraction?**
Extraction methods condition (time, temperature ..) … solvents ….

3. **What bioactive compounds do we find in freshwater green algae extracts? Why are they important from the point of view of cosmetics?**
Fatty acids, sugars, polyphenols, antioxidants, sulphate polysacharides ….

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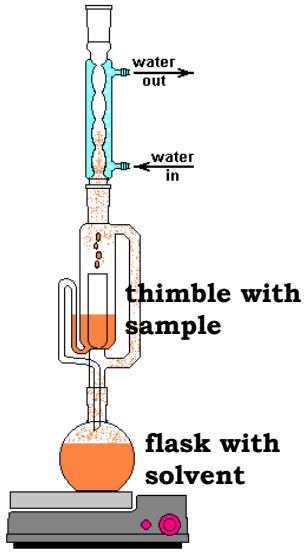
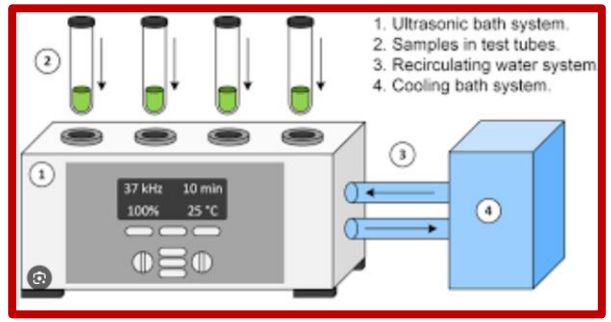
Algae extraction methods for bioactive compounds





Supercritical fluid extraction (SFE) - using carbon dioxide, that is above the critical pressure and critical temperature, so it has properties between a liquid and a gas intended for obtaining extracts from plant materials; it does not require high temperatures; completely safe and environmentally friendly; the final product is characterized by purity and unchanged composition while retaining valuable biologically active substances.

Soxhlet apparatus - the substance from which the extraction takes place does not come into contact with hot vapors of the solvent, but only with the cooled, liquid solvent

Microwave assisted extraction (MAE)
- absorption of microwave energy by chemical substances to extract the extract from the raw material; Material with solvent in a vessel generating microwave radiation; non-zero solvent dipole moment; high efficiency of the method - however, high temperature, which may lead to decomposition of the product.

Ultrasound-assisted extraction (UAE) - involves placing a solid or semi-solid sample together with the extractant in an ultrasonic bath or using an ultrasound-generating probe. The advantage of this method is the short duration of the process, ranging from 10 minutes to 1 hour,

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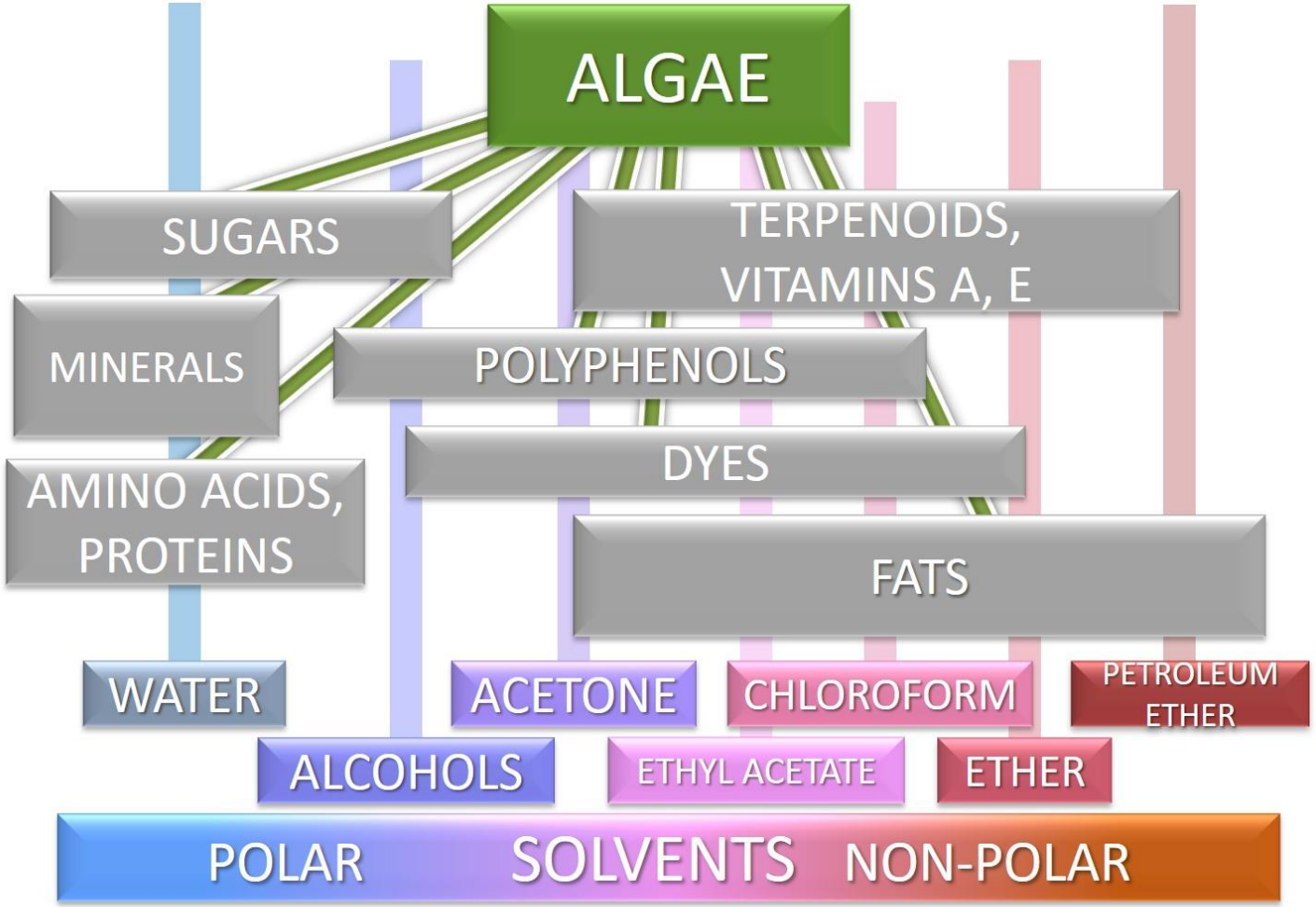
Partner involved:

Adam Mickiewicz University Poznań

Algal extracts for cosmetics



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Algal extracts for cosmetics

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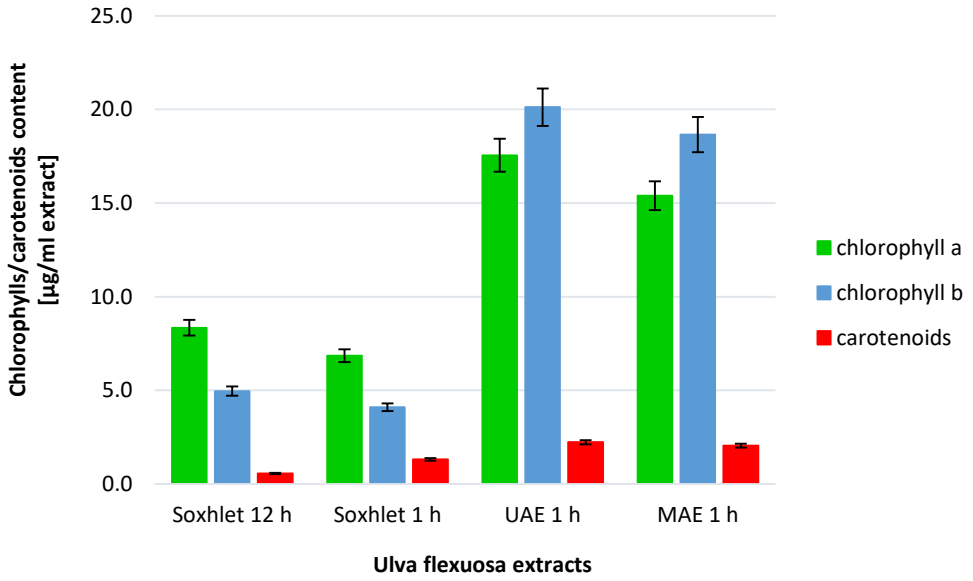
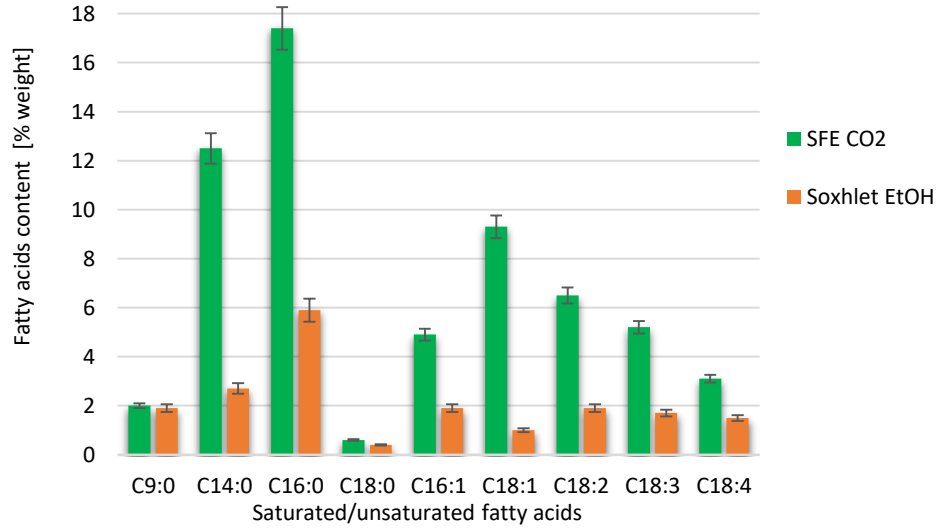
Antioxidants - protect skin against destructive effects of free radicals on skin cells, prevent aging of the skin: **carotenoids, polyphenolic compounds**

How to obtain an extract with the best antioxidant properties?



How the choice of extraction method influenced the results?



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Algal extracts for cosmetics

Partner involved:

Adam Mickiewicz University Poznań

STEP BY STEP | FROM RAW MACROALGAE TO HIGH-VALUE **COSMETIC** PRODUCTS

STEP 1 | Macroalgae raw material is first cleaned, de-encrusted and crushed before extraction.

STEP 2 | Solvent extraction, followed by low-pressure evaporation isolates the active compounds.

STEP 3 | A suitable emulsion base is developed, which will complement the macroalgae extract.

STEP 4 | The final cosmetic product undergoes stability, purity and consumer-based testing.

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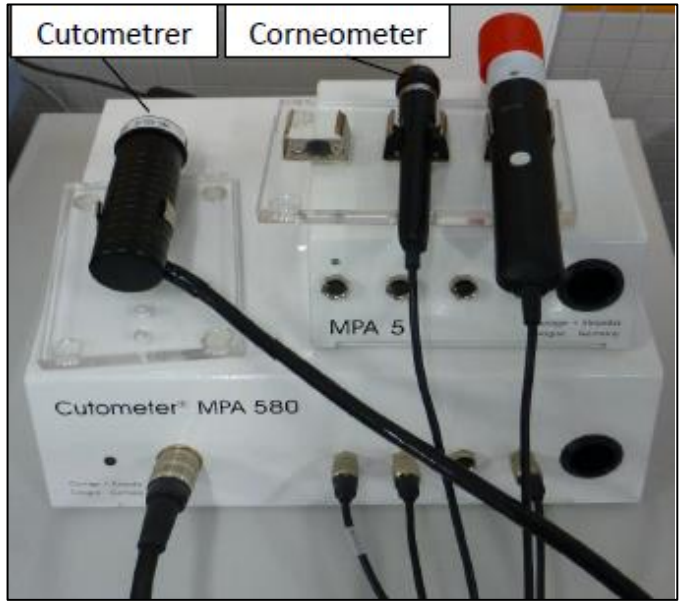
Algal extracts for cosmetics

Partner involved:

UAM Adam Mickiewicz University Poznań

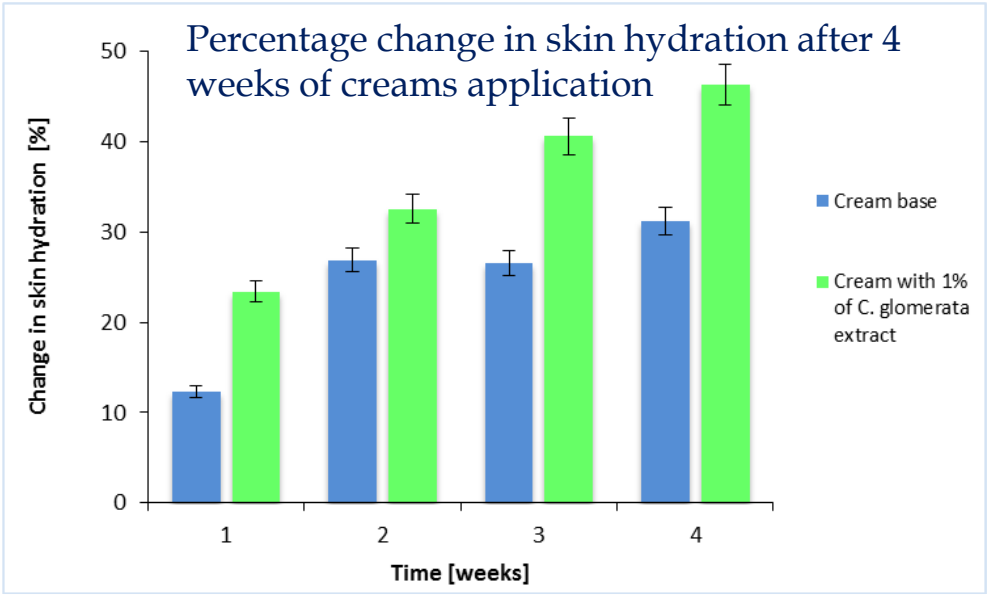
Studies *in vivo* - application study



Courage + Khazaka Electronic GmbH apparatus

Cream with 1% of *C. glomerata* extract obtained by SFE:

- ✓ Skin hydration
- ✓ Skin elasticity



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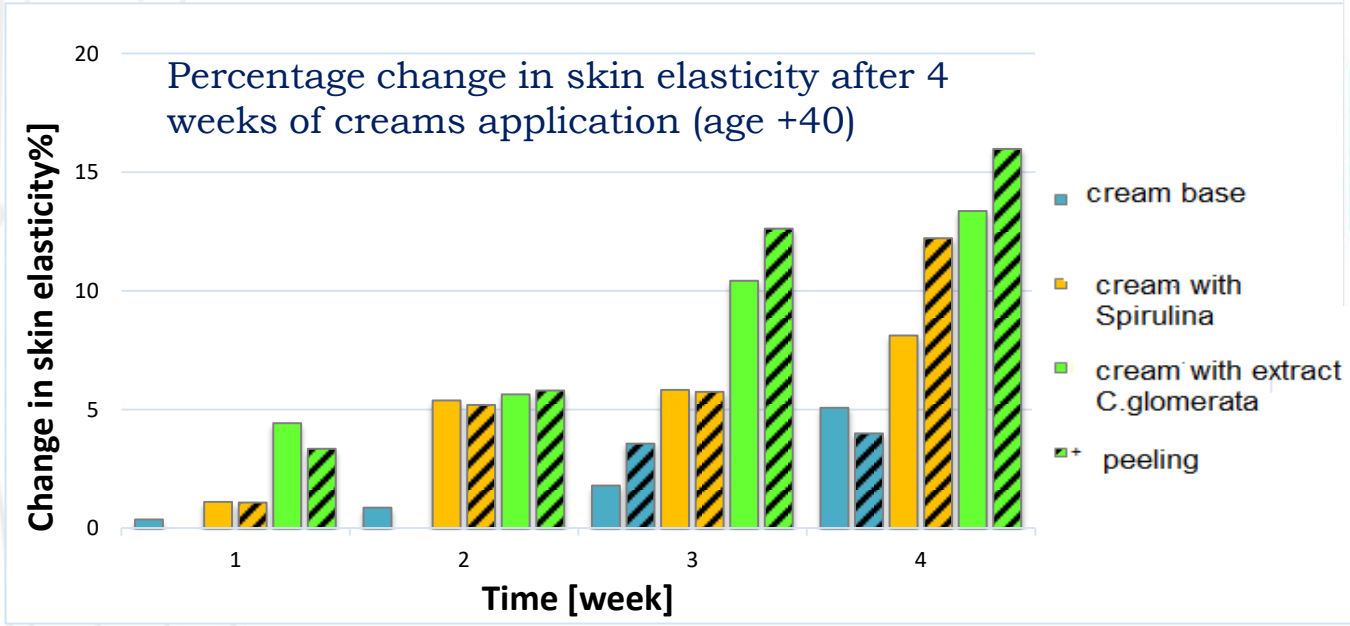
Algal extracts for cosmetics

Partner involved:

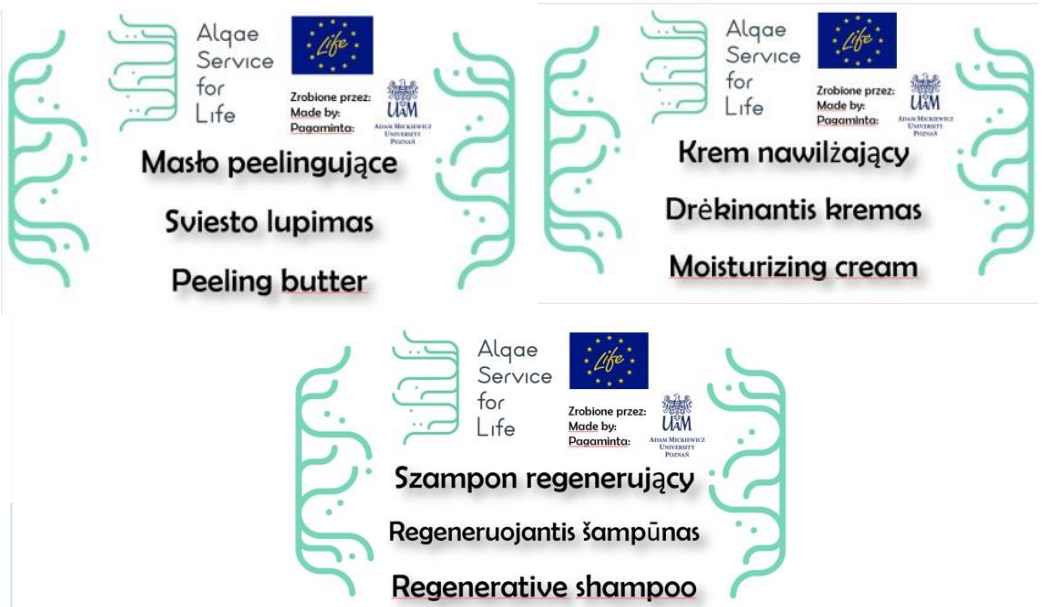
Adam Mickiewicz University Poznań

- Freshwater green macroalga C. glomerata was found as a source of various bioactive compounds:
  - Fatty acids;
  - Carotenoids;
  - Phenolic compounds;
  - Sulfated polysaccharides …
- Algae extracts possess antioxidant properties, added to cosmetics increased skin hydration and elasticity.

Biomass of *C. glomerata* may be used as a new cosmetic raw material.



Our cosmetics with algae extract for today



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Socio-economic (cost-benefit) analysis

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Socio-economic (cost-benefit) analysis

Is biomass harvesting, handling of collected algae and usage of better-quality water bodies beneficial to society?

Partner involved:

Spila

Three steps of socio-economic (cost-benefit) analysis:

A. **Cost assessment** of the biomass harvesting under certain assumptions.

B. **Assessment of benefits** to be received by the environment and humans because of the change.

C. **Comparison of annualised costs and benefits**.

Investment cost item (prototypes)	Preliminary costs, Eur^{2022}
Purchasing and installation of new equipment	400 000
Prototype documentation preparation	3 600
Performace testing and modifications	27 000
Training of employees	150
Research and development	353 000
Permits and taxable activities	1 240
Total	**~ 785 000**

Operating and maintenance cost item	Preliminary costs, Eur/year
Transportation	23 000
Storage of prototypes	7 000
Spare parts	5 200
Personal protective equipment for employees	930
Salary for 7 employees	67 200
Total	**~ 100 000**

Annualised costs – around 180 000 Eur/year

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Socio-economic (cost-benefit) analysis

Partner involved:

Spila

Three types of **benefits**:

- **Environmental (social) benefits to society**
- Direct financial benefits to companies working on biomass harvesting and with specific products, produced from this biomass
- Direct financial benefits to companies, dependent on water quality, such as fisheries, recreation and drinking water provision.

Assessed using **three methodological approaches**

1) *Applying results of the study on Willingness to Pay for increased water quality in Kaunas Reservoir (monetized benefits to society)*

2) *Based on freshwaters ecosystem services (monetization via benefit transfer from studies carried out in LT and PL, available statistics; as well as qualitative descriptions)*

3) *Life Cycle Assessment (to quantify environmental impacts associated with the use of algae in biogas production (and then cogeneration for electricity and heat), and with the use of algae as fertilizer)*

Based on Willingness to Pay study results, aggregate benefits of the increase of water quality - **18.5 - 22.3 million Eur/year**

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Socio-economic (cost-benefit) analysis

2) *Based on freshwaters ecosystem services (monetization via benefit transfer from studies carried out in LT and PL, available statistics; as well as qualitative descriptions)*

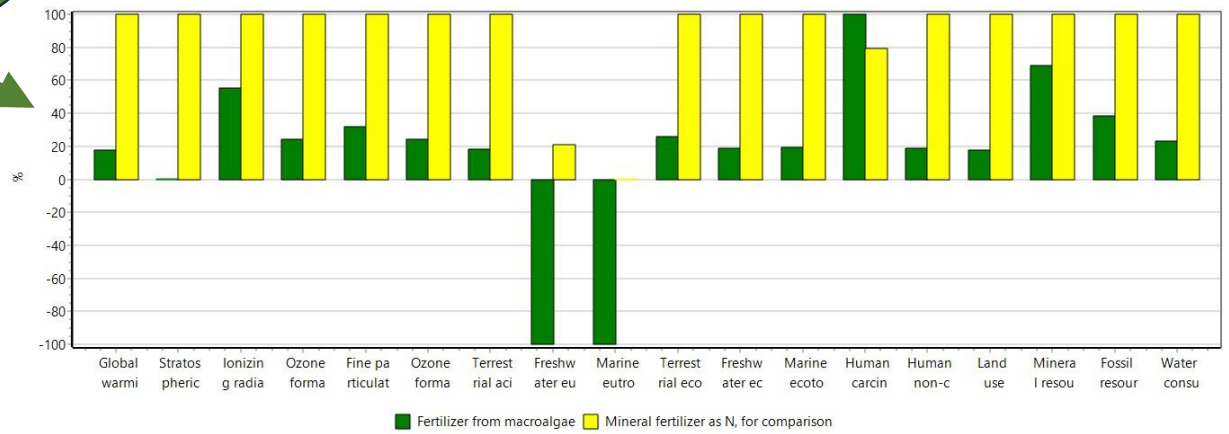
<u>For improved provisioning and regulation ecosystem services:</u>
-Fisheries and aquaculture
-Water for drinking (PL case)
-Raw (biotic) materials
-Raw materials for energy
-Air quality regulation
-Maintaining populations and habitats
-Carbon sequestration
-Cultural services are covered by the Willingness to Pay study

Partner involved:

Spila

3) *Life Cycle Assessment (to quantify environmental impacts associated with the use of algae in biogas production (and then cogeneration for electricity and heat), and with the use of algae as fertilizer)*

Life Cycle Assessment, comparison of N fertilizer production from macroalgae and mineral fertilizers:



+ Creation of jobs for a number of people

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Circular economy approach

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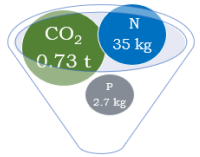
Circular economy approach

Algal biomass – a natural filter of ecosystems capturing excess nutrients from diffuse sources

In 1% of Kaunas Reservoir area **578 tons** of cyanobacteria & **10776 tons** macroalgae in 140 km of rivers



Altogether **36.12 tons** of nitrogen and **3.65 t tons** of phosphorus. Additionally, **16.14** kg pure cyanotoxin.
Facilitate **recovery** of aquatic ecosystems, increase biodiversity

Temporal **CO_2 sequestration** of 1990 tons in the collected biomass if all used for bioproducts

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Circular economy approach

Tools to mitigate algal blooms

Methodology of remote sensing:

- for evaluation of the most suitable water body
- to determine best harvesting time of the bloom
- to determine the approximate biomass suitable for harvesting

Three type of harvesters to collect biomass:

- macroalgae and cyanobacteria
- large and small ecosystems
- floating and from the shore

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Circular economy approach

Excess algal biomass if harvested is a relatively **cheep recourse** for valuable products, but its **application has limitations** because of quality and blooms instability.

MACROALGAE:
- Feed additives
- Extracts for cosmetics
- Slow-release fertilisers

CYANOBACTERIA:
- Phycocyanin (non toxic biomass)
- Feed additives
- Biogas
- Biomass plantations ?
- Bioplastics ?

LIMITATIONS DUE TOXICITY

FURTHER: facilitate increase in recyclability and sustainable use of the renewable recourses
- Focus on particular compounds with specific properties
- Use of several bioproducts from the same biomass – combined benefits high- and low-value products

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THE PEOPLE WHO ARE CRAZY ENOUGH TO THINK THEY CAN CHANGE THE WORLD ARE THE ONES WHO DO.

-STEVE JOBS-