LIFE Project Number

LIFE17 ENV/LT/000407

Mid-term Report

Covering the project activities from 01/08/2018 to 30/09/2020

Reporting Date

30/11/2020

LIFE PROJECT NAME or Acronym

AlgaeService for LIFE

ALGAE – ECONOMY BASED ECOLOGICAL SERVICE OF AQUATIC ECOSYSTEMS

Data Project

Project location:	Lithuania, Greater Poland Voivodeship and Lesser Poland Voivodeship
Project start date:	01/08/2018
Project end date:	31/07/2023
Total budget:	3 674 830 €
EU contribution:	2 193 710 €
(%) of eligible costs:	59.70

Data Beneficiary

Name Beneficiary:	Nature Research Centre
Contact person:	Mrs Judita Koreiviene
Postal address:	Akademijos Str. 2, 08412 Vilnius, Lithuania
Telephone:	+370 650 11742
E-mail:	judita.koreiviene@gmail.com
Project Website:	https://algaeservice.gamtostyrimai.lt/

Contents

1. List of key-words and abbreviations

Abbreviations

AMU	Adam Mickiewicz University in Poznań
ATX	cyanotoxin anatoxin
BE	Joint Stock Company Baltic Environment
Chl-*a*	Chlorophyll-*a*
dw	dry weight
EASME	Executive Agency for SMEs
EHD	Environmental Health Division
EPA	Environment Protection Agency
INC	Institute of Nature Conservation, Polish Academy of Sciences
KPI	Key Performance Indicators
LCA	Life Cycle Assessment
LT	Lithuania
MCs	cyanotoxin microcystins
N	nitrogen
NEEMO	Monitoring LIFE Projects and Communicating about the LIFE Programme
NHF	Nature Heritage Fund
NRC	Nature Research Centre
P	phosphorus
PL	Poland
SPILA	Joint Stock Company SPILA
STX	cyanotoxin saxitoxin
UAV	Unmanned aerial vehicle
WFD	Water Framework Directive
ww	wet weigth

Keywords: circular economy, cyanobacteria, cyanotoxins, macroalgae, nutrient mitigation, water quality,

2. Executive Summary

PROJECT OBJECTIVES AND KEY RESULTS

The report summarizes the activities carried out in the project at mid-term period. The project progress describing fulfilment of the objectives, highlighting the policy impact and sustainability is summarised for each action. The project aims to promote best practices in ecological service and the circular economics approach by implementing innovative complex system which has demonstration and innovation character. The project has three objectives: i) to demonstrate integrated efficient management of nutrients and algal nuisance blooms by harvesting of cyanobacteria scums and macroalgae mats; ii) to test and demonstrate the redesigning of waste biomass of cyanobacteria and macroalgae into potential valuable products; iii) to raise awareness to environmental, water quality and health hazard issues among the national governments, local authorities, the business community and society.

Within the Actions A1 and B1, the construction, testing and demonstration of two different prototypes for harvesting of algal biomass was foreseen. Technical sketches of the small Algae Service-S (**AS-S**) **prototype** that enable to harvest cyanobacterial scums and macroalgae mats were prepared and patented. The manufactured AS-S was technically inspected and registered by LT Transport Safety Administration. Special trailer for transporting AS-S macroalgae biomass unloading mechanism were manufactured. The AS-S operation was demonstrated during the event for governmental organisations and other EU projects organized in Lithuania on 08/2020. Technical sketches of the large Algae Service-L (**AS-L**) **prototype** devoted to collect cyanobacteria scums in the Curonian Lagoon were finalised. Pre-testing of cyanobacteria harvesting system selected in the proposal indicate the necessity to increase its efficiency. Additional survey, discussions with experts, pre-testing conditioned the delay of updated technical sketches preparation. More efficient technology did not enlarge budget costs or influence on other activities, KPI values. Currently, the manufacturing of AS-L is in progress.

In the frame of Action B2, the preparation and testing methods for evaluation of algal biomass agglomerations in aquatic ecosystems combining traditional and distant methods took place in 2018–2019 in order to monitor water quality and improve the cost-efficiency of algal biomass harvesting. Two approaches were used: satellite images for the lagoon and unmanned aerial vehicle (UAV) for lakes, rivers. GIS analysis of Chl-*a* concentrations based on **satellite images** of the Curonian Lagoon (36 data sets) using the tool developed in cooperation with the project EOMORES is in progress. Set of 27 **UAV images** (>100 km of rivers, one lake) in total were produced for the evaluation of baseline situation. Joined images were analysed. Based on prepared methodology, agglomerations of macroalgae comprise 10775 t in the best appropriate for harvesting 34 km of rivers. *In situ* data of macroalgae, cyanobacteria, nutrient and cyanotoxins content in biomass were analysed for UAV methodology and water quality assessment. UAV images will be done in LT and PL during 2020-2022 for the validation of developed methodology. The INC partner stated new cooperation with the Warsaw Institute of Aviation in this way contributing to replication of the project activity.

In the Action B3, collected biomass of cyanobacteria and macroalgae has been tested for biogas, biofertilizers and high value bioproducts application. Overall, 80 kg of cyanobacteria and 14.3 t of macroalgae wet biomass were collected that constitute 1% and 20% from foreseen in KPI. Together with biomass 4.7 kg of P, 38 kg of N, 0.26 g of cyanotoxins (151%, 77% and 0.07 % of KPI, accordingly) were eliminated from water bodies.

Testing of **biogas** started in 2020, 1.2 tons of macroalgae biomass mixed with manure were uploaded. Chemical analysis and first results of plant growth revealed algal biomass suitability as **biofertilizer**. Totally, 6 tons of biomass was prepared in different ways and has been tested to assess the growth and yield of potatoes, barley, corn, peas and wheat at four

testing levels: laboratory, greenhouse, experimental fields and farming fields. Methodological background for the extraction of **high value bioproducts** (phycocyanin as natural dye, extracts of macroalgae for cosmetics) was elaborated. About 7 kg of cyanobacteria wet biomass was used for phycocyanin extraction. Pigment was successfully extracted from *Aphanizomen* biomass, but encountered difficulties extracting from *Microcystis* biomass. The extracted biologically active metabolites from macroalgae had antioxidant, moisturizing and elasticizing properties that open up prospects for using them as a new ecologically friendly raw material for cosmetics.

In the Action C1, the water quality baseline for the selected water bodies was defined in order to assess the improvement after the biomass harvesting during 2020–2023. Historical and ongoing data from 11 water bodies in LT and PL were gathered following the intercalibrated protocol, the requirements of WFD and countries legislation. Over 9000 samples covering physico-chemical and biological parameters were analysed. An amendment to Lithuanian Hygiene Norm HN 92:2018 has been prepared and is under consideration by lawyers. Evaluation of costs of biomass harvesting, incomes from bioproducts, socio-economic effects monitoring is in progress.

In the Actions D1 and D2, raising awareness and dissemination of the project results, effort for replication and transfer were actively implemented on national and international levels. 8 were achieved and 8 are in progress out of 21 communication indicators of progress. Two international project proposals, 3 networking proposals for replication and transfer of project results were submitted, networking with at least four EU projects has been launched. The training seminar and bilateral meetings were organised to reach target stakeholders from governmental organisations, scientific, business communities. ArcGIS application, interactive map and on-line questionnaire in three languages were created, 3 scientific papers were published, in 24 national/international conferences and seminars, workshops were participated. To raise awareness among society, 9 popular publications, 3 radio interviews, 3 social events were organised. Three notice boards at testing sites were erected. Also, project website, social networks were created, over 400 copies of leaflets were spread out.

Within the Action E1, 1st Progress Report was submitted to EASME. Twenty-six direct or online meetings with partners have been organised. Steering committee was launched.

3. Introduction

Description of background, problems and objectives

Aquatic ecosystems due to a growing human population force a challenge with accelerated load of anthropogenic nitrogen and phosphorus resulting in hyper-eutrophication. Import-driven *enrichment* by *nutrients* promotes excessive production and uncontrolled growing of algae and cyanobacteria that condition to harmful blooms. Furthermore, their incidence is further stimulated by climate change *combined* with increased nutrient loads.

Massive growth of macroalgae or cyanobacteria creates the environmental and social problems due to formation of spatially large mats in aquatic ecosystems. Massive growth of macroalgae or cyanobacteria poses an expanding threat to both the environment and society as it leads to reduction in aquatic biodiversity and biotopes, impacts on water supply, restrictions on recreational use, shades and suppress aquatic vegetation/macrophytes. The decaying macroalgae mats cause oxygen depletion, promote secondary enrichment with nutrients in aquatic ecosystems, and trigger off an unpleasant smell, when they are washed ashore on the beaches.

Meanwhile, harmful cyanobacteria blooms (HABs) pose even more significant threats as cyanobacteria produce high variety of cyanotoxins that can cause skin irritation, seriously harm liver, digestive and nervous systems or even lead to death of human, wild animal and livestock. Bad water quality makes high risk to human health or biota, cause significant economic losses to water-related recreational activities and tourism, fisheries, shipping and the other industry sectors.

Currently, diffuse losses of nutrients from agriculture remain the most important hardly controllable source to freshwaters and the Baltic Sea. Cyanobacteria and macroalgae serve as a natural bio-filter that accumulates nitrogen, phosphorus, and CO_2. Therefore, harvesting of their biomass from aquatic ecosystems can be one of the efficient tools for long-term nutrient abatement. The current project creates new prototypes for the collection of excess biomass of algae and cyanobacteria and focuses on the mitigation of nutrients increase, blooms risk in aquatic ecosystems. It is a step involved in creating a circular economy model for redesigning of waste algal biomass into potentially valuable products for sustainable management and recycling of environmental resources.

Project objectives:

Generally, the project seeks to promote best practices in ecological service and the circular economics approach by implementing innovative complex system which has both demonstration and innovation character.

- The primary goal of the project is to demonstrate integrated efficient management of nutrients and algal nuisance blooms at the catchment scale by harvesting of cyanobacteria scums and macroalgae mats in various types of water bodies (rivers, lakes and the Curonian Lagoon).
- To test and demonstrate the redesigning of waste biomass of cyanobacteria and macroalgae into potential valuable products for sustainable management and recycling of environmental resources.
- To raise awareness to environmental, water quality and health hazard issues among the national governments, local authorities, the business community and society for the continuation and transfer of proposed measures application on a broader scale after the end of the Life project.

The objectives of the project will demonstrate the efficiency of the prototypes-harvesters for mitigation of excess algal biomass, as the source of phosphorus, nitrogen and hazardous

cyanotoxins, in the ecosystems to ensure their applicability and transferability to a high variety of EU aquatic ecosystems. Also, this project focuses on developing technologies to provide a reliable, affordable, and sustainable supply of algal biomass as a feedstock source.

Expected long-term results

The proposed measures for ecological service address several European Union directives related to the water quality (Water Framework Directive 2000/60/EC, Marine Strategy Framework Directive 2008/56/EC, Bathing Waters Directive 2006/7/EC, Nitrates Directive 91/676/EEC) and the redesign of waste biomass contributes to new EU Biodiversity Strategy for 2030 (COM (2020) 380) and The European Green deal (COM(2019) 640) strategy.
To achieve the goals of EU Directives the project addresses integrated management of nutrient inputs and organic pollution of agricultural origin and suggests measures on river basin or catchment scale. Removal of nutrients by using "natural-like" processes contributes to the "EU Strategy for the Baltic Sea Region" and provides an integrated framework for improvement of the environmental conditions in the Baltic Sea. The project pursues to promote ecosystem-based approach to control harmful blooms in inland waters and to reduce nutrient loads to the Baltic Sea from the catchments. It is intended to develop the technologies for the provision of water service and gently mitigation of eutrophication.
By implementing the **Water Framework Directive** (2000/60/EC), the project seeks to remove excess biomass of algae and cyanobacteria that assimilate nutrients, and in this way to reduce contamination of surface waters with phosphorus and nitrogen compounds, to improve water quality and preserve biodiversity in aquatic ecosystems. The proposed prototypes-harvesters are the instruments to control diffuse pollution from the catchment to inland waters and from lake sediments. Under the **Marine Strategy Framework Directive** (2008/56/EC), Member States ensure to reach good state and high biodiversity of the marine environment by 2020. The harvesting of excess phytoplankton agglomerations in the Curonian Lagoon and macroalgae collection in the selected rivers of the Nemunas basin will contribute to the reduction of nutrient transit to the Baltic Sea and to the improvement of the water quality on catchment scale.
Following the **Nitrates Directive** (91/676/EEC), the project seeks to eliminate nitrogen compounds assimilated into harvested biomass and to block their flow further through the waterways. The **Bathing Water Directive** (2006/7/EC) is focused on water quality, monitoring of algae (cyanobacteria) blooms, and mitigation of their risks. Cyanobacteria can produce toxic compounds that create health hazard to humans and biota. Therefore, special attention in the project is devoted to mitigation of harmful blooms and protection of bathing water quality. The harvesting of cyanobacteria scums will secure inland aquatic ecosystems relevant for recreation and fishery. The **Drinking Water Directive** (98/83/EC) seeks to protect human health by ensuring the safe drinking water for supply (does not contain poisoning microorganisms or substances). The World Health Organization Guidelines for Drinking water quality recommend provisional value of 1 μg/mL for one of the most potent and commonly occurring cyanotoxin MC-LR.
The proposed nutrient abatement tool is in line with the task "2.2 An EU Nature Restoration Plan: restoring ecosystems across land and sea" of the **EU Biodiversity Strategy for 2030** (COM (2020) 380) that will help to tackle the pollution by nutrients, to control of invasive alien species, to support the recovery of natural biodiversity. The use of biofertilizers redesigned from algal biomass, which is rich in organic compounds, contributes to organic farming and soil restoration. Moreover, innovative complex of system combining the ecological service and the circular economics approach, suggested by the project addresses an implementation of the strategic tasks highlighted in **The European Green Deal** (COM(2019) 640) strategy.

4. Administrative part

The **management structure** of the project was outlined in the Table C2 (Action E1) of the project proposal. The coordinating beneficiary NRC is responsible for the project management, including the technical and financial aspects. The management Group (MG) of the project that constitutes from the Main (coordinator, vice-coordinator, management accountant) and Support (representatives from the institution of each associated beneficiary/partner) groups is involved in joint discussion concerning issues and accepts important decisions and deliverables via voting according to the rules described in the Partnership Agreement. Also, each beneficiary has responsibility for at least one action, where they make the largest contribution to the project. Payments of the prefinancing amounts from the EASME and the national co-financiers were delivered to the partners as was set in the Partnership Agreement. All relevant notifications received from the Agency or NEEMO and the final versions of deliverables and the technical/financial reports were duly transferred to all project participants.

Project implementation plan was detailed in the Gantt Diagram annexed to the Partnership Agreement. The MG meetings took part every quarter to ensure smooth project implementation and discuss issues related. After, the progress was summarised by the consortium in the technical and financial reports. The Minutes of the partners meeting sum up the topic and decisions of the meeting. The bi-lateral meetings, permanent contact by e-mail and/or phone calls took place to solve a particular issues and questions. More information about 26 direct or online meetings is provided in the description of the Action E1 of this report.

Communication with the EASME and Monitoring team. Communication of the project coordinator with the NEEMO Monitoring team and the advisor from the European Commission was constructive. The coordinator and the project managing accountant participated in the LIFE kick-off meeting in Brussels (11/2018). The NRC constantly communicated by phone, e-mail or meetings with the NEEMO Monitoring expert to solve management and administrative doubts. The Coordinating beneficiary organized two annual monitoring visits for the NEEMO expert by providing updated reports, organizing visits on-sites of project implementation and providing requested documents for inspection. All comments provided after each LIFE monitor´s visit were taken into account. Progress report and three sets of modifications necessary to the project were adjusted with Monitoring expert prior sending them to the EASME. Amendments to the project were not necessary. EASME have been informed about all modifications made in the project. Adjustments requested and the responses from EASME acquired are provided in the ANNEX 1; also briefly explained with a particular Action in the Technical part of the report. Communication with EASME concerning information correction in the official project page was performed on 02/2019, however one of the project partners (INC) is still missing.

5. Technical part

5.1. Technical progress per Action

Action A.1. Overview of harvesting instruments worldwide and finalisation of the technical sketches of the prototypes

Summary of project Deliverables and Milestones of the Action A.1

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action A1			***Start* Q3 2018 *End* Q2 2021**	***Start* Q3 2018 *End* Q3 2021**	
A1	The review of the devices used for harvesting of algal scums and mats worldwide	BE	*Start* 08/2018 *End* 12/2018	*Start* 08/2018 *End* 11/2018	Completed; *Deliverable A1.1a* *Deliverable A1.1b*
A1	Design and technical sketches of AS-S prototype	BE	*Start* 08/2018 *End* 04/2019	*Start* 08/2018 *End* 04/2019	Completed; *Deliverable A1.2*
A1	Design and technical sketches of AS-L prototype	BE	*Start* 04/2019 *End* 12/2019	*Start* 04/2019 *End* 09/2020	Completed; *Deliverable A1.3*
A1	Receiving of permits in LT for AS-S operation	BE	*Start* 07/2019 *End* 08/2019	*Start* 02/2020 *End* 06/2020	Completed; *Deliverable A1.4* *Annex A1.1*
A1	Receiving of permits in LT for AS-L operation	BE, NHF	*Start* 04/2020 *End* 07/2020	*Start* 04/2021 *End* 07/2021	Postponed
A1	Overview of harvesting instruments worldwide completed	BE	*Start* 08/2018 *End* 12/2018	*Start* 08/2018 *End* 11/2018	Milestone completed
A1	Elaboration of the detailed sketches of two prototypes completed	BE	*Start* 08/2018 *End* 12/2019	*Start* 08/2018 *End* 09/2020	Milestone completed
A1	Permit for both prototypes operation in LT & PL received	BE			Milestone in progress

result completed activity in progress

Details of Progress:

An **overview** of the devices used for harvesting of macroalgal agglomerations and cyanobacteria scums worldwide is provided in *Deliverable A1.1a*.

Technical sketches of the Algae Service-S (**AS-S**) prototype to harvest cyanobacterial scums and macroalgae mats were completed on time (Fig. 1). Detailed technical sketches and specifications that cover the type and quality of the AS-S prototype parts (pontoons, drainage system, renewable energy system, conveyor, pressing system, engine and management system) are made and provided in *Deliverable A1.2*.

Fig. 1. Schematic view of the AS-S prototype.

Technical sketches of the updated Algae Service-L (**AS-L**) prototype construction with cyanobacteria collection systems, solar panels, engines, compressor, safety equipment, etc. were finished on 09/2020 and are provided in the *Deliverable A.1.3* (Fig. 2). The delay was due to decision of search for the best technological solution for AS-L to collect cyanobacteria in the Curonian lagoon. Therefore, an additional review of algae collection technologies complementing the *Deliverable A.1.1a* was made (*Deliverable A.1.1b*). After careful re-consideration of algal collection technology's advantages, disadvantages, calculations, consultations with producers and discussions between partners, the reverse microalgae filtration system has been selected. A Model system that consists of two perforated cylinders, dense filtration mesh placed on them, pressed air nozzles and water pump was constructed and tested. Since, cyanobacteria collection technology was changed to make the AS-L more effective, additional weight, carrying capacity and biomass transportation logistics calculations were made. All changes concerning the AS-L prototype, such as dimensions, cyanobacteria collection system, as well as delay of technical sketches were communicated to EASME during monitoring expert visit on 08/2020 (ANNEX 1). The changes will not require higher budget. Delay of technical sketches will influence the deadline of manufacturing and acquiring of permits for AS-L prototype. However, significantly increased efficiency of cyanobacteria scums harvesting of revised technology will allow to meet the tasks in the project and is essential for continuation of the activity after the end of the project.

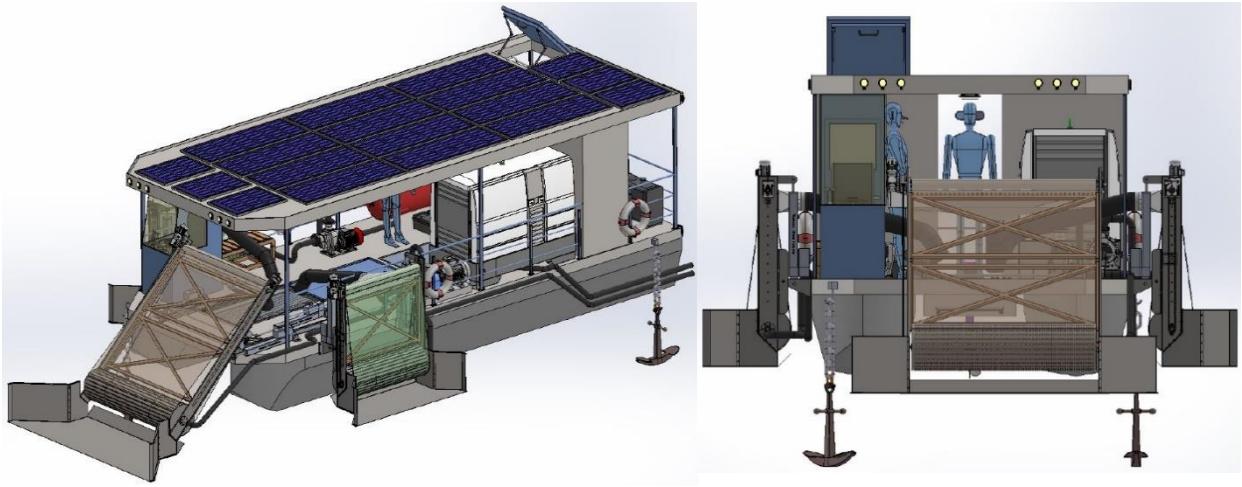


Fig. 2. Schematic view of the AS-L prototype.

Receiving of permits in Lithuania for the AlgaeService-S (AS-S) prototype operation is completed. The Lithuanian Transport Safety administration approved technical project of the AS-S construction (drawings and technical calculations) on 08/2019. Their representatives supervised a manufacturing process of AS-S prototype (01/2020), registered the constructed prototype (02/2020), provided the final registration documents (06/2020), and performed technical inspection. All documents are provided in *Deliverable A.1.4*. "AS-S PROTOTYPE USER MANUAL" with safety and maintenance recommendations was prepared (*Annex A1.1*). Permission to perform macroalgae harvesting in River Šventoji in NATURA 2000 area is provided in the *Annex A1.2*.

Receiving of permits in Lithuania for AS-L operation was postponed with EASME permission in the letter from project adviser received on 07/09/2020 (issue 7) till 31/07/2020.

Action B.1. Construction, testing and demonstration of prototypes for harvesting of cyanobacteria and macroalgae

Summary of project Deliverables and Milestones of the Action B.1

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action B.1			***Start* Q4 2018** ***End* Q3 2023**	***Start* Q4 2018** ***End* Q3 2023**	
B1.1	Manufacture AS-S harvesting prototype	BE	*Start* 12/2018 *End* 07/2019 *Revised end* 04/2020	*Start* 04/2019 *End* 05/2020	Completed; *Deliverable B1.1, Annexes A1.1, B1.1*
B1.1	Manufacture AS-L harvesting prototype	BE	*Start* 09/2019 *End* 07/2020	*Start* 09/2020 *End* 05/2021	In progress; *Deliverable A1.3*
B1.1	Prepared application to patent two prototypes sketches	BE	*Start* 01/2023 *End* 07/2023	*Start* 09/2019 *End* 07/2023	In progress; *Deliverable A1.4*
B1.2	Collected totally up to 80 t algal biomass to perform Action B3	BE, NRC, AMU	*Start* 08/2019 *End* 10/2022	*Start* 08/2018 *End* 10/2022	In progress
B1.3	Prototypes operation demonstrated in 2 small and 1 large aquatic ecosystem	NHF, NRC, BE	*Start* 09/2020 *End* 10/2022	*Start* 06/2020 *End* 10/2022	In progress
B1.1	Manufacturing of two biomass harvesting prototypes achieved	BE	*Start* 12/2018 *End* 07/2020	*Start* 04/2019 *End* 07/2021	Milestone in progress
B1.2	Collected sufficient biomass to run Action B3 activities	BE, NRC, AMU	*Start* 08/2019 *End* 10/2022	*Start* 08/2018 *End* 10/2022	Milestone in progress

Details of Progress:

Sub-action B1.1 Manufacture of prototypes for algal agglomerations harvesting.

Manufacture of AS-S harvesting prototype is completed. Different parts of AS-S prototype were manufactured and/or bought. Steps of manufacturing process: i) manufactured platform was connected with pontoons consisting of segments; ii) the rotating mechanism front head for algae collection was mounted; iii) engines, cutting knifes, equipment hydraulic system were installed; iv) drainage system elements: metal press container, perforated box, chain piston, water pump were constructed separately and connected to the body; v) anchors and system of solar panels were installed; vi) sides and roof were mounted, control panel was installed; vii) the reverse filtration technology with pump for cyanobacteria harvesting was manufactured and installed; viii) design with LIFE and project logo was created and applied on the AS-S. Images of AS-S prototype manufacturing, technical testing are provided in Fig. 3–4, and *Deliverable B1.1, Annex B1.1*. Delay of manufacturing of AS-S prototype and the corrective actions applied were reported to EASME together with 1st progress report on 31/12/2019 (ANNEX 1); the applied corrective actions are described in detail in the section 6.2 of the report.

The special mechanism for unloading of harvested biomass to the shore was made (Fig. 4). The specialised trailer was manufactured to transport the AS-S prototype to the testing sites (Fig. 4). Manufacturing of specialised trailer instead of its rent, as foreseen in the proposal, was decided because of the absence of suitable one in the market and was permitted by EASME in the letter from the project adviser received on 07/09/2020 (issue 9) (ANNEX 1). The sketches of AS-S were patented by the State Patent Bureau of Lithuania Republic (on 11/2019; *Deliverable A1.4*).

Technical testing of AS-S prototype. Technical testing of AS-S prototype separate and joined parts at the construction site took ~400 hours. The AS-S prototype stability, draft, swimming, rotating front collection head, drainage system with metal press-container, perforated box, chain piston and water pump were tested out of construction site in small water body ~70 hours (10/2019, 12/2019, 03/2020, 05/2020). After testing some changes were made to have a better balance of the prototype (shortened rotating front head, adjustable position of biodiesel engine's and control panel's on harvester's deck on special rails). The changes allowed to keep better weight balance during collection of macroalgae as operator could adjust position of biodiesel's and control panel's platform to maintain stability. The hydraulic system was also modified. Macroalgae and cyanobacteria collection systems, press-container, harvested biomass unloading mechanism, the prototype swimming with collected biomass and upstream operating were tested for ~150 hours in real conditions in Kaunas Reservoir (07-09/2020), River Šventoji (08/2020), Lake Simnas (08/2020). Technical testing of AS-S prototype for cyanobacteria harvesting was performed at Kaunas Reservoir (working 18 hours, harvesting 5 hours), whereas for macroalgae – at Kaunas Reservoir (16/12 hours) and River Šventoji (8/4 hours). The modifications of the system to increase effectiveness are under development after larger biomass amounts collection. The constructed special trailer was tested to transport AS-S prototype to River Šventoji and Kaunas Reservoir and to lower the prototype into the water.

Fig. 3. Manufacturing and technical testing of AS-S prototype (more in *Annex B1.1*)

Manufacturing of AS-L prototype. First pre-testing of cyanobacteria harvesting systems was done using pure algal cultures grown at the NRC on 07/2020. Based on the positive results obtained, the model of cyanobacteria collection system was manufactured and tested in Lake Simnas and Kaunas Reservoir (*Deliverable A1.3*). Based on testing results, the changes in AS-L filtration system were made and an additional dewatering system has been foreseen for the prototype. Currently, the manufacturing of AS-L is in progress, however the delay was foreseen and permitted by EASME in the letter from the project adviser received on 07/09/2020 (issue 8) (*Annex 1*). The delay will not substantially influence implementation of other project Actions as cyanobacteria biomass for testing in the Action B.3. will be harvested using the AS-S. The Performance Indicators will be reached in shorter time due to more efficient collection system.

Fig. 4. Manufactured AS-S prototype, biomass unloading mechanism and custom-made trailer for prototype transportation

Sub-action B1.2. Testing of the harvesters in LT and PL water bodies.

Harvesting of algal biomass. Overall, 80 kg of cyanobacteria and 14.25 tons of macroalgae wet biomass were collected from the selected/tested water bodies during period from 08/2018 to 10/2020 (Fig. 5). The harvested biomass constitutes 1% and 19.6% of foreseen amount in the proposal, accordingly. Macroalgae collection was restricted in the rivers Dubysa and Jūra due to low water level because of hydrological draught. Cyanobacteria bloom in Lake Simnas was very intense but short. Therefore, biomass for testing in the Action B3 was collected in water bodies from Reserve List (River Nevėžis and Kaunas Reservoir).

Fig. 5. Macroalgae collected in River Nevėžis on 09/2020

Subaction B1.3. Demonstration of the harvesters in LT and PL water bodies.

Prototype and distant methods **demonstration event** was organized in Anykščiai on 12/08/2020. Participants from governmental institutions such as Municipality of Anykščiai, Anykščiai Regional Park**,** Environmental Protection Agency, State Service for Protected

Areas, Environmental Protection Department, Center for Health Education and Diseases Prevention, Lithuanian University of Health Sciences, Lithuanian Energy Institute, Lithuanian Fund for Nature, etc. and related environmental projects took part in the event (Fig. 6). The Project partners presented theoretical background of distant methods for evaluation of macroalgae in the rivers and technical characteristics of the AS-S prototype as well as demonstrated unmanned aerial systems and macroalgae harvesting using AS-S the field conditions.

Fig. 6. The project demonstration event in Anykščiai.

Action B.2. Testing prepared methods for cyanobacteria scums, macroalgae mats biomass evaluation *in situ* and water quality analysis using traditional and distant methods

Summary of project Deliverables and Milestones of the Action B.1

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action B.2			***Start* Q3 2018 *End* Q3 2023**	***Start* Q3 2018 *End* Q3 2023**	
B2.1	Methodical guideline for evaluation of algal agglomerations using UAV prepared	NRC, INC	*Start* 08/2018 *End* 12/2020	*Start* 08/2018 *End* 12/2022	In progress; *Deliverable B2.1*
B2.1	Methodical guideline for evaluation of algal agglomerations using satellite images prepared	NHF, NRC	*Start* 10/2018 *End* 12/2022	*Start* 10/2019 *End* 12/2022	In progress
B2.2	Intermediate report on nutrients and cyanotoxins elimination via algal agglomerations harvesting	NRC, INC, AMU	*Start* 08/2018 *End* 12/2020	*Start* 08/2018 *End* 12/2020	In progress; *Annex B2.1*
B2.1	Elaborated guidelines for evaluation in situ algal agglomerations using distant methods	NRC, NHF, INC	*Start* 08/2018 *End* 12/2022	*Start* 08/2018 *End* 12/2022	Milestone in progress

Details of Progress:

Sub-action B 2.1. Biomass testing *in situ* using remote sensing**.**

Evaluation of algal agglomerations using unmanned aerial vehicle (UAV). Contracts for purchase the UAV image service (08/2018 and 07/2020) and images analysis service (11/2018) were signed. For the evaluation of baseline situation in the selected water bodies and for methodology preparation, set of 27 UAV images in total (300–900 images per set) were produced during 2018–2019 using visual spectrum image capture camera and thermal imaging camera. Altogether over 100 km of Rivers Šventoji, Dubysa, Jūra, Nevėžis and Lake Simnas were surveyed. Joining of UAV high resolution images and their analysis using software Agissoft, eCognition and ArcGIS were completed; methodology was prepared and provided in *Deliverable B2.1* (Fig. 7). The analysis of *Cladophora* biomass in the tested rivers allowed to evaluate three different types of agglomerations (surface mats, bottom layers, submerged agglomerations) and macroalgae coverage in the areas (Table 2). The analysis revealed some deviations from *in situ* data due to high (> 2m) depth in some places of River Šventoji, shading by riparian vegetation, water surface ripples. Currently, elimination of detected deviations using *in situ* data is in progress.

Following adjustments accepted by EASME in the letter from the project adviser sent on 16/04/2020, agreement between INC and Institute of Aviation in Warszawa was signed. Thus, aerial photography of Tynieckie Circle, Podkamycze and Paprocany was done on 08/2020, and will continue in 2021–2022. Therefore, the UAV images analysis activity was extended in time. Four sets of UAV images (400–900 images per set) of Lake Simnas, Kaunas Reservoir, Rivers Šventoji and Nevėžis were done in 2020 for the validation of prepared methodology. *Deliverable B2.1* will be updated on 12/2022 combining validated data from Lithuanian water bodies and image analysis from Polish water bodies.

Evaluation of algal agglomerations using satellite images. The Horizon 2020 project EOMORES has a series of services for monitoring the quality of inland and coastal water

bodies based on a combination of the most up-to-date satellite data, innovative *in situ* instruments. The validation of proposed tool for measure of chlorophyll-*a* (Chl-*a*) concentration was finished on 10/2019 and data were provided to the NRC for analysis to identify hot-spots of cyanobacteria blooms. GIS analysis was started and data of Chl-*a* concentrations for 2018–2019 (36 data sets) was modelled, while calculations of each dataset are in progress. Methodology of analysis include several steps: i) downloaded data is imported in ArcMap 10.6.1 software and raster dataset converted to point layer; each point contains Chl-*a* concentration in ppb in attribute table of the layer; ii) point data layer was used for IDW (Inverse Distance Weighting) interpolation; this method allowed to highlight the hot-spots of the bloom phenomenon; iii) based on data, the Curonian Lagoon in territory of Lithuania was divided into 6 zones. (Fig. 8). Maps of distribution of Chl-*a* concentrations and statistical data will be provided as a final result of GIS analysis.

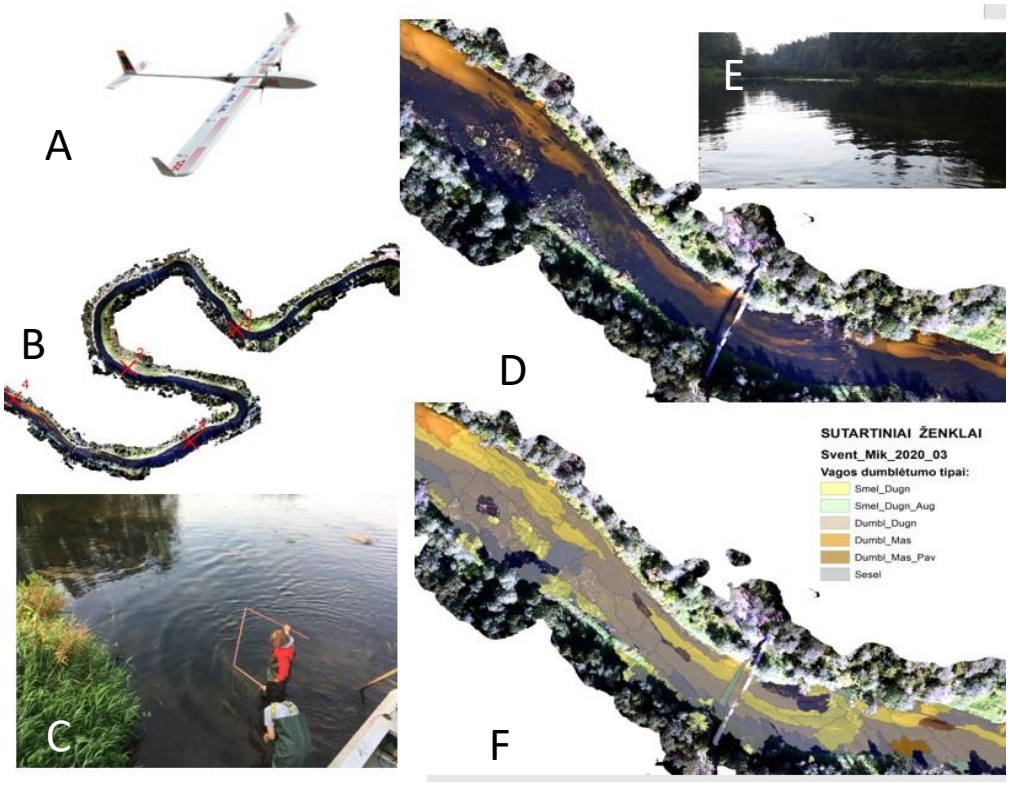
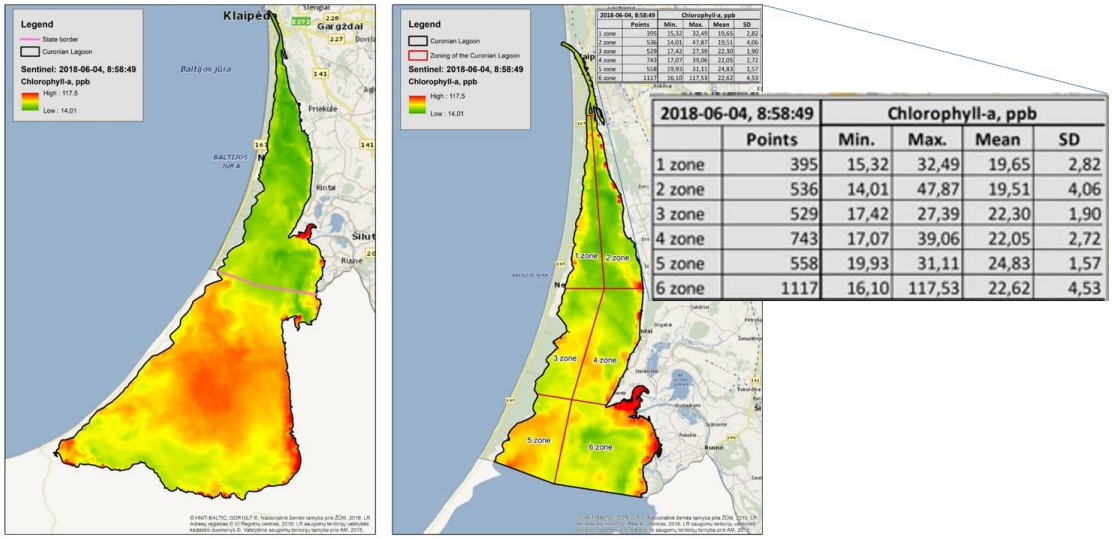


Fig. 7. Evaluation of macroalgal agglomerations in the rivers: A – the UAV used to take images; B – joined UAV images of the river stretch; C – evaluation of macroalgal agglomerations *in situ*. D–F – images of the tested particular river site by UAV (D), by digital camera from the bank (E), image after analysis using software (F).

Table 2. Coverage area, volume and amount of macroalgae in the tested stretches of LT rivers

River, Stretch No	Length of the stretch, km	Macroalgae agglomerations				
		Area covered, ha	Total volume, m^3	Average weight, kg/m^3	Total weight, t	Total weight, t/km
Šventoji - 1	6.6	119.3	32318	2.55	3042.2	460.9
Šventoji - 2	6.1	9.2	52318	2.55	234.6	39.5
Dubysa - 1	6.8	10.8	3243	5.67	612.4	90.1
Dubysa - 2	7.2	11.5	33446	5.67	652.1	90.6
Nevėžis -1	6.9	118.3	58381	5.27	6234.4	903.5
Totally	**33.6**	**269.1**	**179706**		**10775.7**	



2018-06-04, 8:58:49	Chlorophyll-a, ppb			
	Points	Min.	Max.	Mean	SD
1 zone	395	15,32	32,49	19,65	2,82
2 zone	536	14,01	47,87	19,51	4,06
3 zone	529	17,42	27,39	22,30	1,90
4 zone	743	17,07	39,06	22,05	2,72
5 zone	558	19,93	31,11	24,83	1,57
6 zone	1117	16,10	117,53	22,62	4,53

Fig.8. Distribution of chlorophyll-*a* concentration in the Curonian Lagoon applied GIS analysis and zonation of the lagoon based on Chl-*a* data.

Sub-action B 2.2. Water quality testing and the determination of scums/mats in water bodies using traditional methods.

In 2018–2020, samples for determination of cyanobacteria scums and macroalgal mats were collected in the water bodies foreseen in the proposal. The national hydrological drought in 2019–2020 affected the intensity of algal blooms and caused too low water level to harvest biomass in some water ecosystems. Therefore, the reserve water bodies (Kaunas Reservoir, River Nevėžis in LT; the lakes Lekno, Łęgowskie, River Welna in PL) were included for the survey from reserve list. These problems were communicated in the 1st Progress Report and accepted by letter of the project adviser on 16/04/2020. Water quality based on physical, chemical and biological parameters was assessed (*Deliverable C.1.2*). Agglomerations of macroalgae and cyanobacteria scums, aquatic vegetation, C, N, P content and cyanotoxins in biomass, zoobenthos in *Cladophora* agglomerations were analysed.

Type, size of macroalgae agglomerations, biomass per unit area, sites for biomass harvesting in LT rivers were registered along entire survey distance (Table 2, *Annex B2.1*). Macroalgae occurred in patches, bands or covered entire bottom till the river depth of 1.5 m. In Poland, the average weight of macroalgal biomass evaluated in Lake Oporzyńskie and River Nielba. Biodiversity seminar with 12 expert researchers from the NRC was organized on 02/2020 to clarify the potential impact of *Cladophora* harvesting on river habitats, biota and water quality.

Chl-*a*, cyanobacteria biomass, cyanotoxins (microcystins (MCs), anatoxins (ATX), saxitoxin (STX), cylindrospermopsin) in cyanobacteria scums, were tested in 5 water bodies (*Deliverable C.1.2, Annex B2.1*). MCs concentrations in cyanobacterial scums was higher in Lithuanian water bodies compared with Polish. Also, MCs amount was much higher compared to neurotoxins (ATX, STX).

Nutrient and cyanotoxin elimination. Totally, 4.7 kg of phosphorus, 38.3 kg of nitrogen and ~20 g of cyanotoxins were eliminated during the project implementation, and constituted 151%, 77% and 0.07 % of the amount foreseen in the Performance Indicators (*Annex B2.1*). Real estimations reveal that algal biomass contain much more nutrients and toxins than were calculated according to Redfield ratio and based on literature data. 2.43 t of CO_2 were incorporated into collected biomass, but emissions by harvester has to be deducted to have final numbers.

Action B.3. Testing cyanobacteria and macroalgae biomass collected from aquatic ecosystems for potential application for low and high value bioproducts

Summary of project Deliverables and Milestones of the Action B.3

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action B.3			***Start* Q1 2019 *End* Q3 2023**	***Start* Q1 2019 *End* Q3 2023**	
B3.1	Environmental Impact Assessment for biogas production in Technical office	BE	*Start* 08/2019 *End* 09/2019		Cancelled; explanation below
B3.1	Report on efficiency of biogas production from collected macroalgae biomass	BE	*Start* 08/2019 *End* 12/2021	*Start* 09/2020 *End* 07/2023	In progress
B3.2	Report on algal biomass as slow-release fertilisers for plants and growth activity promoters	NRC, AMU	*Start* 06/2019 *End* 12/2022	*Start* 06/2019 *End* 12/2022	In progress
B3.1	Algal biomass testing for biogas production completed	BE	*Start* 08/2019 *End* 12/2021	*Start* 09/2020 *End* 07/2023	Milestone in progress
B3.2	Algal biomass testing as slow-release fertilisers completed	NRC, AMU	*Start* 06/2019 *End* 12/2022	*Start* 06/2019 *End* 12/2022	Milestone in progress
B3.3	Tested algal biomass for valuable bioproducts	NRC, AMU	*Start* 02/2019 *End* 07/2023	*Start* 02/2019 *End* 07/2023	Milestone in progress

Details of Progress:

Sub-action B3.1. Testing of harvested biomass for biogas production.

Biogas production. Public procurement for the rent of bioreactor and photobiofilter were done. Bioreactor started operation on 09/2020 (Fig. 9). From 34 t of algal biomass foreseen in the proposal, currently 1.2 tons of macroalgae biomass from River Nevėžis mixed with manure at the proportion 50:50 was uploaded as substrate for biogas production. Testing of substrate ratio for biogas amount and composition will be assessed in order to increase the efficiency of biogas production. More information is provided in *Annex B3.1*.

Based on Lithuania Republic Law of Environmental Impact Assessment (EIA) No. I-1495 (sec. 11.8), the EIA procedures are not required for short duration non-commercial biogas production in small volume bioreactor such as is used in the project. Explanation of Environment Protection Agency of LT is provided in the *Annex B3.1*.

Fig. 9. System for biogas production: A – macroalgae biomass shredder; B – bioreactor; C – system prepared for biogas production.

Sub-action B 3.2. Testing of macroalgae biomass as natural fertilisers in real-conditions.

Chemical analysis of *Cladophora* biomass revealed algal suitability as fertilisers with high amount of nitrogen in dry biomass, heavy metals were below allowed level. Biomass of

cyanobacteria contained much higher concentration of nitrogen and lower potassium. Four groups of plants are planned to involve into testing: agricultural crops, horticular plants, flowers, energetical plants/forest trees. The strategy of algal biomass testing as fertilizers include several levels:

- *Lab testing*. Pre-testing of seed germination was done in 2020. Larger testing was postponed to spring 2021 due to COVID-19. Auxin coleoptile test with dried and decomposed macroalgae biomass was performed in summer 2020.
- *Testing in greenhouse*. About 1 t ww of *Cladophora* biomass was prepared for testing of seed germination and seedling growth as following: ~ 400 kg dried, ~125 kg frozen, ~125 kg composted with the peat, ~350 kg decomposed in closures. Chemical analysis of macroalgae biomass used for testing as fertilizer was performed. Biomass prepared in different ways and at different concentrations was used to test germination and growth of peas and wheat seedlings in the greenhouse. Testing will be continued in 2021–2022.

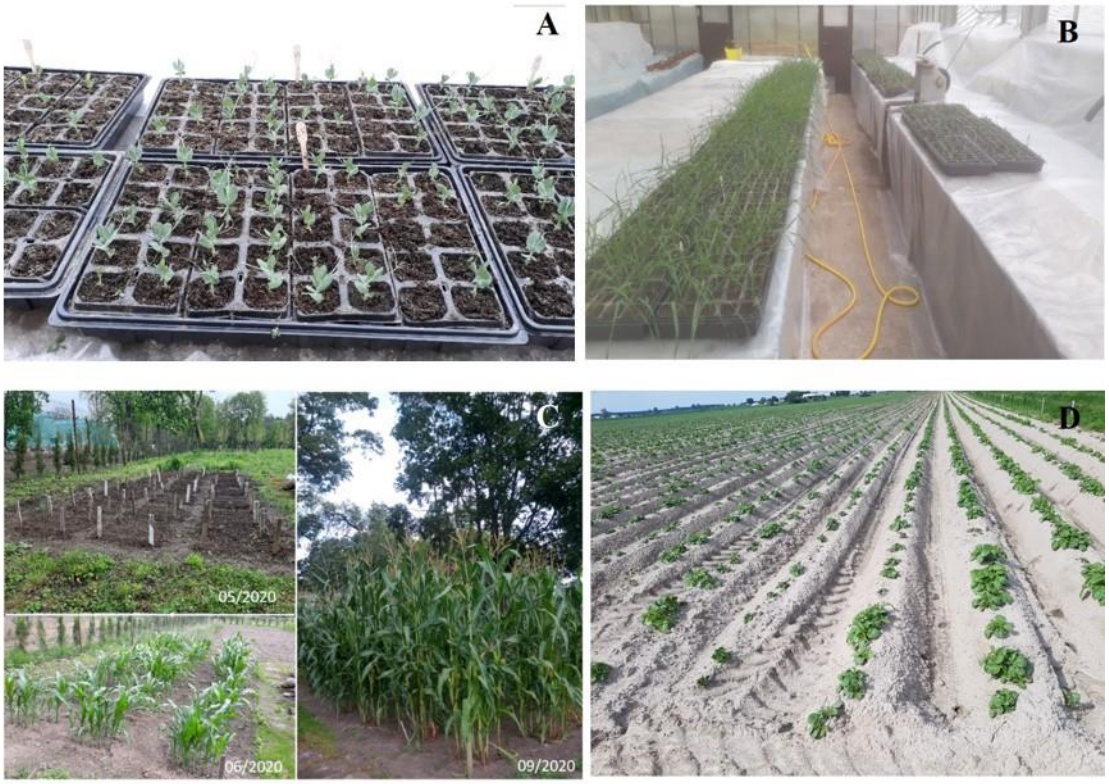


Fig. 10. Macroalgae biomass testing as fertilisers: A Testing of pea seedlings growth; B – testing of peas and wheat germination and growth in greenhouse; C – corn grown in the experimental fields; D – testing of potatoes growth in agricultural field.

- *Field testing on small scale*. Corn plants were grown throughout the growing season in the testing field of 0.5 m^2 area that were enriched with 20% of dried, frozen, composted and decomposed macroalgae biomass.
- *Field testing on large scale*. About 5 tons of macroalgae collected in Lake Oporzyńskie (PL) in 2018 were applied for testing growth of potatoes and barley (6 different testing sets). Macroalgae biomass increased the yield of barley and potatoes more efficiently than organic manure or mineral fertilizer during the first field testing in Poland.

For declaration of market-friendly bioproduct, consultations with the representatives of The State Plant Service under the Ministry of Agriculture concerning ecological fertilisers from macroalgae biomass was started on 08/2020. An additional expert on plant growth and

fertilisation was accepted in the letter from project adviser (16/04/2020) and was hired since 06/2020 by NRC (*Annex 1*). Collaboration for macroalgae biomass composting was agreed with the enterprise "Juknevičiaus kompostas", whereas for application algae biomass for energetical tree plantations – with the LIFE project *NutriBiomass4LIFE*.

Sub-action B 3.3. Testing of cyanobacteria and macroalgae biomass extracts for valuable bioproducts.

About 7 kg of cyanobacteria wet biomass from various water bodies was used for elaboration of method of phycocyanin extraction. The process included cell disruption, chemical extraction, protein solution dialysis and filtration. Phycocyanin was successfully extracted from cyanobacteria biomass with dominant *Aphanizomenon flos–aquae* (Fig. 11, A, B). Purity and stability of pigment were tested.

For biomass application to cosmetic various bioactive metabolites (polyphenols, fatty acid, polysaccharides, carotenoids, amino acids, etc.) of macroalgae species (*Cladophora glomerata*, *Ulva flexuosa*) biomass were tested. For creation of commercial products, preparation of algae extracts was done using different extractions methods: microwave-assisted, ultrasonically-assisted, Soxhlet. Various groups of biologically active metabolites with unique multidirectional properties have been found. *In vitro* tests on the antioxidant properties of extracts were carried out.

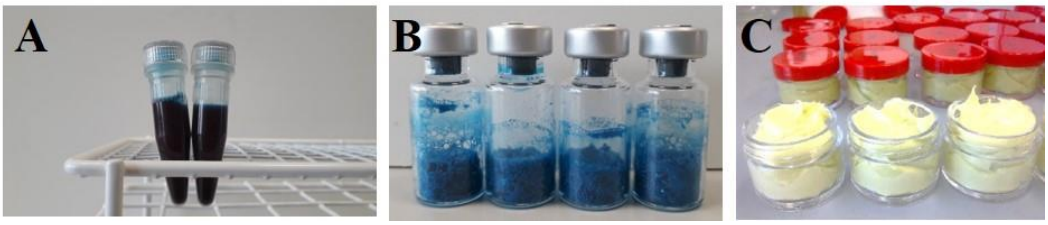


Fig. 11. Phycocyanin extracted from cyanobacteria biomass: A – liquid extract; B – powder, and C – cosmetic emulsions containing *C. glomerata* extract.

Action C 1. Defining of the water quality baseline for all water bodies selected for testing of the prototypes

Summary of project Deliverables and Milestones of the Action C.1

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action C 1			***Start* Q3 2018** ***End* Q3 2023**	***Start* Q3 2018** ***End* Q3 2023**	
C.1.1	Preparation of protocols for water quality monitoring and calculation of the ecological benefits	NRC, INC, AMU, NHF	*Start* 10/2018 *End* 05/2019 *Revised end* 08/2019	*Start* 10/2018 *End* 09/2019	Completed; *Deliverable C1.1*
C.1.1	Defining of the water quality baseline for all water bodies selected for testing of the prototypes	NRC, INC, AMU	*Start* 08/2018 *End* 10/2020	*Start* 08/2018 *End* 10/2020	Completed; *Deliverable C1.2*
C.1.1	Report on water quality monitoring provided with the Mid-term report	NRC, INC, AMU	*Start* 08/2018 *End* 10/2020	*Start* 08/2018 *End* 10/2020	Completed; *Deliverable C1.3*
C.1.3	Preparation of socio-economic assessment strategy	SPILA	*Start* 08/2018 *End* 12/2018 *Revised end* 08/2019	*Start* 08/2018 *End* 03/2020	Completed; *Deliverable C1.4*
C.1.3	Intermediate report on calculation of incomes from bioproducts application	SPILA	*Start* 01/2020 *End* 10/2020	*Start* 01/2020 *End* 10/2020	Completed; *Deliverable C1.5*
C.1.3	Intermediate report on socio-economic impact assessment	SPILA	*Start* 01/2020 *End* 10/2020	*Start* 01/2020 *End* 10/2020	Completed; *Deliverable C1.6*
C.1.4	Report on key project-level indicators of the Webtool provided with the Progress, Midterm and Final report	SPILA	*Start* 10/2019 *End* 07/2023	*Start* 01/2020 *End* 10/2020	In progress
C.1.1	Evaluated efficiency of nutrients and cyanotoxins elimination from aquatic ecosystems	NRC, INC, AMU	*Start* 08/2018 *End* 06/2023	*Start* 08/2018 *End* 06/2023	Milestone in progress

***Details of Progress*:**

Sub-action C1.1. Monitoring of the harvested algae and cyanobacteria biomass impact on nutrient removal and improvement of the water quality.

The NRC, INC, AMU gathered information regarding water quality at selected sites for the LIFE project implementation. For the data intercalibration, the protocols for water quality monitoring and calculation of the ecological benefits has been prepared (*Deliverable C1.1*). Historical and ongoing data from monitoring sites during vegetation season in six Lithuanian (Lake Simnas, Rivers Šventoji, Dubysa, Jūra, Nevėžis, and the Curonian Lagoon by NRC) and five Polish water bodies (Podkamycze ponds, oxbow Tynieckie Circle by INC, Lake Oporzyńskie, River Nielba by AMU) in 2018–2020 were summarized in *Deliverable C1.2*. Data for physico-chemical and biological (Chl-*a*, phytoplankton, macroalgae, species diversity, cyanotoxins, zooplankton, macrophytes) parameters were obtained. Totally, over 9000 of various samples and measurements were analyzed. Based on Water Framework Directive requirements and countries legislation, the data acquired during the project implementation were summarized in the Report on water quality monitoring and provided in

the *Deliverable C1.3.* Further collection and analyses of samples during 2021–2023 will be done to assess changes in physico-chemical and biological parameters compared to the *baseline* period after algal biomass harvesting.

Monitoring studies performed according to the schedule; however, some modifications by inclusion additional water bodies were necessary. Water level in some selected water bodies dropped significantly because of hydrological draught in 2019–2020, therefore new water bodies (Kaunas Reservoir, River Nevėžis in LT; Lakes Łegowskie, River Wełna in PL) were included from the reserve list and tested in 2019–2020. The Podkamycze ponds that are used as a drinking water system for Krakow were closed for any activity because of pandemic Covid-19, therefore they were replaced by Lake Paprocany in 2020. Due to absence of bloom in the Curonian Lagoon during last sampling years, monitoring was also started in Kaunas Reservoir, as an alternative large water reservoir for cyanobacteria harvesting. Monitoring of phytobenthos for water quality in the rivers was replaced by macrophytes survey that is less time consuming and macrophytes are better indicator for assessing effect of macroalgae. The change was communicated in the letter to EASME sent on 05/04/2020 (section 2.1) and accepted by the letter of the project adviser on 16/04/2020.

Sub-action C1.2. Evaluation of proposed distant methods efficiency to define algal agglomerations and the methodology suitability for application for water bodies monitoring.

Activity is in progress. Data from *in situ* measurements of macroalgae agglomerations and Chl-*a* content in cyanobacteria scums are combined with the analysis of UAV images.

Sub-action C1.3. Evaluation of the biomass harvesting costs using prototypes, possible incomes from bioproducts and monitoring socio-economic effects.

Questionnaire for the cost assessment was prepared and include two general cost types: investment and operation & maintenance. The following cost elements data such as material and energy use, maintenance, labour expenditure, discharges/emissions to the environment, management of waste and sales revenue will be collected.

Initial calculation of incomes from bioproducts application, mainly use of biomass as slow release fertiliser based on partners from AMU data, is presented in the Intermediate Report (*Deliverable C1.5*). Concerning monitoring socio-economic effects of the proposed technology, first searches of the existing monetised assessment of potential environmental/social effects of the biomass harvesting started. Firstly, Lithuanian contingent and other type valuation studies, devoted to the ecosystem services and/or environmental status change assessment studied to extract monetised values, which potentially might be applied for the project. Intermediate Report is provided in the *Deliverable C1.6*.

Sub-action C1.4. Monitoring of key project-level indicators.

Required data were filled on online LIFE programme system KPI web tool and submitted to EASME on 12/2019 prior 1st Progress Report. Selection of proper indices and information has been discussed and filled to the system after consultations with project Monitoring expert. KPI targets are described and deviations justified in Section 7 of this report.

Action D1. Raising awareness and dissemination of the project results on national and international levels

Summary of project Deliverables and Milestones of the Action D.1

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action D.1			***Start* Q3 2018** ***End* Q3 2028**	***Start* Q3 2018** ***End* Q3 2028**	
D 1.1	Communication plan	NHF	*Start* 08/2018 *End* 09/2018 *Revised end* 07/2020	*Start* 08/2018 *End* 07/2020	Completed; *Deliverable D1.1* *Annex D1.1*
D.1.1	Four training seminars in LT and PL	All partners	*Start* 06/2020 *End* 09/2022	*Start* 06/2020 *End* 09/2022	In progress; *Annex D1.2*
D.1.1	Networking	NRC, AMU, INC	*Start* 08/2018 *End* 08/2023	*Start* 08/2018 *End* 08/2023	In progress; *Annex D1.3*
D.1.2	Website, mobile application and social networks	NHF	*Start* 08/2018 *End* 07/2028	*Start* 08/2018 *End* 07/2028	In progress; *Annex D1.4*
D.1.2	Notice boards erected	NHF	*Start* 10/2019 *End* 09/2020	*Start* 10/2019 *End* 06/2021	In progress; *Deliverable D1.2*
D.1.2	Handout materials	NHF	*Start* 10/2018 *End* 09/2021	*Start* 10/2018 *End* 09/2021	In progress; *Deliverable D1.3*
D.1.1	Training seminars accomplished	All partners	*Start* 06/2020 *End* 09/2022	*Start* 06/2020 *End* 09/2022	Milestone in progress
D.1.1	Networking with EU projects developed	NRC, AMU, INC	*Start* 08/2018 *End* 07/2023		Milestone in progress
D.1.2	LIFE attribute materials and handouts prepared	NHF	*Start* 10/2018 *End* 09/2021	*Start* 10/2018 *End* 09/2021	Milestone in progress
D.1.2	Maintenance awareness and results dissemination through websites and media	NHF, NRC, INC, AMU,	*Start* 07/2019 *End* 07/2023	*Start* 08/2018 *End* 07/2023	Milestone in progress
D.1.2	Project website, mobile application, social networks created, activated, functioning	NHF	*Start* 08/2018 *End* 07/2028	*Start* 08/2018 *End* 07/2028	Milestone in progress

***Details of Progress*:**

Sub-action D1.1. Dissemination project results threw communication.

As foreseen in the project proposal, 1st version of **Communication plan** was prepared on 09/2018 and revised on 06/2020 addressing comments provided by EASME (*Deliverable D1.1*). Indicators of progress of communication activities are provided in *Annex D1.1*.

Training seminar for stakeholders together with demonstration of harvester AS-S in River Šventoji was organized on 12/08/2020 in Anykščiai (https://algaeservice.gamtostyrimai.lt/communication-event-demonstration-of-algae-harvesting-in-the-river-sventoji/). Forty-one participant from different institutions took part in the seminar (*Annex D1.2*). Project partners presented not only the aim of the project, tasks and activities, but also ecological conditions and status of biodiversity in River Šventoji, ArcGIS application "Mark an algal blooms in water bodies!", use of distant methods for evaluation of macroalgae blooms in River Šventoji and operation of harvester AS-S prototype for collection of macroalgae and cyanobacteria (Fig. 12). Two presentations (one on-line via ZOOM platform) were presented by the project partners from Poland. The second part of the seminar was dedicated for the demonstration of distant methods in the field using unmanned aerial systems and demonstration of macroalgae

harvesting using the prototype AS-S in River Šventoji. Feedback from 10 participants about the seminar have been gathered by special electronic questionnaire and analysed.

Networking was launched with five EU projects from 5 foreseen in the Communication plan. Partners participated at 7 networking events from ten foreseen. Networking with following EU projects has been launched: i) *COSTAL BIOGAS*: exchange of information on biogas production from macroalgae, presentation of AS-S prototype at manufacturing site and oral presentation at annual conference of the project; ii) *NutriBiomass4LFE*: agreement to apply algal biomass to grow biomass plantations; iii) *Building LIFE Capacities in Lithuania*: taking part in 4 organised events, providing information for press release, informational papers, video of advertising LIFE projects; iv) Horizon 2020 project EOMORES: tools developed are used for the analysis; v) *NUTRIMAN*: questionnaire on nutrient management, involvement in the database of projects dealing organic fertilisation. Networking opportunities and projects' cooperation was discussed with following projects *Life EcoSens Aquamonitrix*, *IDEA*, *MicroBiorefine*, *CYANO* and representatives of *Riga Technical University* (Latvia), *Sofia K. Ohriski University* (Bulgaria), Institute of Aviation (Warsaw, Poland). The NRC, AMU and INC took part in LIFE project networking events *Baltic Networking Meetings* (2018, 2019) and LIFE days in Warszawa (2019). Three project proposals for networking was submitted by NRC with partners from different EU countries: i) *Baltic-TransEco* to Swedish Institute, Baltic Sea Cooperation program (submitted 02/2019); ii-iii) two COST actions *CyanoAction* and *ALBIOME COST* (submitted 09/2019, resubmitted 11/2020) (*Annex D1.3*).

Fig. 12. The training seminar in Anykščiai on 12/08/2020.

Sub-action D1.2. Dissemination project results threw social networks, media and printed materials. **Website** containing all the information about the project, its results and communication outputs has been launched on 01/2019 in three languages. The project website (https://algaeservice.gamtostyrimai.lt/) was updated regularly with the information about events that took place or are still upcoming. There are 256 unique visitors from 500 foreseen in KPI and 1075 visits of the project website. **ArcGIS application** "Mark a blooming water body" (https://arcg.is/0jqvCn) have been created. This mobile application is designed to mark locations of blooming water bodies. The information gathered is used for data analysis according to the distribution of locations of blooming water bodies. In parallel, **Interactive map** (https://arcg.is/1v5faT) of ArcGIS application with the distribution of blooming water bodies has been created. This helps for further promotion of ArcGIS application, to control the quality of gathered data and to define water basins where measures to decrease load of nutrients have to be applied first. It will allow to plan continuation of activities after LIFE project. To date, 85 blooming water bodies in LT and 80 in PL have been marked.

Questionnaire "Water blooms" (https://bit.ly/2LnUa9J) has been created in EN (04/2020), in LT (06/2020) and PL (08/2020) languages to conduct a study on the knowledge about water blooms. 65 feedbacks have been acquired, promotion to EU countries will continue from next season. **Quick Response** (QR) **codes** were generated for the project website, mobile application, interactive map and questionnaires and are used on all printed materials (leaflets, notice boards, etc.). Furthermore, accounts and profiles of the project in **social networks** (Facebook, YouTube channel and ResearchGate) have been created and serve as an additional communication tool for reaching wider public and scientific community. There are 83 views in Youtube of uploaded video promoting project idea. Also 7 posts (19 likes) were uploaded to the Facebook profile. 6 publications with total 610 reads, 7 followers were uploaded to the ResearchGate. Three out of 5 foreseen **notice boards** have already been erected in strategic places accessible to the public near Rivers Šventoji and Nevėžis, Lake Simnas (*Deliverable D1.2*). These notice boards are near the places where the activities of testing, demonstration and harvesting of algae are performed. They include short project description for visitors explaining the threats of excessive biomass of algae and importance of algae harvesting in particular water bodies as well as the application of algal biomass into valuable bioproducts. Also, they include additional, promotional information via QR codes and links. Due to the postponed harvesting activities in Kaunas Reservoir and the Curonian Lagoon notice boards will be erected till 06/2021.

Handout materials. Project **leaflet** has been produced (100 copies in EN, 200 in LT). In addition, 200 copies in PL, 100 copies in EN have been published by Polish partners. About 55 leaflets have been distributed during the training seminar in Anykščiai, also for various stakeholders (administrations of Vilnius municipality and Kuršių Nerija national park, parishes of Simnas and Babtai, business enterprises, etc.). The **attributive materials** (300 units of notebooks, folders, pens) have been produced. Part (41 units) of attributive materials has been distributed for participants of demonstration event in Anykščiai while others will be distributed during the upcoming project events. Preliminary results reached during the first half of the project will be published in the **brochure**. Deadline of production of brochure is 06/2021. **Roll-up stand** has been produced to advertise the project at various events (*Deliverable D1.3*). Creation of **video clip** has been started (deadline 12/2021). Video material was collected in River Šventoji and Širvinta, Lakes Simnas and Dusia as well as during the training seminar and demonstration event with stakeholders in Anykščiai.

Media and printed materials. In total 7772 reads were achieved by nine popular papers published in **news portal**s (6), **newspapers** (2) and **journal** (1). The aims of these popular papers were not only to acquaint public with the problems and dangers of algal blooms in water bodies but also to promote the ongoing project. Three **interviews** in news portals (lrytas.lt and lrt.lt) have been published. One of these interviews contains video material. These portals do not provide any publicly available statistics of views or visits, nevertheless these portals are very popular in Lithuania. Also, representatives of project partners participated in 3 **seminars**, 4 **workshops** and 3 **social events** (more than 210 participants attended). During the seminars and workshops 4 oral presentations have been given. Their topics included innovations of the renewable energy, water and health, Baltic networking, etc. One of the workshops organized in the Poland was dedicated for training of PhD students (40 participants). Social events were organized for pupils and general public. Additional promotion of the project activities has been carried out via advertisements on **websites** of different institutions (State Service for Protected Areas under the Ministry of Environment, Education Development Centre, etc.).

All activities carried out in Action D1 and the effectiveness of dissemination of project results expressed through indicators is presented in the *Annex D.1.4*. All dissemination outputs of the project contain LIFE and project logo according the LIFE programme requirements.

Action D.2. Replication and transfer of the project results

Summary of project Deliverables and Milestones of the Action D.1

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action B.1			***Start* Q4 2018** ***End* Q3 2023**	***Start* Q4 2018** ***End* Q3 2023**	
D2.1	Layout of the replicability and transferability strategy	NRC, INC, AMU	*Start* 10/2018 *End* 12/2018 *Revised end* 08/2019	*Start* 10/2018 *End* 08/2019	Completed; *Deliverable D2.1* *Annex D2.1*
D2.4	Ten national and international conferences	NRC, INC, AMU	*Start* 08/2018 *End* 07/2023	*Start* 08/2018 *End* 07/2023	In progress *Annex D2.1*
D2.4	Five publications prepared submitted	NRC, INC, AMU	*Start* 08/2018 *End* 07/2023	*Start* 08/2018 *End* 07/2023	In progress; *Annex D2.1*

Details of Progress:

Sub-action D2.1. Defining strategy on planning for maintaining the project actions and results.

Final version of the **Layout of the replicability and transferability strategy** was prepared on 08/2019 (*Deliverable D2.1*). The delay was approved by EASME in the letter from the project adviser received on 09/09/2019. (ANNEX 1).

For the transfer of acquired experience, two **project proposals** related with the LIFE project were submitted. The NRC acts as a partner in *EUREKA* – ECO-AQUA-RECYCLE (Promoter – Lithuanian University of Heath Science). Currently, application passed the quality threshold to be considered for funding. The second proposal to *Baltic Research Programme* – ECo-CC (LT-LV-EST-NO, Promoter – Klaipėda University, partner – NRC) seeks to apply modelling for evaluation of nutrient balance is under evaluation.

For implementation, replication and extending of project activities, over 20 meetings with **target stakeholders** took place (details provided in *Annex D2.1*). In cooperation with the *Health Education and Disease Prevention Center (Ministry of Health)*, the recommendation to policy makers for the changes of Lithuanian Hygiene Norm HN92:2018 related with cyanobacteria blooms was provided and currently is under consideration by lawyers. Information on application macroalgae as fertilisers has been published in the brochure of the Ministry of Agriculture of the Republic of Lithuania. An issue of macroalgae certification was discussed with The State Plant Service under the Ministry of Agriculture (LT). Experts from the State Forestry Enterprise contacted due to application of algal biomass for reforestation. Contacts have been established with Institutions of protected areas (Žuvintatas State Reserve, Kuršiu Nerija National Park, Anykščiai Regional Park) and municipalities (Anykščiai, Simnas and Babtai) in the sites of the project activities implementation.

For further development of products created during the project discussions with the business companies have been performed. The Yacht club at Kaunas Reservoir express willingness to apply harvesting of cyanobacteria scums to increase cleanliness and attractiveness of the area. Possibilities of application of algal biomass as fertilisers was discussed with two business companies and farmers. Number for key stakeholders were invited to Demonstration event in Anykščiai. In Poland, the general assumptions of the project and the possibilities of using algae biomass have met with great interest of representatives from agricultural companies during conference-workshop "*Chemistry for Agriculture in Karpacz"*. The AMU established contacts with agricultural companies, recognized their expectations and interest in the use of macroalgae biomass in crops cultivation. The AMU established contact with Wągrowiec municipality due to issues of the water quality in the region.

Sub-action D2.2. Defining replicability and transferability strategy of extending the prototypes and distant methods application to a larger scale within the project countries and possibly in other EU countries.

In project proposal, distant methods were foreseen to be developed only in Lithuania. With EASME permission communicated in the letter from the project adviser (16/04/2020) (ANNEX 1), the INC PAS (PL) re-allocated some costs for the implementation of new task "Analysis of cyanobacterial and algae blooms with the help of aerial photography" and this way extended geography of the task implementation in sub-action B1.2. Agreement for service was signed with the Institute of Aviation, Warsaw. The project amendment allows broadening the final achievement in the project and applying distant methods for monitoring of water quality in another EU country.

Sub-action D2.3. Identifying the conditions necessary for industrial scale-up and commercial replication of the proposed technology. Activity not started.

Sub-action D2.4. Transfer of the project results to scientific community.

In the project proposal, 10 **scientific conferences** were planned, but partners from NRC, INC, AMU already participated at 14 international scientific events. Additional budget for conferences was acquired from other foundations. More than 2400 participants attended these conferences. Topics of conferences were diverse: phycology, chemistry for agriculture, environmental fate and safe water supply, toxic cyanobacteria, limnology, etc. 9 poster and 8 oral presentations have been given during these conferences. Three **scientific articles** from 5 foreseen have been published: i) Koreivienė J. et al., 2019. *Botanica*, 25(2): 176–185; ii) Koreivienė J. et al., 2019. *Botanica*, 25(1): 65–73; iii) Korzeniowska K. et al., 2020. *Algal Research*, 48:101912. The content of two articles is directly related with activities foreseen in the project. In total, articles have 575 reads, 2 citations and 10 recommendations (according ResearchGate). All activities carried out in Sub-action D2.4 are presented in the *Annex D2.1*.

Action E.1. Project management and monitoring of project progress

Summary of project Deliverables and Milestones of the Action E.1

Sub-action	Short Activity title	Partner	Foreseen dates	Actual dates	STATUS of progress; output
Action C.1			***Start* Q3 2018** ***End* Q3 2023**	***Start* Q3 2018** ***End* Q3 2023**	
E1.1	Green procurement guidelines for public and non-public bodies	All partners	*Start* 08/2018 *End* 09/2018	*Start* 08/2018 *End* 09/2018	Completed; *Deliverable E1.1*
E1.1	Preparation of the Steering Committee constitution and launching agreements	NRC	*Start* 08/2018 *End* 12/2018	*Start* 08/2018 *End* 02/2019 *Updated* 11/2019	Completed; *Deliverable E1.2*
E1.1	Intermediate financial audit report	NRC	*End* 12/2020	*End* 09/2020	Completed; *Deliverable E1.3*
E1.1	Steering Committee constitution agreed	NRC	*Start* 08/2018 *End* 12/2018	*Start* 08/2018 *End* 11/2019	Milestone completed
E1.2	Project results presented in three progress reports	NRC	*Start* 08/2018 *End* 12/2019	*Start* 08/2018 *End* 12/2022	Milestone in progress

Details of Progress:

Subaction E1.1. Management group and action leaders' meetings to discuss on-going project activities and solve troubleshooting.

Communication with the project partners was organised via direct or online meetings with all partners, only LT partners, or with a particular partner, and by e-mails or phone.

Introductory meetings of LT partners (07/2018, 09/2018) and the kick-off meeting of all partners took place at NRC (08/2018) to discuss project activities and partnership agreements. Eight project progress meetings of Management Group (MG) took place every quarter (12/2018, 03/2019, 05/2019, 09/2019, 12/2019, 03/2020, 06/2020, 08/2020) to update achievements in the project and to discuss issues occurred. LT partners meet at NRC and join on-line with the partners from INC and AMU. Technical and financial reports for the reporting period were prepared. Partners approve prepared to EASME deliverables by voting. Eleven bilateral NRC and BE meetings were organised for acquiring information on algal agglomeration by visiting selected water bodies in PL and LT (08-09/2018), to discuss harvesting technologies and sketches of prototypes or biomass harvesting issues, logistics (12/2018, 04/2020, 05/2020, 08-09/2020). Socio-economic strategy and deliverables were discussed with the SPILA (10/2019, 10/2020), whereas dissemination materials with NHF (03/2020, 05/2020). Due to restrictions related with COVID-19, mainly online meetings were organized during the periods 03-06/2020 and 09-10/2020. Mid-term meeting of the project partners in Krakow was planned on 09/2020, however it was moved to summer 2021 due to COVID-19 and combined with the demonstration event. To manage the risk, the special agreement with hotel was made which allowed flexibility of the meeting date. Green procurement guidelines of each project partner as public and non-public bodies have been prepared (*Deliverable E.1.1*).

Communication with supervising institutions. The Coordinator and financier of the project participated in LIFE kick-off meeting in Brussels (11/2018). Monitoring experts from NEEMO were invited to project partners kick-off meeting (08/2018), were hosted for the annual check. The NRC provided the requested documents for verification and the reports (07/2019; 08/2020; 11/2019). Partners addressed all remarks provided by EASME. Adjustments and changes necessary to the project implementation were reported to EASME during annual monitoring visits, together with 1st progress report or via separate letter. The NEEMO expert was consulted concerning sub-action C1.3 implementation and for filling of KPI in the on-line system (12/2019). Communication with EASME concerning information correction of the official project page was performed, however one of the project partners (INC) is still missing.

Steering Committee (SC) constitution was completed, agreements launched with the particular representatives on 01/2019 (*Deliverable E1.2*). Setting-up of the SC slightly delayered from foreseen schedule due to getting responses from some institutions because of non-expected political changes. One per year meeting was foreseen in the rules and procedures of the project SC. First meeting was organised on 11/2019, the second is foreseen on 12/2020. The head of the Steering Committee was invited to the meeting of annual project check in 2020.

Agreement for co-financing between the Ministry of Environment of LT and the NRC was sign on 04/2019. Documents for the 1st and 2nd LT prepayment provided to co-financier (09/2019, 09/2020), pre-payments were delivered to the partners. Accounting office of NRC gathered financial reports for the period 01/08/2018 to 30/05/2020 and prepared Consolidated financial statement of all project partners. Auditing of LT project partners financial reports for the second prepayment of the LT co-financier was performed (*Deliverable E1.3*).

Sub-action E1.2. Preparation of 3 Progress reports, Mid-project report and Final report of the project. 1st Progress Report was prepared and after adjustment with the monitoring expert provided to EASME on 30/12/2019, respecting the submission deadline.

Sub-action E1.3. Preparation of the After-LIFE Plan. Activity not started.

5.2. Evaluation of Project Implementation

The project has been implemented following activities and methodologies foreseen in the project proposal. The necessary corrective actions and problems encountered are described in Section 6.2. The cost-effectiveness of the activities implemented in general is satisfactory. Delays that occurred in some activities did not affect the project progress negatively. The shift of some periods of activity's implementation is shown in the Section 9 of the report.
Several methodological adjustments were made to achieve project results more effective and to increase the cost-efficiency of the activities: i) reconsidering of some technological solutions for harvesting algal biomass by prototypes; ii) macrophyte parameters instead of phytobenthos were chosen for assessment of water quality; iii) extending UAV analysis by joining the partners from Poland to contribute *in situ* data for preparation refinement of monitoring programs in both countries; iv) an expert for macroalgae biomass testing for fertiliser was hired to strengthen implementation of Action B3. EASME accepted those project adjustments in the communication letters received on 09/09/2019, 17/04/2020 and 07/09/2020.
The assessment of the results achieved against the objectives and the expected results foreseen in the proposal is provided in the Table 4.

Table 4. Assessment of objectives and expected results.

THE RESULTS ACHIEVED AGAINST THE OBJECTIVES AND EXPECTED RESULTS FORESEEN IN THE PROPOSAL		
Objective: To demonstrate integrated efficient management of nutrients and algal nuisance blooms at the catchment scale by harvesting of cyanobacteria scums and macroalgae mats in various types of water bodies (rivers, lakes and the Curonian Lagoon). **Action 1 and Action 2 are involved.**		
Expected result	**Achieved**	**Evaluation**
Manufactured two prototypes for harvesting different type of algal agglomerations: cyanobacteria scums and macroalgae mats in various types of aquatic ecosystems.	The AS-S prototype having dual application to collect macroalgae & cyanobacteria was manufactured, tested and started operation. The AS-L prototype manufacturing is in progress.	BE partner is seeking to find the best technological solutions; therefore, the prototypes undergo some modifications to increase the efficiency and suitability to water bodies.
Demonstration and testing of biomass harvesting prototypes for 500 operation hours *in-real* conditions and totally collection up to 7.8 t of cyanobacteria and up to 72.8 t of macroalgae biomass.	From foreseen 334 h for the AS-S operation, macroalgal biomass was harvested for 60 hours; 80 kg of cyanobacteria and 14.25 tons of macroalgae wet biomass was collected.	The AS-S operated 18% of time foreseen in the project. Collected amount of biomass constituted 1% of cyanobacteria and 19.6% of macroalgae foreseen in the project.
Preparation and validation of the methodology for evaluation of algae agglomerations in inland aquatic ecosystems *in situ* applying distant methods.	Methodology for evaluation of algae agglomerations using UAV was prepared. Factors conditioning errors will be eliminated during the validation process. Based on methodology and *in situ* measurements, it was calculated that in 33.6 km of the LT rivers macroalgae totally cover 270 m^2 and constitute 10755 tons. The satellite images	Complete methodology for evaluation of agglomeration by distant methods will contain two parts: UAV images and satellite images analysis. To date, UAV images analysis of LT water bodies was prepared. Joining the INC partner will strengthen the cyanobacteria analysis using UAV in both countries. The methodology using satellite images

	analysis is in progress.	analysis will be prepared till the end of 2022.
Guidelines for refinement of monitoring program for the inland water bodies, and proposed new solutions for mitigation of nutrients from non-controllable sources in the catchment to improve water quality.	Monitoring protocol for the water quality baseline was prepared, over 9000 samples were analysed and summarized in two deliverables.	Guidelines for refinement of monitoring program will be continued based on the water quality analysis data, the methodology prepared based on results of distant methods and water quality validation. The results are in progress.
Evaluated and validated ecological benefits: up to 15 t of CO_2 reductions, elimination up to 50 kg nitrogen and 3 kg phosphorus, up to 0.38 kg of cyanotoxins from aquatic ecosystems.	To date, 4.7 kg of P, 38.3 kg of N, 0.26 g of cyanotoxins were eliminated. Calculations are based on data of algal dw biomass and chemical analysis of biomass. 2.43 t of CO_2 were incorporated into collected biomass, but emissions by harvester is under evaluation.	Currently, P, N and cyanotoxins elimination constitute 151%, 77% and 0.07 % of the amount foreseen in the KPI. Estimations revealed higher amounts of N, P compounds and cyanotoxins in algal biomass. Elimination of cyanobacteria biomass in water bodies can substantially increase safety of the water used for drinking or recreational purposes.
Established replicability and transferability strategy of the prototypes broader employment, transfer of technical knowledge, outcomes obtained.	Layout of replicability transferability strategy was prepared; target stakeholders were contacted; results were introduced during conferences, networking and demonstration events; new project proposals have been submitted.	A lot of effort has been put to replicate and transfer project results. Major success is the submitted EUREKA project application that already passed the quality threshold to be considered for funding.
Objective: To test and demonstrate the redesigning of waste biomass of cyanobacteria and macroalgae into potential valuable products for sustainable management and recycling of environmental resources. **Action 3 and Action 4 are involved.**		
Expected result	**Achieved**	**Evaluation**
Validated efficiency of biogas production by testing up to 34 t of harvested pure algal biomass and in combination with other biodegradable biomass.	Activity started in 2020. 1.2 tons of macroalgae was mixed with manure for biogas production.	Different substrate ratio for biogas amount and composition will be assessed in order to achieve the highest efficiency of biogas production.
Validated suitability of collected cyanobacteria/macroalgae biomass (about 27 t) as slow-release fertilisers and growth activity promoters for plants.	Overall, 6 t of macroalgae have been applied for testing as fertilisers at four different levels: laboratory, greenhouse, experimental fields and fields.	Positive results were obtained, however more testing is necessary for the reliable results.
Determined and validated market-friendly product obtained from the harvested cyanobacteria and/or macroalgae biomass.	Two products: biomass as biofertilzer and phycocyanin are tested as market-friendly product.	More testing is needed to select the most valuable product. Certification possibilities to use biomass as biofertilizer is under consideration.
Objective: To raise awareness to environmental, water quality and health hazard issues among the national governments, local authorities, the business community and society for the continuation and transfer of proposed measures application on a broader scale after the end of the Life project. **Action 5 involved**		
Expected result	**Achieved**	**Evaluation**

Developed and implemented project communication and results dissemination plan.	Performance indicators and measures were defined in prepared Communication plan.	The plan is actively implementing: 8 indicators are achieved, 8 - in progress of 22 indicators foreseen.
Increased public awareness on eutrophication, algal blooming and their biomass sustainable use.	The issues were presented at 9 interviews and papers, 14 scientific conferences, etc. The questionnaires about blooms and ArGIS application to mark water bodies have been created.	In total, over 2.6 thous. people participated in these events. Papers, interviews achieved over 8 thous. reads and views, 160 blooming lakes were marked, 65 feedbacks to questionnaires were received.
Expected results of summarising project achievements. **All Actions involved**. Below the expected project results which will become visible after the implementation of the project activities are provided, because they are only in data collection stage: • Assessed socio-economic effect of water quality improvement measures and proposed biomass harvesting technology; • Developed business opportunities plan for the proposed technologies: supply chain from biomass harvesting to its application for industrial use; • Project Life Cycle Assessment: evaluation of the ecological service cost and benefit from algae biomass application; • Elaborated After-Life plan for replication and transfer of project achievements.		

Project added value. The **replication and transfer efforts** of the project results were defined in the *Deliverable* "Layout of the replicability and transferability strategy". Currently the focus is on further use of manufactured prototypes, monitoring system, and bioproducts.

The manufactured AS-S prototype operation has been shown during the demonstration event to the representatives of LT governmental institutions responsible for implementation of River Basin Management Plan. Representatives from Kaunas municipality expressed interest to apply the technology for cyanobacteria harvesting in order to improve bathing water quality in Kaunas Reservoir. The project COSTAL BIOGAS interested in the possibility to use AS-S prototype to harvest drifted macroalgae biomass to the sea shore or to collect microalgae in inland waters of Denmark. A virtual tour about AS-S was presented at the project COSTAL BIOGAS annual conference (09/2020), also during other conferences and workshops. More results on harvesting efficiency of algal biomass are necessary to continue the to conclude the debate on this issue.

Developing monitoring system of water blooms using distant methods a cooperation with Horizon 2020 project EOMORES for applying created by them tools to evaluate blooms not only in the Curonian Lagoon as foreseen in the proposal, but also to Kaunas Reservoir was discussed. The Kaunas Reservoir was selected from the reserve list because of absence strong cyanobacteria blooms in the Curonian lagoon over the last two years. An international project proposal ECo-CC was submitted to explore new ways to control eutrophication in coastal and inland waters of the Baltic States through biomass harvesting and to disclose how future climate scenarios could impact the efforts in reducing the nutrient.

The replication efforts were focused on stakeholders from agriculture sector. Macroalgae biomass increased the yield of barley and potatoes more efficiently than organic manure or mineral fertilizer during the initial field testing in Poland. The results of algae biomass application were met with great interest by agricultural and industrial companies at two forums "Chemistry for Agriculture in Karpacz". The beneficiary AMU established contacts with companies, identified their expectations on macroalgae biomass use for crops cultivation. In partnership with NutriBiomass4LIFE (LT) algal biomass is expected to be used to grow the biomass plantations. Also, the representatives of the enterprise "Juknevičiaus kompostas" expressed the interest to use algal biomass as a feedstock for compost. The Ministry of Agriculture (LT) announced the project among innovative bioeconomy projects

and included it in the brochure "BIOeconomy in Lithuania: new opportunities for rural areas and agriculture" which is targeted to farmers, entrepreneurs, and craftsmen.
The results of redesign waste biomass into high value bioproducts are focused to broaden the field of sustainable algal biomass use. The Eureka project proposal was submitted to extend the sustainable use of algal biomass by testing possibility of them for creation of functional food for fishes. The proposal passed the quality threshold to be considered for funding.
To extend the implementation of proposed measures in other EU countries, the project proposal "Baltic-TransEco" was submitted to Swedish Institute, Baltic Sea Cooperation program, but it was not approved. To replicate/transfer the proposed measures to target stakeholders is planned when more results on harvesting efficiency and cost will be obtained after prototypes testing and algal biomass suitability as value-added bioproducts analysis. Issues related to algal blooms, water quality, sustainable use of biomass were presented for 2.6 thousand individuals during various events (conferences, workshops, seminars).
Policy impact. The project contributes to the implementation of EU Bathing Water Directive (2006/7/EC). In LT, water quality in bathing sites is monitored mainly based on microbiological parameters, however assessment of cyanobacteria faced difficulties. The discussions with the Head of Environmental Health (EHD) Division under Ministry of Health (EHD) for simplification and optimisation of cyanobacteria monitoring procedures took place. Prepared amendment to Lithuanian Hygiene Norm HN 92:2018 is currently is under consideration with lawyers of the Ministry. The workshop on cyanobacteria blooms with the representatives responsible for bathing water quality from 40 municipalities in LT was organised by EHD.
Preliminary results of macroalgae accumulation and other biota analysis, revealed that the proposed measure can improve the quality of living environment for NATURA 2000 species, increase the stock of salmon fishes, heterogeneity of biotopes and biodiversity. Measure of algal biomass harvesting is in the line with a task "2.2 An EU Nature Restoration Plan: restoring ecosystems across land and sea" implementation of the new EU Biodiversity Strategy for 2030.
To date, there were not met any barriers for project implementation related with policy.

5.3. Analysis of benefits

The project is achieving following general benefits:

- To improve aquatic ecosystem services by reducing amount of nutrients, cyanotoxins with the help of two specialised newly developed prototypes;
- To test possibilities of waste algal biomass application to valuable bioproducts, particularly biofertilizers, biogas, natural dye phycocyanin and use extracts for natural cosmetics;
- *The benefits* of a *circular economy* as well as evaluation of environmental impacts by applying LCA analysis.

Environmental benefits
Direct / quantitative environmental benefits. To the date of mid-term report, the AS-S prototype has been manufactured and started to operate. The AS-S prototype has solar panels which produce electricity power and biodiesel engine for hydraulic systems, instead of traditional diesel engine. These lead to reduction of CO_2 and other hazardous pollutants emissions. During the operation of the AS-S in 2020, amount of electric power (~ 108.98 kWh) produced with solar panels exceeded the values foreseen in the performance indicators (up to 100 kWh/year).
Totally, 14.33 t of macroalgal and cyanobacteria biomass that comprised 17.8% of biomass foreseen was collected. A larger amount of biomass, especially cyanobacteria, is expected to

be collected next year when the AS-S will operate in PL and the AS-L will start operating. Chemical analysis of harvested algal biomass revealed that in biomass is much higher content of phosphorus (P) and nitrogen (N), also cyanotoxins as was foreseen in the proposal. To date, 1.4 times higher amount of P and more than half of intended quantity of N (71.9%) has been removed together with algal biomass from aquatic ecosystems. Therefore, based on KPI indicators better environmental results will be achieved at the end of the project.
Moreover, UAV and *in situ* analysis of macroalgae biomass agglomerations indicated much larger amount of excess biomass in some stretches of the rivers (~11 thous. tones of biomass at 33.6 km of the tested rivers) and revealed much bigger problem in the ecosystems than was expected before the start of the project. The applied distant methods are very valuable, time-saving, ecologically friendly tool to find the target hot spots of algal agglomerations. Unique information from aerial photographs can aid in solutions to emerging challenges in ecological research and management, and they may be further used with supplementary data sets.
14.7 t of CO_2 accumulated in algal biomass is expected to be removed from aquatic ecosystems are foreseen in Performance Indicators. However, CO_2 emitted by the prototype-harvester and for biomass transportation has to be deducted while calculating benefits. More data are necessary to give reliable results. Testing of biogas productions just started, therefore exact numbers the benefits will be provided with the next progress report.
The data obtained throughout all project implementation period will be included into the LCA analysis that will help to quantify more benefits.
Qualitative environmental benefits. The actions implemented so far do not allow a comprehensive evaluation of the qualitative environmental benefits as a larger data set covering a longer period of the service are necessary. Nevertheless, it is clear that in addition to the benefit quantification, qualitative benefits will be described, as not all ecosystem services, which will be improved by the project activities, will be quantifiable. The manufactured AS-S prototype as sustainable technology uses renewable energy and is manufactured for harvesting excess algal biomass for improving water quality and for further creation of valuable products from algal biomass.
Based on the data obtained, much greater visibility of the environmental (eutrophication) problems has already been achieved in the government institutions and the society via various dissemination activities. The created interactive map with marked blooming water bodies is important for the identification of problems in the ecosystems, management of algal blooms, and for involvement of the society in solution of environmental issues.
The application of algal biomass as fertilizes that is under consideration for the certification can be one of the most promising long-term sustainable technology proposed in the project, however, the improvement of the soil by applying algal biomass will give the best results not earlier than after 3-5 years.
We expect to improve water quality, the recreational value of the tested water bodies and to continue the discussion with the governmental institutions on the tools proposed for sustainable water resources management and ensure long-term implementation of technologies, thus addressing EU Directives and The European Green Deal course in general.

Economic benefits
Direct economic benefits can be seen practically in all the project activities under implementation. The biomass collection and the development of products from the harvested biomass will create new working places on the local and regional level. Improved quality of water will also increase water-related recreational activities and tourism. All the benefits will be known and provided at the end of the project, when the LCA and socio-economic assessment will be performed.
The best economic solutions will be included into the *After LIFE Plan* and business opportunities will be highlighted in the *Busines Opportunities Plan* foreseen at the end of the

project. It is reasonable to think that new jobs will be created in some companies that will start to implement the project results. Students preparing the thesis have been involved into the project indirectly and gained new, valuable work-job experiences, skills, network contacts, and developed a professional network to positively impact job.

Social benefits

Humans are an integral part of the environment. Project activities will make cleaner from contaminants, safer and healthier for society living environment. Good quality of waters will help to increase/maintain the employment (e.g. fishermen) and health (good quality of drinking water, less harm for ecosystem and people, better integration because more possibilities of outdoor activity). Socio-economic assessment will cover the mentioned issues.

Replicability, transferability, cooperation

The current project has a high likelihood of transfer because other bioproducts and measures related to the service and technology provided by the project will be developed and tested in another consortium.

The project has a high likelihood of replication as well, because two COST networking projects of related topics are submitted, started cooperation with other EU projects, and governmental institutions (Vilnius and Kaunas municipalities) non foreseen in the proposal are interested in application of harvesting technology in the water bodies. However, the particular contractual agreements need to be discussed and elaborated.

Best Practice lessons

The project *AlgaeService for LIFE* itself already declared willingness to promote best practices in ecological service and the circular economics approach by implementing innovative complex system which has both demonstration and innovation character. Currently, discussions are ongoing with the target stakeholders on some part of the complex system (prototype use in some water bodies of Vilnius. Kaunas municipalities; interest of business companies in using/upgrading biofertilisers from macroalgae), and the final benefits will become apparent at the end of the project or even after its implementation.

Innovation and demonstration value

The project itself has demonstrative character of circular approach: combining ecological service measures with waste redesigning into valuable bioproducts and encourage the search for other innovative solutions for the sustainable use of renewable resources. The proposed new technology such as monitoring of water ecosystems using UAV is a future method, which allows to monitoring water ecosystems faster, cheaper and nature friendly, and can be available for everyone using drones. Following implementation of distant methods, a new cooperation between the PL partners and the Warsaw Institute of Aviation is started. The cyanobacteria harvesting technology as one of possible bloom control method will increase capacities throughout Europe for sustainable management of cyanobacterial blooms. The project also develops a technology of extraction of phycocyanin from wild cyanobacteria biomass that had never been tested before.

Policy implications

The suggested changes in the amendment on LT Hygiene Norm HN92:2018 allow to simplify and optimize procedures of monitoring bathing waters quality based on cyanobacteria parameters in LT and timely identify of health risks in order to ensure safety for humans.

6. Key Project-level Indicators

KPIs have been introduced in the online KPI webtool together with the 1st Progress Report. Two KPI were achieved: i) phosphorus reduction – due to higher actual concentration in the algal biomass; ii) raising awareness – due to active implementation of various activities (Table 5). Six KPI are reaching the value, while 4 indicators are in the beginning of the data collection, therefore reliable data will be provided with the next progress report.

indicator achieved indicator reaching value activity not started

Table 5. KPI indices and their reached impact.

Indicators		**Estimated Impact (absolute values)**	**Reached impact /** % of foreseen
Objective: Improved Environmental and Climate Performance			
Reduction of greenhouse gas emissions (GHG)	CO_2 reduction	14.7 t/5 years	**2.43 t** / 16.5%
Air quality and emissions	Air Pollutants (CO, NOx, PM, NMVOC)	CO up to 0.99 kg/year; NOx up to 0.08 kg/year; PM up to 0,006 kg/year; NMVOC to 0.039 kg/year/	
Reduction of dangerous substances	Cyanotoxins reduction from water bodies	0.382 kg / 5 years in 4 water bodies	**0.26 g** / 0.07 %
Waste management	Cyanobacteria biomass harvested from the Curonian Lagoon	6.5 tones / 3 years	
	Cyanobacteria biomass harvested from lakes	1.3 tones / 4 years	**80 kg** / 6.2%
	Macroalgae biomass harvested from rivers and lake	72.8 t tones / 4 years	**14.25 t** / 19.6%
Water	Phosphorus reduction from water bodies	3.11 kg / 5 years in 9 water bodies (~0.34 kg per water body)	**4.37 kg /**140 %
	Nitrogen reduction from water bodies	49.8 kg / 5 years in 9 water bodies (5.53 kg on average per water body)	**35.8 kg** / 2 years 72%
Energy	Energy from Renewable Energy Sources	Energy up to 100 kwh/year from solar panels; energy up to 1500 kwh/year after algae treatment in bioreactor	**109 kWh** in 2020 from solar panels / 119%
Objective: Improved Nature, Species and Biodiversity			
Improved phytoplankton biodiversity	Reduced biomass of alien and bloom forming cyanobacteria	20% change	
Objective: Communication, dissemination, awareness rising			
Awareness raising	Number of entities/individuals reached/made aware	220 individuals per project	**>10000**
Website	Number of entities/individuals reached/made aware	500 individuals per project	**256**

ANNEXES

I. ADMINISTRATIVE ANNEXES

Annex 1_Project adjustments

II. TECHNICAL ANNEXES

DELIVERABLES

Deliverable A1.1a_Review_devices_used_for harvesting
Deliverable A1.1b_Comparison_water filtration_algae collection_technologies
Deliverable A1.2_Design_technical sketches_AS-S prototype
Deliverable A1.3_Design_technical sketches_AS-L
Deliverable A1.4_Permits_AlgaeService-S operation_Lithuania
Deliverable B1.1_Manufactured AS-S prototype
Deliverable B2.1_Methodical guidelines_evaluation_agglomerations using UAV
Deliverable C1.1_Protocol_water quality monitoring_calculation ecological benefits
Deliverable C1.2_Water quality baseline_water bodies_selected
Deliverable C1.3_Water quality monitoring_water bodies selected
Deliverable C1.4_Socio-economic assessment strategy
Deliverable C1.5_Calculation_incomes_bioproducts application
Deliverable C1.6_Report_socio-economic_assessment
Deliverable D1.1_Communication plan
Deliverable D1.2_Notice boards
Deliverable D1.3_Handout materials
Deliverable D2.1_Layout_replicability_transferability_strategy
Deliverable E1.1 Green procurement guidelines
Deliverable E1.2_Steering Committee_constitution_agreements_documents
Deliverable E1.3_Intermediate financial audit

ANNEXES

Annex A1.1_AS-S prototype user's manual
Annex A1.2_Permission_perform macroalgae harvesting_NATURA 2000 area
Annex B1.1_video_ AS-S_operation
Annex B2.1_Nutrients_cyanotoxins elimination by harvesting
Annex B3.1_Explanation_energy production from biogas
Annex D1.1_Indicators_progress_communication activities
Annex D1.2_Training seminar_stakeholders_Anyksciai
Annex D1.3_Networking
Annex D1.4_Website_mobile application_social networks
Annex D2.1_Replication_transfer project results

FINANCIAL REPORTS

Annex_2_AMU_Mid-term report_Financial Statement_2020-09-30
Annex_3_BE_Mid-term report_Financial Statement_2020-09-30
Annex_4_INC_PAS _Mid-term report_Financial Statement_2020-09-30
Annex_5_NHF_Mid-term report_Financial Statement_2020-09-30
Annex_6_NRC_Mid-term report_Financial Statement_2020-09-30

Annex_7_SPILA _Mid-term report_Financial Statement_2020-09-30
Annex_8_AMU_Financial statement_signed
Annex_9_BE_ Financial statement_signed
Annex_10_INC_PAS_Financial statement_signed
Annex_11_NHF_Financial statement_signed
Annex_12_NRC_ Financial statement_signed
Annex_13_SPILA_Financial statement_signed
Annex_14_ Consolidated_Financial_Statement_AlgaeService_signed
Annex_15_Consolidated_Financial_Statement_AlgaeService