LIFE Project Number

<LIFE16 ENV/ES/000196>

Final Report

Covering the project activities from 01/09/2017[1] to 31/12/2021

Reporting Date[2]

<17/01/2022>

LIFE PROJECT NAME or Acronym

<LIFE ECOGRANULARWATER>

Data Project

Project location:	Andalusia, Spain
Project start date:	<01/09/2027>
Project end date:	<31/10/2020> **Extension date:** <30/09/2021 >
Total budget:	€995,000
EU contribution:	€546,113
(%) of eligible costs:	54.94 %

Data Beneficiary

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[1] Project start date

[2] Include the reporting date as stipulated in part C2 of Annex II of the Grant Agreement

This table comprises an essential part of the report and should be filled in before submission

Please note that the evaluation of your report may only commence if the package complies with all the elements in this receivability check. The evaluation will be stopped if any obligatory elements are missing.

Package completeness and correctness check	
Obligatory elements	**✓ or N/A**
Technical report	
The correct latest template for the type of project (e.g. traditional) has been followed and all sections have been filled in, in English *In electronic version only*	✓
Index of deliverables with short description annexed, in English *In electronic version only*	✓
<u>Mid-term report</u>: Deliverables due in the reporting period (from project start) annexed <u>Final report</u>: Deliverables not already submitted with the MTR annexed including the Layman's report and after-LIFE plan Deliverables in language(s) other than English include a summary in English *In electronic version only*	✓
Financial report	
The reporting period in the financial report (consolidated financial statement **and** financial statement of each Individual Beneficiary) is the same as in the technical report with the exception of any terminated beneficiary for which the end period should be the date of the termination.	✓
Consolidated Financial Statement with all 5 forms duly filled in and signed and dated *Electronically Q-signed or if paper submission signed and dated originals* and in electronic version (pdfs of signed sheets + full Excel file)*	✓
Financial Statement(s) of the Coordinating Beneficiary, of each Associated Beneficiary and of each affiliate (if involved), with all forms duly filled in (signed and dated). The Financial Statement(s) of Beneficiaries with affiliate(s) include the total cost of each affiliate in 1 line per cost category. *In electronic version (pdfs of signed sheets + full Excel files) + in the case of the Final report the overall summary forms of each beneficiary electronically Q-signed or if paper submission, signed and dated originals**	✓
Amounts, names and other data (e.g. bank account) are correct and consistent with the Grant Agreement / across the different forms (e.g. figures from the individual statements are the same as those reported in the consolidated statement)	✓
Mid-term report (for all projects except IPs): the threshold for the second pre-financing payment has been reached	N/A
Beneficiary's certificate for Durable Goods included (if required, i.e. beneficiaries claiming 100% cost for durable goods) *Electronically Q-signed or if paper submission signed and dated originals* and in electronic version (pdfs of signed sheets)*	N/A
Certificate on financial statements (if required, i.e. for beneficiaries with EU contribution ≥750,000 € in the budget) *Electronically Q-signed or if paper submission signed original and in electronic version (pdf)*	N/A
Other checks	
Additional information / clarifications and supporting documents requested in previous letters from the Agency (unless already submitted or not yet due) *In electronic version only*	✓
This table, page 2 of the Mid-term / Final report, is completed - each tick box is filled in *In electronic version only*	✓

**signature by a legal or statutory representative of the beneficiary / affiliate concerned*

1. Table of contents

2. List of key-words and abbreviations

AALTO: Aalto University.
AB: Associated Beneficiary.
AGS: Aerobic granular sludge.
AGT: Aerobic granular treatment.
CB: Coordinating beneficiary.
CIC: Scientist Instrumentation Center of UGR.
DIPGRA: Provincial Council of Granada.
DNA: Deoxyribonucleic acid.
DWTS: Drinking water treatment station.
EEA: European Environment Agency.
EGW: Ecogranularwater.
EIONET: European Environment Information and Observation Network.
ELCD: European Life Cycle Database.
ERP: Enterprise Resource Planning.
EU: European Union.
FB: Facebook.
GA: Grant Agreement.
GEDAR: Gedar SL Company.
HRT: Hydraulic retention time.
ILCD: International Reference Life Cycle Data System.
KPI: Key Project Indicators.
LCA: Life Cycle Analysis.
LCIA: Life Cycle Impact Assesment.
LI: LinkedIn.
MEUR: Million of euros.
NVZ: Nitrate Vulnerable Zone.
OTERO: Construcciones Otero Company.
PCR: Polymerase Chain Reaction.
PLC: Programmable Logic Controller.
RO: Reverse Osmosis.
SBR: Sequencing batch reactors.
SC: Steering Committee.
UGR: Granada University.
WWTP: Waste Water Treatment Plant.

3. Executive Summary

The main objective of the LIFE ECOGRANULARWATER project was to demonstrate the effectiveness of a biological system, until then used only in wastewater treatment, for the removal of nitrates and other pollutants of agricultural origin present in water intended for human consumption. An additional aim was to demonstrate that this water purification process is cheaper and has a smaller carbon and environmental footprint than other systems currently used, such as RO.

The project was carried out between September 1, 2017 and September 30, 2021, taking 11 months longer than initially planned due to circumstances and incidents that occurred during its implementation. On the one hand, problems have arisen internally, due to the intrinsic difficulties of water management in small municipalities, the implementation of an innovative pilot project, as well as the financial difficulties that affected one of the beneficiaries in the middle of the project, with the consequent need to look for a new partner to continue its implementation. On the other hand, externally, the Covid-19 pandemic has caused delays in the implementation of actions due to temporary restrictions imposed on industrial activity and mobility. The request and subsequent approval of the change of partner and the extensions of the time frame, included in two amendments to the AG, have finally enabled the satisfactory completion of all the project actions.

Initially, two preparatory actions were carried out. On the one hand, groundwater samples were collected in order to analyze the hydrochemical characteristics of the water supplying the community. Several parameters were analyzed and specific monitoring of nitrate concentrations was carried out over several months in the light of fluctuating initial results. Knowledge of the groundwater status is essential. On the other hand, laboratory experiences permitted the defining of the best combination of the necessary elements in terms of the design of a full-scale purification plant; for example, dimensions, operating conditions, best bacteria inoculum for stable granular formation, the carbon source selected, optimal concentration, hydraulic retention time, system performance, etc.

When designing the pilot-scale plant, it was decided, after consultation with EASME, to build it in two phases, slightly varying what was foreseen in the proposal. It was found that the dimensions initially described could not produce a sufficient volume of drinking water to achieve the objective of supplying a population of 500 inhabitants. It was therefore decided to first build a bioreactor in (transparent) methacrylate, and when its efficiency and optimum operating conditions had been verified, four more bioreactors out of polyester (less expensive) would be installed in parallel to increase the volume of purified water. From the beginning, photovoltaic solar panels and batteries were installed to provide the electricity needed to operate the biological plant during most of the year.

The start-up of the methacrylate bioreactor also required two stages. The first inoculation with sewage plant sludge proved to be inadequate, mainly due to the difficulty and slowness of granule formation. It was therefore decided to inoculate directly with granules formed in the laboratory, which produced better results. Monitoring of the system also confirmed that the best carbon source is food grade sodium acetate and the optimum dosage was adjusted to maintain nitrate removal efficiency of around 80%. The salts necessary for a complete transformation of nitrates to nitrogen gas were also adjusted.

Once the efficiency of the biological system had been demonstrated with the first bioreactor, when the time came to expand the plant, another change was proposed: instead of installing 4 bioreactors of similar dimensions, a proposal was made to build two bioreactors out of polyester of larger diameter and volume. This way, the efficiency of the system could also be demonstrated with dimensions other than those of the first bioreactor, without affecting the objective of supplying a population of 500 inhabitants.

The installation and start-up of the prototype has been involved numerous difficulties and incidents that have been solved along the way. Both the shortcomings typical of small municipalities and the implementation of innovative technology have presented obstacles for which immediate solutions have been found.

Monitoring of the system has demonstrated an efficiency of around 80% in the elimination of nitrates and over 95% in the elimination of organic matter. Ecotoxicity tests have proven the absence of pathogenic microorganisms in the treated water.

The life cycle analysis performed to compare the impact of producing 1 m^3 of water with both systems (RO and EGW), has shown that the carbon footprint of the biological system is 2.5 times lower than that of the RO, mainly due to lower electricity consumption by the EGW system and lower water consumption with respect to the RO. On the other hand, the analysis of economic and financial costs also corroborates that the cost of making water drinkable with the EGW system is 45% cheaper than with RO.

Since the beginning of the project, a series of works have been carried out to promote the replicability of the technology in other regions. The areas in Europe with nitrate water pollution problems have been identified, with greater detail in the Mediterranean countries. In addition, the economic activities with the highest consumption of drinkable water have been identified. A business plan has been designed, with three stages in the commercialization of the technology and three possible scenarios have been defined for a 5-year time horizon, identifying the impact that its development would have on job creation and income generated in relation with the number of plants installed in other regions.

One milestone that has not been reached in time has been to obtain a health permit for this infrastructure. At the date of completion of the project, the health report request file is still open. The competent health authority has requested amendments that are being responded to by the Municipality of Torre Cardela with the support of DIPGRA and the project partners. Among the requirements is the designation of head of treatment. In this regard, the Town Council does not have the required human resources and the Granada Provincial Council is taking steps to provide the necessary technical support. The permit is expected to be obtained in early 2022.

In terms of dissemination, all the project's progress has been published mainly through the web page www.lifeecogranularwater.com and through the 10 distributed periodical bulletins. Two documentary videos and two commercials have been produced. Two technical conferences have been held to disseminate the project, one two years after its inception and the other at the end of the project. In addition, there has been participation in numerous technical-scientific events on specialized topics and scientific papers have been published. Contact has also been maintained with other LIFE projects that promote other techniques to eliminate nitrates from water, in order to exchange experiences. A technical operating guide and the Layman report have been published, allowing the technology to be disseminated to different target audiences.

The partners have agreed on a strategy to give continuity to the project, mainly to permanently integrate the plant into the Torre Cardela DWTP and to replicate the project in other regions, initially at the provincial level and subsequently further afield.

4. Introduction.

Groundwater pollution by nitrates and pesticides is important on a European level as groundwater is used as drinking water by roughly 75 percent of the population. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption establishes the nitrate concentration limit for water intended for human consumption at 50 mg/l and a limit of 0.10 mg/l for nitrites. In the case of pesticides the value established for total pesticides is 0.50 µg/l and, for individual pesticides, 0.10 µg/l, with the exception of aldrin, dieldrin, heptachlor and heptachlor epoxide, for which the parametric value is 0.03 µg/l. The municipality of Torre Cardela, Granada, exceeded nitrate concentration limit values, causing the regional health authority to declare the water unfit for human consumption for an extended period in the past.

RO, ion exchange and other methods are used for the removal of nitrates and other pollutants such as pesticides, and while these systems remove nitrates and other pollutants they also involve high-energy consumption, high maintenance costs, brine generation and additional water consumption.

This project proposes an aerobic granular system on the basis that previous lab experiences have offered excellent results in terms of nitrate and agrochemical removal without generating brine and with low investment and operating costs. The innovative aspect of the project lies in the fact that it consists of the development of a biological water treatment system for drinking water supply, the technology previously only having been used for the treatment of wastewater.

In addition, the proposed system is intended to demonstrate that it is more energy efficient and less expensive than other technologies currently available on the market. Furthermore, another objective is to prove that the biological system does not generate waste (brine) as part of the process, since the nitrates are completely transformed into nitrogen gas. Likewise, no waste is generated since the reduced volume of water with organic matter generated by the system in the sand filter is planned to be released to a small artificial wetland for purification.

The proposed technology is based on the use of an **aerobic granular sludge** system in a **sequential batch reactor** in a cylindrical column. The compact structure of the bioreactor and the excellent settling capabilities of biomass are also advantageous as compared to conventional treatments and RO. The granular conformation allows for the presence of a wide variety of microbes and heterotrophic microorganisms in the external rise and the presence of denitrifying microorganisms involved in the denitrification process in the core or internal layers. Granular sludge is formed by the shear force generated by the hydrodynamic movement.

The expected results were:

1. The development of a biological system that enables organic and inorganic pollutant removal (nitrates, phosphates and pesticides) from the groundwater supplying small communities in compliance with Directives 98/83/EU (currently Directive 2020/2184), 2000/60/EU and 2013/39/EU.

2. Demonstration of the feasibility of an energetically self-sufficient pilot-scale plant comprising aerobic granular technology that ensures complete release of nitrogen as N_2, guaranteeing that N_2O greenhouse gas emissions will be zero. Since photovoltaic solar panels and batteries installed in situ will provide 100% of the energy required by the plant, it is expected that the plant's carbon footprint will be zero.

3. Selection of the most efficient carbon source, operational conditions and microbial inocula for this technology, ensuring the removal of more than 90% of nutrients from

the volume of water treated, zero waste generation in the treatment process, and avoiding the discharge of brine into the environment.

4. Production of drinking water with total biosafety from a chemical and biological perspective.
5. Evaluation of the costs, benefits and socio-economic and environmental aspects of this technology as compared to other existing groundwater treatment technologies. A more favourable cost-benefit ratio is also expected, in comparison to other systems, reducing energy consumption by 70%, maintenance costs by 50% (membrane and chemical products) and waste treatment costs by 100%.
6. The drafting of a business plan and the commitment by 15 European-level organisations to installing the proposed purification plant in other areas with similar environmental problems.

An important objective of the project was the **design of a business plan** that allows for replication of the technology in other areas affected by the same problem. The partners will promote the replication of this technology, as it is described in the After LIFE Plan and the Replication and Transferability Plan.

For the design of the business plan, it is necessary to know, through the **life cycle analysis** methodology, the study of the carbon footprint and the environmental footprint, the environmental benefits (reduced energy consumption, reduced water consumption, zero brine generation) that this technology provides in comparison with reverse osmosis. The financial benefits (acquisition and maintenance costs) of this technology compared to other water treatment systems should also be studied. While it will not alter the legally established limits for the pollutants, this biological system will surely represent a more accessible, more attractive solution for small communities and for business activities isolated from a supply network.

The Project also foresees the **generation of several deliverables and the holding of informative events** that will make the technology known among different target groups. The creation of a web page, pages on social networks (Facebook and LinkedIn), the filming of documentary videos and advertising spots, newsletters, brochures and noticeboards among other dissemination tools, as well as the holding of technical informative conferences, make it possible to extend knowledge of EGW biological technology among different target groups: political and technical personnel of public administrations (local, regional and state), companies in the water sector (construction and management companies), academic and research institutions, non-governmental organizations and interested professionals. The project also aims to create networks with other related LIFE projects, to have scientific documentation to support the effectiveness of the technology, to raise awareness of it at scientific technical events at European level, and to publish an operating guide to facilitate its replication in other regions.

EGW technology is intended to be a tool that will help water service managers to comply with the legislation on water quality for human consumption at European level with more favourable economic conditions and a lesser environmental impact than other conventional technologies, such as RO. This is related to better management of the whole water cycle in small municipalities that can help to increase the cost recovery rate of the service, by having a lower cost technology for drinking water treatment. The use of this technology will also reduce the environmental impact of the water treatment process, mainly by reducing energy consumption, reducing GHG emissions and saving water.

5. Administrative part

The CB has been entrusted with project management, for which reason it has nominated a project manager and a financial manager. Each AB has been responsible for project management on an internal level and has maintained direct contact with the coordinator.

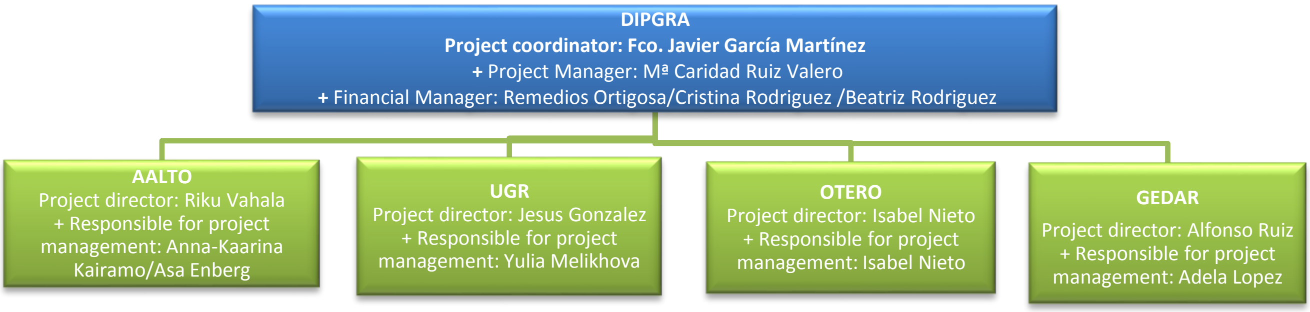


Figure 1. Outline of administrative management.

In May of 2018 the legal representatives of the partners signed a partnership agreement (Annex I.1) establishing the relationship between the organisations, the role of each of these, the functioning of the Steering Committee (SC) in terms of project coordination, and the establishment of procedures to be followed in terms of confidential information and payment terms, among other issues. Subsequently, modifications to the internal agreement have been signed, related to amendments to the Grant Agreement. Highlights:

- Amendment nº 3 - Withdrawal of OTERO and addition of GEDAR from 01/12/2019 as a partner. Extension of the project's duration (until 30/04/2021). Signed on 03/06/2020.
- Amendment nº 4 - Extension of the project's duration (until 30/09/2021). Signed on 27/04/2021.

The SC was constituted on March 8, 2018, and consists of Mr. Jesus Gonzalez (representing UGR), Mr. Riku Vahala (representing AALTO), Mrs. Isabel Nieto (representing OTERO) and Mr. Francisco Javier García (representing DIPGA). With the incorporation of GEDAR as of 1/12/2019, Mr. Alfonso Ruiz joined on behalf of said company.

On a quarterly basis, on average, a meeting of the SC has been held. These meetings were open to all personnel involved in the project, to share information regarding the progress of the project, clarify management issues and make decisions on any other matters that may arise. A total of 14 SC meetings were held on the following dates:

SC I	18/09/2017	**SC V**	30/01/2019	**SC IX**	10/12/2019	**SC XIII**	26/05/2021
SC II	11/10/2017	**SC VI**	30/04/2019	**SC X**	07/07/2020	**SC XIV**	08/07/2021
SC III	08/03/2018	**SC VII**	08/07/2019	**SC XI**	16/10/2020		
SC IV	10/07/2018	**SC VIII**	27/09/2019	**SC XII**	16/02/2021		

In addition, other working meetings have been held for designing the plant, the presentation of the project in Torre Cardela, for the start-up of the bioreactor, etc.
Communication with external monitoring teams is carried out through Borja Domínguez, who has been in close contact with the project managers and quickly and decisively answered all questions raised by them. He has also offered well-directed advice regarding doubts relating to difficulties encountered during project development or concerning management issues. Mr. Domínguez has made five visits to the project, one per year and two in 2021. In three of them, he visited the facility where the project has been implemented in person. In addition, Federico de Filippi, CINEA's project manager, made a videoconference visit during the final phase of the project (September 22, 2021). We are very grateful to Mr. de Filippi for his willingness to

accept the changes proposed during the project and for his interesting contributions throughout this time and especially during the visit.

6. Technical part

6.1. Technical progress, per Action.

Action A1.- Groundwater characterization.

	EXPECTED	ACTUAL
Start date:	09/2017	12/2017
End date:	12/2017	12/2018
Milestone: Start field's campaign	09/2017	12/2017
Milestone: Expected End field's campaign	09/2017	11/2018
Deliverable: GW hydrochemical characterization report.	12/2017	12/2018

The purpose of this action is to carry out a comprehensive hydrochemical characterization of the groundwater body "*Calcarenitas de Torre-Cardela*", the only drinking water resource in the municipality and the site chosen for construction of the full-scale plant. An accurate, reliable groundwater sampling campaign was scheduled during project preparation in order to obtain in-depth knowledge of the water scheduled for treatment.

Although the expected start date was set for September, 2017, administrative issues resulted in this being postponed until December 2017 (reasons for the delay included money transfers by the coordinator and deadlines for the public tender for a hydrogeologist). Furthermore, unusual weather conditions for the hydrological year (Oct 2017-Sept 2018), when rainfall arrived several months later than usual and was mainly concentrated in just one month (Fig. 2, bars representing daily rainfall volume), had to be taken into consideration. This fact conditioned both the sampling campaigns and behaviour of the aquifer (water level and hydrochemistry).

Interpretation of the hydrochemical data showed fluctuations and spatial variability in nitrate concentrations that were higher than previously expected, given the available information (Table 1 and Figure 2, where red dots show nitrate concentrations in the main abstraction well). This situation meant it was necessary to rethink the groundwater study. In accordance with these circumstances, periodical monitoring was implemented up to the end of the 2018 in order to acquire information about the seasonal trend of nitrate concentrations and, as a result, to be able to predict fluctuations and improve the treatment plant's operation. The frequency of monitoring campaigns was established at two to three weeks and sampling focussed on nitrate content and the main abstraction well used for drinking water. When the plant becomes operational the nitrate content in raw water will be monitored in the facility.

For the above reasons, the expected termination date was postponed from December of 2017 to December of 2018 and the deliverable "GW hydrochemical characterization report", expected in December of 2017, was delivered in December of 2018 in order to include all the information generated (annex II.1). In addition, a synthesis document including the data available up to October of 2018 has been produced for publication on the project website.

Neither these adjustments nor the planning of the extensive monitoring over time have affected the laboratory test schedule or the deadlines for full-scale plant design and implementation. As of the 30th November 2018, 48 water samples have been collected from springs, abstraction wells and boreholes (Fig 3 shows some of these). Pesticide analysis has been carried out in 10 of these (in the laboratory of the Department of Physical and Analytical Chemistry of the University of Jaen), major compound analysis in 19 (by the Agri-Food Laboratory of the Regional Government of Andalusia), and nitrate concentrations in a further 19 (laboratory of the Provincial Council of Granada). The results of pesticide analysis showed low concentrations of this type of organic substance. Table 1 summarizes the available hydrochemical data.

Table 1. Summary of water chemical analysis

[mg/L]	**Minimum**	**Maximum**	**Average**	**[mg/L]**	**Minimum**	**Maximum**	**Average**
Sulphates	18	195	71	Potassium	0.4	26	3.9
Nitrates*	0.4	105	52	Magnesium	4.7	41	20
Chloride	11	38	19	Electrical conductivity (µS/cm)	233	971	692
Bicarbonates	93	410	288	Hardness	464	600	549
Carbonates	0	1.5	0.5	pH	7.2	8.5	7.6
Calcium	35	134.6	103	Nitrites	0.01	0.08	0.03
Sodium	2.7	57	17	Phosphates	1	5.4	1.6

n = 19 data ***n = 40 data**

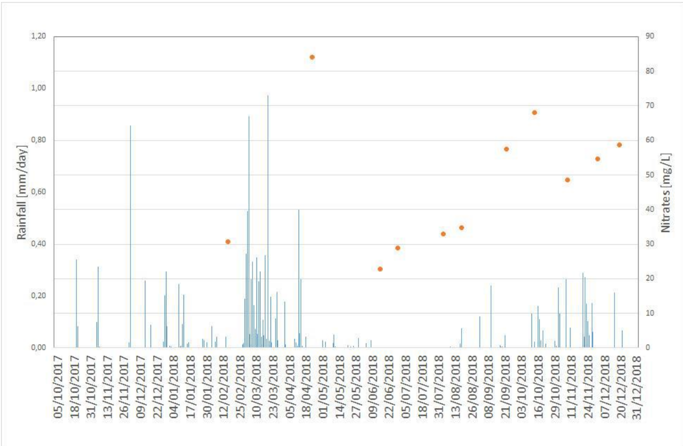


Figure 2. Bars represent daily rainfall for the hydrological year 2017-18; Points represent nitrate concentrations found in samples taken from the abstraction well used for drinking water.

The results indicated that the groundwater body has a moderate productivity. Main hydrochemical facies is calcium-bicarbonate and the nitrates concentration varied during the study time between 0.4-105 mg/L. Regarding the content of pesticides, only two substances were detected above 0.100 µg/L (0.148 µg/L of diphenylamine, 0.377 µg/L of fluazifop) at two different sampling points and none of them used to supply drinking water. In general, the load of organic pollutants is low (from 0.072 to 0.474 µg/L). The main abstraction well nitrate concentration wavered between 23-84 mg/L. These fluctuations are a consequence of the combination of the fertilization cycles of the crops and rainfall events that allow the percolation of the accumulated excess in the soil to the water table. Therefore, it is essential to anticipate these variations in nitrates concentration in order to adapt the operation of the plant to the treatment needs of the water entering the plant at all times, with higher content detected after rainfall events occurred after olive tree fertilization periods.

Figure 3. Some sample points.

Action A2.- Selection and evaluation of the organic carbon source, the selective bacterial inoculum and the operational conditions of the aerobic granular system amended with or without pesticide compounds.

	EXPECTED	ACTUAL
Start date:	09/2017	09/2017
End date:	06/2018	01/2019
Milestone: Design and construction of the pilot plant at laboratory scale	01/2018	01/2018
Milestone: Determination of operational conditions, selection of carbon sources and microbial inoculums.	06/2018	07/2018
Deliverable: Microorganism selection, carbon sources and operational conditions report.	06/2018	01/2019

The aim of this action has been to carry out a detailed characterization of the lab-scale granular aerobic technology for the treatment of groundwater polluted by nitrates and pesticides from agricultural activities. Detailed characterization of the operating conditions and study of system performance allowed us to obtain more in-depth knowledge for starting-up a full-scale plant to treat groundwater containing pollutants resulting from intensive agriculture in the Torre Cardela area.

The start date was September 2017, and sub-actions *A.2.1. Selection and evaluation of the organic carbon source* and A*.2.2. Selection and evaluation of the bacterial strains for a selective inoculation* were developed by AALTO and the Water Research Institute (UGR) as scheduled. While the proposal did not foresee personnel costs for the UGR in this action, the truth is that a lot of work was required and a contracted researcher and three permanent professors have dedicated many hours to the project. Personnel costs attributed to this action has been deducted from the budget assigned for action B1.

Firstly, in AALTO, two anaerobic granular sludge systems were implemented in cylindrical sequential reactors (SBR1 and SBR2) inoculated using cold-adapted sludge from Rovaniemi WWTPs (Finland). These bioreactors were aerated with nitrogen gas and fed with synthetic water simulating groundwater. For the start-up and operation of this technology two different organic matter sources were tested for the growth of heterotrophic denitrifying bacteria, namely ethanol and sodium acetate. The granulation process in the bioreactor fed with ethanol (SBR1) presented some difficulties and development of the biomass proved to be unacceptable, due to the growth of filamentous bacteria. As a result, ethanol was discarded as a carbon source. On the other hand, the bioreactor fed with sodium acetate (SBR2) proved to be successful, and the concentration of sodium acetate was reduced over the course of the experiment, showing values from 1g L-1, 0.5g L-1, 0.25g L-1 and 0.2g L-1 compared to 0.132g L-1 for sodium nitrate. While the stages operating below 1 and 0.5g L-1 generated high quality outflow that was suitable for drinking water, the stages operating with concentrations ≤ 0.25g L-1 exceeded the limits of nitrite concentration for drinking water. During the experiment, biomass samples were collected for the study of bacterial, archaeal and fungal communities in the granules using massive parallel sequencing.

Following this experiment, granules cultivated in SBR2 were used for the inoculation of the sequential bioreactor using aerobic granular sludge technology for denitrification under aerobic conditions. The experiment was carried out using synthetic groundwater simulating the drinking water supply in Torre Cardela (Granada, Spain) according to the data provided by action A.1. under different concentrations of carbon and nitrate. In AALTO, during the first stage of operation sodium acetate was used as a carbon source, with decreasing concentrations from 1g L-1 to 0.1g L-1, generating high quality outflow up to 0.4g L-1. In the second stage at

UGR, the bioreactor was fed with methanol as a carbon source. In this stage a very low concentration of carbon, around 0.077g L-1, was used. The results of this stage were very successful, as nitrite was not detected and nitrate concentration was under 10mg L-1. Sub-action A.2.1 was completed in August, 2018, due to experimentation time being extended in an effort to gain more accurate and concise knowledge of the biological process that occurs with very low concentrations of carbon and in order to establish the optimal operational conditions in the laboratory and extrapolate these for the design of the full-scale plant.

On the other hand, at the UGR, the development of new technology based on aerobic granules of pure culture operated in a sequential batch reactor was started using a group of denitrifying heterotrophic bacteria which are able to perform the denitrification process to eliminate nitrite. The pure bacterial cultures were developed in flasks and subsequently used to inoculate each bioreactor. While the pure cultures of selected *Bacteria* established in the proposal were *H. pseudoflava*, *P. mandelii*, *X.autotrophicus* and *Comamonas sp*.; in the end, for the purposes of this experiment, four strains belonging to *Pseudomonas* genus were selected: *P. flourescens PSC26*, *P.fluorescens 436*, *P.stutzeri* and *P. denitrificans*, as it had been reported that these strains possess *nosZ* genes, which transform nitrous oxides (greenhouse gases) to nitrogen gas, thereby avoiding the emission of greenhouse gases via the metabolism of microorganisms.

Each bacterium strain was inoculated in an SBR reactor for the purposes of monitoring both the granulation process and depollution performance. The bioreactors were fed with synthetic groundwater in decreasing concentrations in an effort to establish the ideal carbon concentration for complete nitrate removal. Six bioreactors were started up, of which four were fed with sodium acetate as a carbon source and two fed with methanol. The selected strain of *Pseudomonas denitrificans* did not granulate and, as a result, this phylotype was discarded. The bioreactors with different concentrations of sodium acetate performed successfully and the quality of outflow up to 0.4g L-1 reached the optimum concentration for tap water. On the other hand, the bioreactors operating with methanol as a carbon source only performed with < 0.3g L-1 of methanol. Despite the low concentration, the development of the granulation process and the performance in terms of organic matter and nitrogen were high. However, these pure-culture reactors must operate for long periods of time to observe the stability of the system. The selection and evaluation of bacterial strains used for selective inoculation was completed in July 2018.

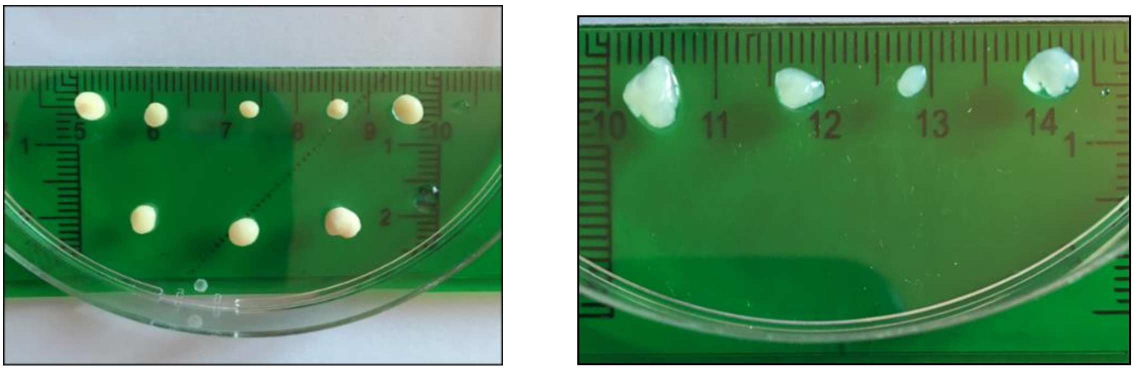


Figure 4. Aerobic granular sludge aerated with air < 100mg L-1 of methanol (left) and granules of *Pseudomonas stutzeri* after 30 days of operation (right).

In conclusion, the results suggested that full-scale reactor inoculation of a full-scale reactor should be carried out using activated sludge operating under aerobic conditions and fed with methanol as a carbon source.

**As will be described below, the full-scale prototype start-up has shown that the system works best when inoculated with using granular aerobic sludge previously formed in aerobic granular denitrifying reactors, thus achieving a reduction in system start-up times. Moreover, it has also been observed that using acetate as a carbon source offers important advantages (low cost in particular) in relation to using methanol, although both carbon sources can be useful in the denitrification process.*

Finally, sub-action *A.2.3 Study effect of pesticides on the performance (...)* was initiated at the UGR, in September 2018, due to extension of the evaluation period for concentration of organic matter relating to sub-action A.2.1.

The bioreactor (SBR2) has been operated using chemical pesticides in order to see whether or not biological technology can remove these compounds from the groundwater. On the other hand, this experiment also studies the robustness of this technology in terms of formation of granular biomass and nitrate removal for different concentrations of pesticides. The pesticides selected were simazine, diuron and carbedazim, described by the research of Belmonte-Vega et al., 2005, as being the most widespread in our study area.

The study of the effects of pesticides was carried out using three different concentrations in order to gain more knowledge about how concentration affects nitrate removal ratios and granular formation. Analytical samples were sent to CIC (the Scientific Instrumentation Centre of the UGR) for analysis of pesticide removal ratios using biological technology. On the other hand, molecular analysis was carried out using DNA extraction with the aim of performing both quantification studies of denitrifier microorganisms and community studies using massive sequencing. Plasmids of interest were obtained and the thermal profile protocol and melting curves for the target genes were optimized for absolute quantification using Real-Time PCR. The experiments were completed in December of 2018. The results of the study carried out with different pesticides have not yet been published. They are still in the writing process. Another article corresponding to the experiments carried out with pure cultures in the inoculum selection phase has been published. This article was published in April 2021 and it is attached in Annex III.11.c).

The deliverable "Selection and evaluation of organic carbon source, the selective bacterial inoculum and the operational conditions of the aerobic granular system amended with or without pesticides compounds" was completed in January 2019. It describes in detail all the laboratory process and is included in Annex II.2.

Figure 5. Cylindrical bioreactor treating polluted groundwater in sequential stages.

Action B1.- Design of the full-scale purification plant.

	EXPECTED	ACTUAL
Start date:	01/2018	03/2018
End date:	09/2018	10/2018 (first phase) 03/2020 (full scale)
Milestone: Start of design works	02/2018	03/2018
Milestone: End of design works.	09/2018	10/2018 (first phase) 03/2020 (second phase)
Deliverable: Design of the full-scale plant report.	09/2018	10/2018 (first phase) 03/2020 (second phase)

This action began at the end of March 2018 (later than foreseen) with bibliographic reviews and previous meetings, but it has ended as planned. Due to the technical requirements of the full-scale plant, the collaboration of OTERO, AALTO and the UGR in this action was deemed a necessity. In addition, the starting-up and operation of sequential batch reactors was essential in terms of determining the design and operational conditions:

- hydraulic retention time (HRT);
- time of each cycle period;
- cycle exchange;
- addition of organic matter (and what type of carbon source to use);
- hydrodynamic shear force;
- relation between height and diameter;
- viability of pesticide treatment compounds and of reactor start-up using different inocula.

For these reasons, the researcher contracted by the UGR was actively involved in the preparation of Actions B1 and A2 in conjunction with AALTO and OTERO. They jointly worked on the development and optimization of the design of the water purification reactor in Torre Cardela as it had been described in the initial proposal. While the proposal did not foresee personnel costs for OTERO in this action, its personnel have dedicated many hours to the design of the plant, the design of the process scheme and the infographics. Personnel costs attributed to this action have been deducted from the budget assigned for action B2.

The functional characteristics of the equipment required for construction of the prototype have been defined in detail, including definition of diameters, materials, operating ranges, valves, connection pieces, pumps, tanks, filter, diffuser, compressor, boiler, blower, etc. Annex II.3 includes the process flow diagram and description of the materials required for the implementation of the full-scale purification reactor.

Analysis of the system operating times was carried out in an effort to gauge energy consumption with a view to calculating the photovoltaic system needed to supply the energy required by the plant.

All operational parameters were also revised and defined, including pH, potential redox, temperature, dissolved oxygen, water levels, etc.; in other words, all the parameters that need to be measured in order to adjust the operation of the plant and optimize performance. Subsequently, the necessary sensors and instrumentation to be implemented in the plant were defined. An operational schematic (annex II.3) and detailed diagrams have been prepared for the various parts of the plant to be manufactured, as well as the framework required for implementation of the equipment.

Changes were made to the performance of Action B.1 for reasons that will be explained below. First of all, the maximum height of the enclosure where the bioreactor has been installed is 4m, meaning the initial proposal, calling for the bioreactor to be 4m high, had to be discarded, maximum height being limited to 3.52m. The second characteristic to be altered was the reactor material. In order to optimize monitoring of reactor performance and the development of the biological process, methacrylate was used instead of polypropylene, as specified in the initial proposal, because the transparency of methacrylate enables observation of the granular formation, hydrodynamic shear and granular movement inside the reactor. The maximum diameter available on the market for this material is 0.49 m, meaning the reactor diameter was reduced by 10 cm. In addition, a 6-hour HTR with 50% volume discharges was initially proposed to ensure adequate nitrate removal from the raw water.

The combination of these dimension parameters means that the total volume of water treated is less than what was stated in the original proposal, where the operation of the bioreactor was continuous (without HRT). In order to solve this problem and increase the volume of water treated, it was necessary to construct additional bioreactors in parallel. This new design for the prototype, slightly different from the one in the proposal, was communicated and agreed on with the EASME's Project Adviser in September 2018 (Annex I.4).

The deliverable "**Design of the full scale plant report**" was completed in October 2018 (first phase of the prototype) and it is included in the annex II.3. While the acquisition of graphic design software was initially budgeted, in the end this proved to be unnecessary.

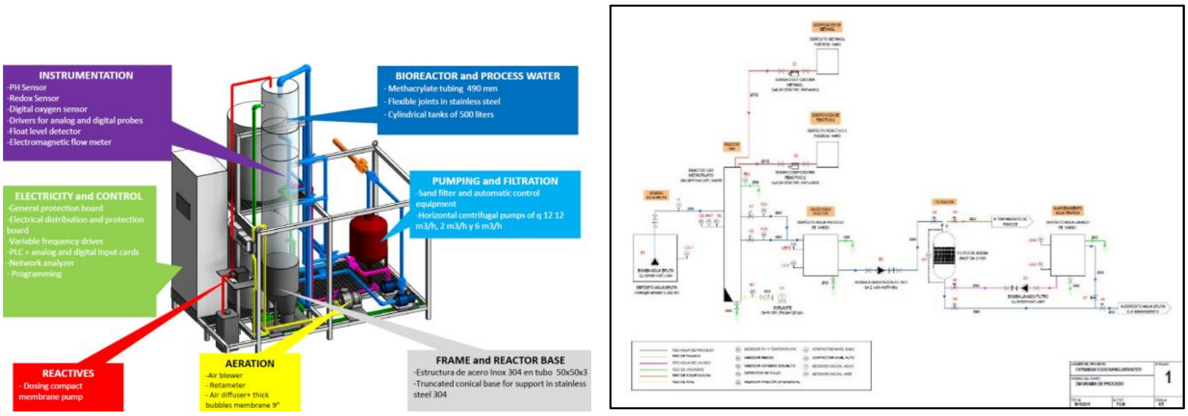


Figure 6. Infographic of the first phase of the plant (one bioreactor) and process diagram.

Later, once the first phase of the prototype was installed and needed to be expanded, it was decided to design two larger bioreactors that together would purify the necessary volume to supply a population of 500 inhabitants and use standard market materials. Two glass fibre reinforced polyester bioreactors were designed with a cylindrical shape, an inclined and narrower base and dimensions of 3 m in height and 1 m in diameter. The interior volume is 2,160 L with two outlets, one located at 1.5 m and the other at 1.8 m from the top. A schematic of the new bioreactors as well as the final design of the pilot plant is presented in Annex II.3.

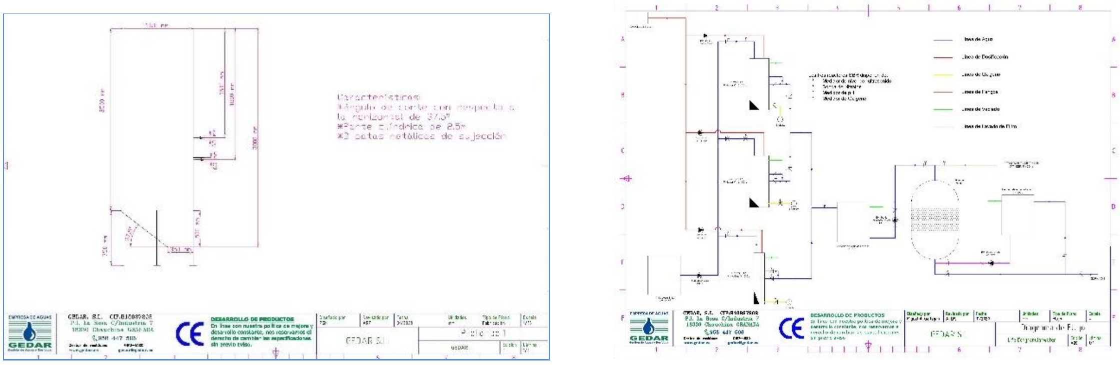


Figure 7. Schematic of the polyester bioreactors and flow diagram of the complete pilot plant.

Action B2.- Construction and maintenance of the full-scale purification plant and sludge.

	EXPECTED	ACTUAL
Start date:	07/2018	10/2018
End date:	09/2021	09/2021
Milestone: Construction of the artificial wetland system	04/2019	05/2021 (in full operation)
Milestone: Implementation of full scale plant in the existing facilities.	04/2020	02/2019 (first phase) 07/2020 (second phase)
Milestone: Permit obtained	07/2021	Not obtained
Deliverable: Full scale purification plant.	04/2020	07/2020 (completed)
Deliverable: Biosafety report.	06/2021	07/2021

The action started in October 2018, once the new prototype design was approved and has continued up to the end of the Project. The action was carried out by OTERO from inception until its departure from the project and has been continued by GEDAR from December 2019 up to the end of the project.

OTERO carried out the construction of the first phase of the prototype, consisting of the methacrylate bioreactor together with the sand filter, pumps, electrical system, piping, control system, etc.

In February 2019, the installation of the first phase of the prototype was carried out in Torre Cardela, which required civil engineering works, the installation of all the equipment that forms part of the prototype and its connection to the existing facilities, placement of the photovoltaic solar panels and batteries and configuration of the electrical panel.

After the equipment start-up tests, the bioreactor was inoculated and the follow-up tasks detailed in action C1 were carried out.

In this first phase, numerous maintenance tasks were carried out to solve the intrinsic problems of the municipality in terms of frequent power outages, broken borehole pumps, among others.

OTERO's financial problems prevented the progress of the second phase of the prototype as planned. GEDAR joined the project in December 2019, when the consortium agreed to expand the prototype with two fibreglass reinforced polyester bioreactors of larger volume than the first one.

Work began on the design and construction of the second phase and within a few months a state of alarm was declared in Spain (March 2020), temporarily paralyzing industrial activity, population mobility and the pace of work. GEDAR was able to continue working, as its sector is an essential activity, but not without difficulties due to the lack of suppliers in operation, as well as the temporary reduction of its own workforce.

Gradually activity was resumed and during the first half of 2020 the prototype expansion work could be carried out. Once the two bioreactors were built, they were installed in Torre Cardela in July 2020, making all the hydraulic and electrical connections necessary for their integration with the first phase of the prototype and with the Torre Cardela DWTP. The prototype, in its first phase and as a whole, is shown below.

Figure 8. First stage of the prototype (left and centre) and complete prototype (right).

The components of the EGW plant are as follows:

- Bioreactors. These are three cylindrical tanks with a truncated cone base and a volume of 660 L for the first one and 2163 L for the other two, in which aeration is carried out from the lower part through a fine bubble diffuser. The reactors are filled from the top with the water to be treated. They have two outlet openings, as indicated in action B1. They also have different measuring probes (dissolved oxygen, nitrates, ammonium, pH, temperature and redox potential) located in the upper part of the bioreactor.
- Intermediate tanks. The plant has two intermediate tanks for emptying and filtering the bioreactors. The water leaving the bioreactors passes to a tank where it accumulates and is then filtered. The second tank is similar to the first one and is where the already filtered water accumulates, always maintaining the amount needed for the operations of cleaning the filtration system.
- Prechlorination system. Once the water passes the filtration stage, the water treated by the system is automatically chlorinated (chemical disinfection). This is done in the intermediate tank, before the sand filter.
- Sand filter. Its function is to remove particles that have escaped from the decantation stage.
- Nutrient storage tank. It is a 1,000 L tank with a hermetic lid and equipped with a mechanical agitation system, to prepare the nutrient solution inside and provide each of the reactors with a dose at the beginning of each operation cycle.

Figure 9: Detail of the probes and measuring systems (left), buffer tank (centre) and nutrient tank (right).

- Blowers. This is an aeration system capable of provoking the complete movement of the entire water column to keep the biomass in suspension during the aeration stage. They are located in the lower truncated cone part of the reactors.
- Pumps. Together with the blowers, they make the installation's various operations possible (filling, filtering).

- Feed pumps. There are three injector pumps which supply the nutrient supplement to each of the bioreactors from the nutrient storage tank.
- Piping and valves. They are connected to the system's automatic emptying and filling control system, as well as the rest of the piping and conduits between the different elements of the installation. For safety reasons, a flow sensor was installed in the emptying circuits of each reactor to verify that the emptying solenoid valves are not left open, to prevent the reactor from entering the aeration phase and the biomass from being lost (as already happened accidentally).
- Probes. These include probes for nitrates, dissolved oxygen, pH, temperature, chlorides.
- Electrical system. One was installed with the first phase of the prototype but proved insufficient to run everything related to the expansion. Gedar needed to install a new one.
- Control System. The entire plant is kept running by an automated control system that regulates all the times and stages of the installation, allowing autonomous operation as well as remote control of the process. An internet connection was contracted, as these services do not reach the plant's location. With these components, the "scada" technology, developed by GEDAR and GEDAR's operator service, can monitor the plant 24 hours a day, 7 days a week. It was later transferred to the Provincial Council's remote control system in order to provide support for it to city council.
- Work platform. To improve access to the upper part of the reactors, it was decided to install a platform to be able to work safely, accessing the upper part of the reactors to perform the relevant tasks (sampling, probe cleaning, etc.).
- Phytodepuration system. The installation does not produce any type of rejection flow, but the sand filtration system has to be cleaned periodically by performing the relevant backwashing operations, this process generates a small amount of sludge that has to be treated in a small wetland installed outside of the facilities (Figure 10).

Figure 10: Plant control system (left), nutrient dosing pump (centre) and artificial wetland (right).

In addition to remote control, preventive maintenance has been carried out. On a weekly basis, a GEDAR operator has visited the plant to perform the following tasks: i) cleaning and verification of the analytical control probes; ii) verification and manual cleaning of the sand filter; iii) verification and purging of the compressor; iv) review of the wetland; v) cleaning of the flow sensors; vi) review of the chlorine dosing system.

Difficulties encountered and proposed solutions.

Throughout the installation, numerous problems have arisen that have been solved on the fly by GEDAR and the UGR. The main problems included difficulties in electrical connections, integration of all equipment and instruments in the remote control system. GEDAR was required to install a new electrical panel and the entire plant was integrated into DIPGRA's remote control system for proper management after completion of the project. There have been pump failures that have been repaired, as well as numerous power outages that have led to energy consumption programmes that enabled the accumulation of an energy reserve in the batteries to cope with unforeseen outages, even in adverse weather conditions.

The most serious problem was the loss of granules in November 2020 due to a failure of the bioreactor water outlet solenoid valve. It was an accident that required an accelerated production of granules in the laboratory to enable the inoculation of the three bioreactors. This led to a request for an extension of time, which was granted.

The initiation of the request for a sanitary report on the new biological DWTP project by the Torre Cardela municipality began in February 2021. In March, two inspectors from the competent authority visited the plant to see its operation first hand. Subsequently, the Health Delegation issued a report requesting clarification and further documentation on the facility. A first response was made by the municipality (with the support of the partners) where they again requested more information, including the designation of a person in charge of the DWTP and the presentation of a complete analysis.

The partners are taking the necessary actions to resolve the incidents that arise and to obtain the pertinent health permits. A complete analysis of the sand filter outlet water was performed and the results showed microbiological contamination. It has been shown that the cause may have been remnants from granules which got out of the bioreactor. The sand has been replaced with fibreglass and the pre-chlorination system has been modified. Samples will be taken in January 2022 again for a complete analysis.

Part of these actions have been carried out outside the project period, in the fourth quarter of 2021, without cost allocation. This demonstrates the partners' commitment to the continuity of the project, the acquisition of health permits and the beginning of promotional actions for the installation of new plants in other territories.

Action B3.- Promotion of transferability and replicability of the project.

	EXPECTED	ACTUAL
Start date:	09/2017	09/2017
End date:	09/2021	09/2021
Milestone: Draft of the business plan	06/2020	06/2020
Milestone: Establishing contacts and negotiations in order to implement the project in other areas of the EU.	10/2020	Not achieved
Deliverable: A proposal of the municipalities with the greatest potential for replicating the project. Map of the identified areas.	07/2018	07/2018
Deliverable: Study of the project beneficiaries, both productive and non-productive	03/2019	07/2019
Deliverable: Business plan.	07/2021	09/2021
Deliverable: Economic guide for the study of the costs and investments in relation to the transfer and replicability of the project	09/2021	09/2021
Deliverable: Replication and Transferability Plan	07/2021	09/2021
Deliverable: Study of the social, economic and environmental impact in the areas of the EU identified in the project	07/2021	09/2021
Deliverable: Patent document	09/2021	09/2021

In terms of execution, action B3 has been implemented on schedule and all deliverables have been completed. The action was carried out with the UGR's own personnel.

Action B3 includes actions oriented towards the transferability and replicability of the purification technology developed as part of the project in EU areas experiencing problems relating to groundwater pollution from nitrates. The objective is to design a realistic and effective Business Plan that is consistent with the possibilities of implementing this technology in the greatest number of municipalities, both within the execution horizon of the project (4 years), and subsequent to its completion.

In order to achieve this, a work plan was designed from the outset that would gradually distribute the workload throughout the lifespan of the project (September 2017 to September 2021) in accordance with the progress of the various scheduled actions. The heaviest workload of Action B3 was located in the second half of the project implementation period, once the new technology had been successfully tested at full scale at the Torre Cardela pilot plant and economic data obtained to determine the operating costs of one cubic meter of treated water, necessary to study the financial viability of the project.

The following is a more detailed description of the activities carried out:

i) Identification of municipalities and regions within the EU registering levels of groundwater pollution by nitrates in order to allow us to determine the potential market to aim the Business Plan at, given that these are the areas that are most affected by this problem and thus potentially are the most likely to require treatment. The results of this task are reflected in the delivery attached in Annex II.5.1.

ii) To this end, an in-depth investigation of the available information sources was carried out in an effort to gather information that would enable the elaboration of a Map of the EU municipalities most vulnerable to groundwater nitrate pollution, particularly in the Mediterranean region. In these areas the scarcity of water resources means that, in many cases, the groundwater supplies drinking water, despite being areas with extensive agricultural activity, one of the main sources of groundwater nitrate pollution.

The resulting map includes the main southern EU countries, such as Spain, Italy, Malta and Greece. It has not been possible to incorporate Portugal, because the data had restricted access and permission to process it has not been obtained. This study has revealed the existence of a large potential market for replicating the project, since the areas most affected by nitrate contamination of groundwater are home to around 22 million people, who require the treatment of more than 1.6 billion m3 of drinking water per year to meet their needs (Annex II.5.1.).

Figure 11. Maps of Spain and Italy, identifying areas affected by nitrate contamination.

iii) Identification of the main beneficiaries after the implementation of the new biotechnology, distinguishing between productive or entrepreneurial activities and non-productive activities. Approximately 25-30% of the drinking water supplied in the EU Mediterranean countries is consumed by business activities, while the remaining 70-75% of the water is consumed by non-productive activities, mainly by households.

Within the productive activities, the "Food and beverages" and "Chemical, rubber and plastic materials" industries, as well as accommodation and restaurant services, stand out due to their higher water consumption. These four branches absorb about 50% of the water supplied to business activities. Therefore, there is also an interesting market for marketing the biological granular technology among these companies, as an individual solution to obtain nitrate-free water, which they can use in their production processes. The results of this study are contained in Annex II.5.2.

iv) Design of a Transferability and Replicability Plan (Annex II.5.6.).

This plan contemplates **three stages for marketing**, depending on the target market established. The first stage, which coincides with the technology introduction phase, covers the first three years, and has the Andalusia region as its target market, due to the proximity to the pilot plant and the possibility of exploiting the demonstration effect in other municipalities. In the second stage, which will last between 4 and 6 years, we will seek growth in the rest of Spain and Portugal. Finally, in the long term (7-10 years), we expect to open new markets in other EU Mediterranean countries. However, although marketing actions will be directed at these priority markets in each of the planned stages, demand from any area of the EU will be met from the outset.

The project replication objectives set out in the plan have been defined for **three demand scenarios**, over a 5-year time horizon. In the worst case demand scenario, a sales target of 20 plants over a 5-year period is estimated, in the intermediate scenario of 40 plants, and in the most optimistic scenario, a total of 60 plants would be reached.

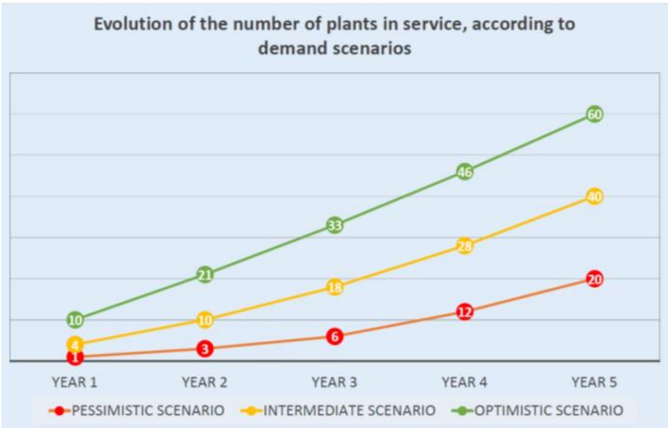


Figure 12: Evolution of the number of EGW plants in service in each year of the period, according to the demand scenario.

v) Another important task has been the preparation of the Economic Guide to Costs and Investments (Annex II.5.4.) This is used to compare the technology developed in this project with other water treatment technologies on the market, such as reverse osmosis. From an operational point of view, it has been found that EGW technology reduces water treatment costs by 31% compared to RO, mainly due to energy savings and osmosis membrane and filter costs.

vi) The Business Plan (Annex II.5.3.) is the key document for action B3, as it outlines the fundamental guidelines to be followed over a five-year time horizon, with the objective of ensuring the transferability and replicability of the project. To this end, the business plan includes an analysis of the general and specific environment, which will condition the commercialization of the new technology, concluding with the preparation of a SWOT matrix. A strategic plan has also been drawn up to guarantee the success and continuity of the commercialization company in the medium, and in the long term, a marketing plan, which includes the strategies and actions to be developed to sell EGW technology on the market, an organization and human resources plan and an analysis of the economic and financial viability of the project.

The results obtained in the business plan have been very positive, as they determine that the project is viable from an economic and financial point of view. Under the assumption that the commercialization of this technology is carried out by an industrial company, specialized in water treatment and purification systems, and with a medium size, between 20 and 50 workers, it has been estimated that this company could obtain an average profitability, after five years, of between 12% and 20% on the initial investment, depending on the demand scenario. In other words, the company would be able to double its turnover after five years and recover the initial investment.

vii) Finally, the socioeconomic and environmental benefits that would be generated if the objectives set out in the transferability and replicability plan were met have been quantified in Annex II.5.5. During the first five years, and depending on demand behaviour, the direct and indirect production of goods and services would be boosted by almost 10 million euros in the intermediate scenario, and an annual average of 19 jobs would be created, having a significant impact on multiple branches of industry and on services. From an environmental point of view, the impact would be highly beneficial, since the installation of new plants with EGW technology, to the detriment of RO plants, would reduce the carbon footprint and the environmental footprint by more than 50%.

Finally, it has not been possible to patent the system, since the progress of the project has been publicized and disseminated since its inception and this is incompatible with the granting of patents.

Action C1.- Monitoring of the impacts of the full-scale purification plant.

	EXPECTED	ACTUAL
Start date:	01/2019	03/2019
End date:	09/2021	09/2021
Milestone: Start plant's monitoring	01/2019	03/2019
Milestone: End plant's monitoring	07/2021	09/2021
Deliverable: Monitoring report (I)	10/2019	12/2019
Deliverable: Monitoring report (II)	02/2021	02/2021
Deliverable: Monitoring report (III)	05/2021	06/2021
Deliverable: Monitoring report (IV)	09/2021	09/2021

The objective of this action was to monitor the full-scale impacts of the plant after its construction and start-up. For this purpose, an evaluation of the physical and microbiological parameters of the water produced by the facility was carried out, as well as a detailed study of the microbiological characteristics of the aerobic denitrifying granules used in the process.
This action was completed in a series of sections detailed below, and at all times linked to the construction process of the full-scale plant detailed in other actions included in this report. The action was carried out by the company's own personnel and additional personnel hired for the project.

In relation to the sub-action *C1.1 Evaluation of water quality and the mineralisation process of the sludge generation,* the following activities have been carried out:

1. **Inoculation of Bioreactor 1 made of Methacrylate.**

Inoculation with activated sludge. Once the first phase of the EGW plant was built by the company OTERO, the first of the methacrylate bioreactors was inoculated. First, the bioreactor was inoculated with 300 L of activated sludge from the Baza WWTP (Granada), an area considered to have cold temperatures, during March 2019. The main objective was to achieve the optimal inoculation of the sequential reactor, in terms of inoculum volume and origin. Three successive inoculations were carried out at intervals of 2 weeks, in order to maintain sufficient sludge density to allow granulation (Figure 13).

After this period, no positive trend was observed in terms of granulation, biomass concentration and nitrate and organic matter removal. The results of this phase can be found in Monitoring Report No. 1 (Annex II.6.1.). Different nutritional and operational conditions led us to the conclusion that inoculation of the bioreactor with activated sewage sludge is not the most appropriate way to implement our technology. Therefore, it was decided to change the conditions to achieve a satisfactory start-up.

Inoculation with formed granules. Based on the laboratory studies, a new start-up of reactor 1 was undertaken using granular denitrifying sludge obtained from a laboratory-scale granular denitrifying reactor located at the UGR Water Research Institute facilities. The total volume used was 6 L of granules. The feeding strategy was based on increasing the concentration of carbon, nitrogen and trace elements compared to conventional groundwater. The feeding strategy is shown in detail in the Monitoring Report No. 3 (Annex II.6.3.). The nutrients necessary for the operation of the bioreactor were dissolved in groundwater from the installation itself and were dosed at the beginning of each operating cycle in the appropriate proportion. Another relevant point was the change in the carbon source, since in this case sodium acetate was used instead of methanol, because this carbon source showed advantages in the laboratory experiments in relation to its efficient use and low acquisition cost. This process was carried out at the end of April 2019.

In contrast to inoculation with active sludge, inoculation with granular sludge allowed a rapid start-up of the plant and the formation of a stable granulation as can be seen in Figure 13.

Figure 13: Bioreactor 1 after inoculation with activated sludge (left) and after start-up with denitrifying granules (right).

2. **Adjustment of organic matter and operating cycles.**

Once the start-up was completed in a period of one month, we continued with the adjustment stage of the minimum amount of nutrients necessary to optimize the biological denitrification process.

The inoculation of bioreactor 1 with previously formed granules was started on 1st April 2019, and the monitoring phase of it was maintained until 1st November 2020 (575 days in operation), a period in which the bioreactor was operating non-stop. In this sense, a gradual reduction of salts and carbon source was carried out until reaching the minimum amount of nutrients for the correct operation of the system, establishing this amount at 100 mg of sodium acetate per liter of water to be treated. It should be noted that this stage took longer than expected due to the disruption caused by the pandemic, which made it necessary to maintain salinity conditions during the months of confinement, which delayed the expansion of the plant. Finally, the operating cycles were adjusted and defined as 3 hours of aeration and 3 minutes of decanting of the biomass. During this period the system was operating with a single bioreactor.

3. Inoculation Bioreactors 2 and 3.

In the first half of 2020, the construction and installation of the 2nd phase of the plant was carried out, as described in action B2. In November 2020, the integration of the electrical and computer systems of the new bioreactors with the first bioreactor caused a failure in the systems resulting in the accidental emptying of bioreactor 1, and the consequent loss of all the granular biomass. This caused further delays in plant start-up, since bioreactor 1 had to be re-inoculated with previously formed granules, as was done in previous stages.

Once the biomass was recovered and stabilised in bioreactor 1, bioreactors 2 and 3 were started up again.

This start-up process was carried out with previously formed granules from bioreactor 1, extracting 6 L of granules and introducing them into bioreactor 2. The same start-up strategy used in bioreactor 1 was then followed, as described in the scientific paper, Annex III.11. a). This stage was carried out in December 2020.

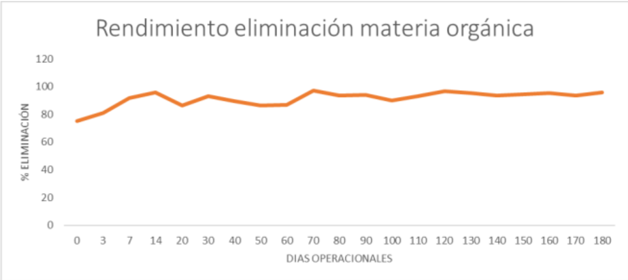
Once bioreactors 1 and 2 were recovered from the inoculation process, bioreactor 3 was inoculated in February 2021 using the methodology described above. Next, the filtration system, consisting of a sand filter, was set up to retain particles larger than five microns that might be released from the bioreactors. Finally, the plant was completed with an artificial wetland to treat the sludge generated during the cleaning of the filtration system. In addition, the plant was configured with a sodium hypochlorite disinfection unit that guarantees the sanitary quality of the treated water, allowing a residual chlorine level of between 0.5 and 1 mg/L in the outlet water. This system is upstream of the main DWTP tank where disinfection of the DWTP (water currently treated with the RO) is carried out. In this way, the plant can be considered fully constructed and operational.

It is worth mentioning the self-regulation process of the biomass in this type of system, i.e., the biomass present in the reactors is capable of self-regulating, and it is not necessary to extract or add biomass from the reactors, unless an accident occurs.

4. Follow-up and results.

During the phase of analysing the results of the finished installation (from March 1 to August 31, 2021), it was observed that the system offered very good organic matter removal and nitrate removal performances, operating with an emptying volume of 60% of the total capacity of the bioreactors, and with shorter operating cycles than those initially used (3h). Therefore, the system's operating cycles were reduced to two hours, using 60% of the system's operating volume. This resulted in a considerable increase in daily water production and a good optimization of the process. In this sense, the operating cycles have been adjusted to 2 hours of aeration and 3 minutes of decanting, with automated emptying and filling.

The removal efficiencies of added organic matter and nitrate were gradually increased as the system reached stability, achieving organic matter removal efficiencies of over 90% and nitrate removal efficiencies of 60%, as shown in Figure 14. However, it should be noted that the yields achieved were always highly conditioned by the concentration of nitrates present in the influent, since in general terms these values never reached amounts higher than 60 mg/L. The rest of the operational parameters are shown in Monitoring Report No. 3 (Annex II.6.3.).



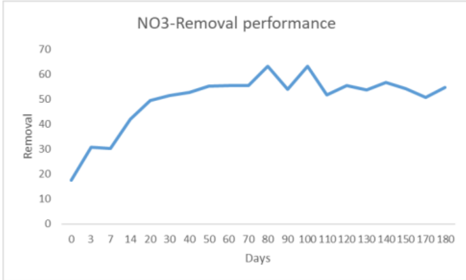


Figure 14: Performance for organic matter and nitrate removal (%).

5. Biosafety controls.

Once the system reached stability, various biosafety controls were carried out to ensure the absence of harmful microorganisms and metabolites in the water leaving the facility.
An ecotoxicity study of the outlet water was carried out using the MICROTOX® technique. These studies were carried out during June 2021 and three replicates of the outlet water from each of the bioreactors were performed. The results of this analysis showed the total absence of harmful metabolites in the bioreactor outlet water.

In relation to sub-action *C1.2. Control of the microbial community structure of the SBR*, microbiological counts were performed for 21 days and every 72 hours during the months of June and July 2021, in accordance with current regulations for water intended for human consumption, to verify compliance with the microbiological parameters required by law. These studies showed positive results, and in none of the samples analyzed were microorganisms found in a number greater than that required by current regulations for drinking water. A complete analysis of the drinking water was performed to confirm these first approximations of sanitary quality. These analyses were performed by an accredited external company.
Control of the microbial community structure of the SBR During this stage, an exhaustive study of the microbial communities present in the granule was carried out. This study was carried out during 2019 and early 2020, 5 samples distributed in 234 days of operation, of biomass from the facility were taken and sent to the López-Neyra Laboratory (CSIC) for massive sequencing. Each of the samples corresponded to the successive nutrient drawdowns performed in the bioreactor. The results obtained were analyzed using bioinformatics techniques (MOTHUR software) to determine the composition of the microbial community present in the pellets. The dominant phylotypes in the aerobic granule correspond to denitrifying saprophytic microorganisms of environmental origin belonging to the families *Comamonadaceae* and *Pseudomonadaceae*. Along with these microorganisms, phyla of the orders *Rhizobiales*, *Rhodobacterales*, *Burkholderiales*, *Rhodocyclales* and *Xanthomonadales* were also found at a higher taxonomic level.
In relation to the genus level, the prokaryotic community was dominated by the genera *Corynebacterium*, *Leucobacter* and *Leadbetterella*. In addition, the genus *Leucobacter* was found in all granules examined. In all cases, these are environmental microorganisms frequently found in water. None of the microorganisms found in the system have potentially pathogenic characteristics, and the microbiota should be understood as saprophytic as a whole. During the same period and for the same scientific article of which the above results are part, a quantification of the target genes involved in the nitrogen elimination process was also performed, which helps us to know first hand the nitrogen elimination process that takes place inside the granules. The copy number of the bacterial 16S rRNA gene, the amoA gene, the norB gene and the nosZ gene were quantified using nucleic acids using DNA extracted by quantitative real-time PCR. The number of bacterial 16S rRNA genes remained stable

throughout the operation in the granular sludge, and these results suggest that once the denitrifying granular biomass is stable at laboratory scale, the operation in real conditions acts similarly, as there was no negative impact due to changes in operating and environmental conditions. These studies are detailed in the scientific paper Annex III.11.c).

Finally, in sub-action *C1.3 Monitoring of gas emissions*, a series of studies were carried out to rule out the formation of greenhouse gases. Greenhouse gas emissions, specifically N_2O, during the denitrification process in aerobic granular systems was analyzed in experiments prior to this project. On this occasion it was confirmed by molecular analysis, establishing that the biological elimination of nitrate is mainly carried out by microorganisms of the genus *Pseudomonas*, which convert nitrate into molecular nitrogen (N_2 gas), since they possess the whole set of enzymes (nitrate, reductase, nitrite reductase, nitric oxide reductase and nitrous oxide reductase). This means that the EGW system does not produce significant quantities of greenhouse gases (NO and N_2O) during the denitrification process.

In this project and at real scale it was not possible to carry out greenhouse gas measurements due to the technical difficulties existing in a high volume bioreactor such as those found in the facilities. Therefore, we relied on previous studies carried out in laboratory scale plants.

Action C2.- Analysis of socio-economic and environmental sustainability: Cost-benefit analysis and carbon and environmental footprint analysis.

	EXPECTED	ACTUAL
Start date:	09/2017	09/2017
End date:	09/2021	07/2021
Milestone: Start various analysis with current technology	11/2017	11/2017
Milestone: Start various analysis with ECOGRANULARWATER technology	01/2019	01/2019
Deliverable: Economic and Financial Report	07/2021	07/2021
Deliverable: Life-cycle assessment report	07/2021	07/2021
Deliverable: Product Carbon Footprint and the Product Environmental Footprint	07/2021	07/2021

The **action C2 was carried out as initially planned**. The planned objectives were met and deliverables have been submitted on time. The deliverable "Economic and financial report, life cycle assessment, carbon footprint and environmental footprint" is included in Annex II.7. Most of the work has been carried out by UGR staff. The action C2 contains two lines of study, namely economic and environmental. Both lines were prepared throughout the duration of the project. With respect to the initial proposal, a contingent valuation analysis was included as a **complementary action**, as described below. Regarding the **prospects for continuation**, subject to the prior obtaining of health permits, the UGR will promote quantitative and qualitative studies to determine the degree of acceptance of the biological technology among the population.

A. Economic line: In this line of work, the following studies have been carried out:

i) Financial situation of the municipal water service.

The first task consisted of ascertaining the status of the service's accounts. It became clear that the municipality does not keep separate accounts for the water service and it has not been easy to extract all the related revenues and costs from the municipal budget. It is concluded that the **cost recovery rate** for the water service is around **60%**. The study is detailed in chapter 1.2 of the deliverable.

ii) Contingent valuation analysis.

The possibility of complying with the cost recovery principle by **raising the tariff** was then analyzed. Considering the binomial tariff applied in Torre Cardela, and with information provided by the City Council on the number of subscribers and cubic meters of water consumed in each tariff block, it was concluded that the price of water would have to increase by 60% in all tariff items to achieve cost recovery. A **Contingent Valuation Analysis** was conducted to ascertain residents' willingness to pay to contribute to achieving cost recovery. Information gathered by additional personnel hired for 3 months, through a questionnaire sent to 468 people, showed that slightly less than 40% of the population would be willing to pay more for water in order to contribute to the financial balance of the service. Furthermore, depending on the estimation method, the willingness to pay more for water would be between 9% and 20%, far from the 60% needed for cost recovery. In the best-case scenario, only **71%** of the cost could be recovered by raising tariffs. Detailed results can be found in chapters 1.3. and 1.4. of the deliverable.

iii) Cost-Effectiveness Analysis.

The objective was to compare the cost of producing one m3 of water with both technologies (RO and EGW). In a first approximation, a **financial analysis** was made: the financial costs - operating and investment costs (annual equivalent cost) - were taken into account. Team members from three specialities - microbiology, engineering and economics - worked on the data processing. **Cost savings of 30%** are possible with biological technology. In a second approach, an ***economic analysis*** was made with the environmental costs and resource costs. The methodology proposed in the Guadalquivir Hydrological Plan was used to calculate these costs. **Cost savings of 45%** are possible with biological technology. The above results were obtained with plants operating with power from the electric grid. Estimates were also made with an energy mix of conventional grid (33%) and photovoltaic energy (66%). The results obtained with the energy mix were similar to those obtained with the grid connection. Chapter 1.6. of the deliverable contains all the information in this regard.

iv) Impact on the financial balance of the service at the municipal level.

If the biological plant were put into operation, mainly due to savings in energy costs and, to a lesser extent, savings in reagent costs**, the cost recovery rate could increase from 60% to 85%**. See chapter 1.7 of the deliverable.

B. Environmental Line:

The environmental analysis has been carried out from a Life Cycle Analysis (LCA) approach. From the beginning of the project, we have opted for this formula to address environmental impacts, since it deals with the problem in a holistic manner, thus avoiding the displacement of impacts to other phases of the life cycle. SimaPro software was acquired.

LCA addresses the environmental aspects and potential environmental impacts (e.g. use of resources and the environmental consequences of releases) throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave). There are four phases in an LCA study:

a) the goal and scope definition phase,
b) the inventory analysis phase,
c) the impact assessment phase and
d) the interpretation phase.

In this case, in order to focus the comparison strictly on the production process and not be altered or distorted by other factors, we have chosen to use a Gate to Gate scope, also known as a process scope. In addition, infrastructure impacts have also been evaluated. It is widely accepted, based on the literature reviewed, that infrastructure has a negligible impact with respect to the production stage of the product, in this case 1 m^3 of drinking water, but we wanted to compare this study with real data.

Detailed data of the LCA phase corresponding to the Life Cycle Inventory can be found in chapter 2.7 of the deliverable. This evaluates the quality of the data, which is good for the infrastructure and excellent for the production process. Infrastructure and treatment process inventory data can be reviewed in sections 2.8 and 2.9 respectively of the deliverable.

The Life Cycle Impact Assessment (LCIA) was performed using a midpoint approach. The method used for the classification and characterization of the inputs and outputs of the inventory was the ILCD 2011 Midpoint+ v. 1.08/EU27 2010, equal weighting (European Commission, 2012). The five midpoint impact categories included in this study were carbon footprint, in kgCO_2 eq, photochemical ozone formation, in kg NMVOC eq, acidification, in molc. H+ eq, freshwater eutrophication, in kg P eq, and freshwater ecotoxicity, in CTUe.

The results and their interpretation can be consulted in point 2.10 of the deliverable, highlighting the following aspects:

- In the analysis of the impact of the infrastructure at the EGW plant, the most impacting material is Reinforced Glass fibre (RGF), which accounts for 77% of the total impact of the infrastructure, both for the carbon footprint and the environmental footprint. In contrast, the element with the most impact in RO is the PVC.
- When comparing both infrastructures, both in terms of carbon footprint and environmental footprint, the EGW plant infrastructure has a greater impact than the RO infrastructure. However, over its entire lifetime, the infrastructure accounts for only 1.5% of the total impact of the EGW plant and 0.01% of the RO plant. Therefore, infrastructure is not considered to have a significant impact on the overall lifetime of both systems.
- Regarding production processes, in the case of the EGW plant, the main impacts are due to the inputs of reagents and electricity, which account for around 90%, and in the case of the RO, the input with the greatest impact is electricity, accounting for approximately 93%.
- When comparing both production processes, both in terms of carbon footprint and environmental footprint, out of a 100% impact, approximately 28% is due to the EGW plant and 72% to the RO. The same results are obtained if the impact of the infrastructure is added to the previous analysis since, as mentioned above, this impact on the useful life of the plant is not significant.

The results show that, in terms of infrastructure, the EGW plant, due to its greater weight and higher material requirements, mainly concentrated in the biological reactors, which are made of Glass Fibre Reinforced Polyester (GRF), has a much higher impact than the RO plant, although the contribution of both infrastructures to the total impact of the plant is not significant. And finally, the contribution to the impact of the EGW plant is 28% compared to that of the RO plant, which is 72%, thus reducing both the carbon footprint and the environmental footprint by an average of 60% through treatment with the EGW plant.

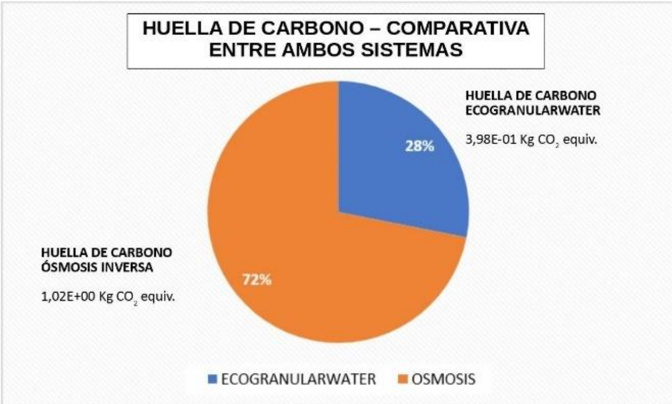


Figure 15. Comparison of the carbon footprint of both plants.

Action C3. Monitoring of the impact of the project actions.

	EXPECTED	ACTUAL
Start date:	09/2017	01/2018
End date:	09/2021	09/2021
Milestone: Shipping of Indicators (I) *(Mid-term Report)*	01/2019	01/2019
Milestone: Shipping of Indicators (I) (*Progress Report*)	01/2020	01/2020
Milestone: Shipping of Indicators (I) (*Final Report*)	12/2021	01/2022
Deliverable: Indicators chart (I) (*Mid-term Report*)	01/2019	01/2019
Deliverable: Indicators chart (II) (*Progress Report*)	01/2020	01/2020
Deliverable: Indicators chart (III) (*Final Report*)	12/2021	01/2022

The objective of this action was to monitor the indicators established by the LIFE Programme from the beginning of the Project until its completion and three years after that.

Once the project started, the KPI webtool (Key Project-level indicators) was created by the LIFE Programme. In January and February 2018, the indicators defined in the proposal were adapted to the new indicators defined in the general webtool database. The selected indicators were calculated and the information was completed on the platform.

With the help and advice of the external monitor, the contexts and indicators to be measured at that time (according to the expected results), and that has been measured on completion of the project and three years later, were selected. Two specific contexts were defined: the province of Granada and the area supplied by the drinking water. Thirty indicators were chosen as a means of measuring the impact of the project, in accordance with the indicators defined by the LIFE Programme.

During the Interim Report period, a review of the indicators was carried out and some forecasts of possible changes detected were highlighted. At that time, the plant was not fully installed, so conclusive results were not yet available regarding the effectiveness of the system, the possibilities of replicability, energy consumption, greenhouse gas emissions, etc. Therefore, in general, the estimates provided in the proposal were maintained.

Now the project is completed, definitive data are available on system energy consumption, volume of rejected water, operating costs, business plan estimates, etc., which allow recalculation of the indicators for the final period of the project.

The values of the indicators have been uploaded to the platform and, for their calculation, the following results achieved for the project have been taken into account:

- At the end of the project the EGW plant cannot be considered to be operational. It is in operation, but **the water cannot be introduced into the supply network** because it does not yet have the health permits.
- Three **scenarios** have been defined in the business plan for the **commercialization** of the technology and its **replicability** in other territories. To calculate the indicators, the **intermediate scenario** has been considered, which foresees that after 3 years, 18 more EGW plants will have been installed in municipalities of 1,000 inhabitants, which means the creation of 19 jobs, both direct and indirect.
- **Water consumption.** Although reverse osmosis generates 42% rejection, not all of the volume of water supplied to the population passes through osmosis, but rather there is a mixture of raw and treated water. This has been taken into account when calculating the water savings that EGW technology can generate after three years.
- **Carbon Footprint.** The proposal envisioned a carbon footprint close to zero due to the use of renewable energy. Although energy consumption is greatly reduced with the EGW plant, the carbon footprint is not zero because it requires the addition of nutrients and a small amount of grid consumption determined by weather conditions.
- **Dissemination indicators**. The initial indicators have been found to be overestimated and the impacts have been lower than expected.

Action D1. Dissemination Planning, Development of the Dissemination Pack and Networking.

	EXPECTED	ACTUAL
Start date:	09/2017	09/2017
End date:	09/2021	09/2021
Milestone: Website start up.	02/2018	02/2018
Milestone: Presentation of the project video.	07/2021	09/2021
Deliverable: Facebook page	02/2018	02/2018
Deliverable: Informative leaflets (I) ***(500 in Spanish and 500 in English were printed as foreseen*).**	02/2018	02/2018
Deliverable: Notice boards (5 in total)	02/2018	02/2018
Deliverable: Project's logo	02/2018	02/2018
Deliverable: Project's website	02/2018	02/2018
Deliverable: Digital newsletter: no 1	03/2018	04/2018
Deliverable: Digital newsletter: no 2	06/2018	07/2018
Deliverable: Digital newsletter: no 3	09/2018	11/2018
Deliverable: Digital newsletter: no 4	12/2018	03/2019
Deliverable: Digital newsletter: no 5	03/2019	06/2019
Deliverable: Digital newsletter: no 6	06/2019	10/2019
Deliverable: Digital newsletter: no 7	02/2020	04/2020
Deliverable: Digital newsletter: no 8	05/2020	09/2020
Deliverable: Digital newsletter: no 9	03/2021	04/2021
Deliverable: Digital newsletter: no 10	07/2021	09/2021
Deliverable: Informative leaflets (II) **(It was foreseen to print *500 in Spanish and 500 in English and finally were printed 300 in Spanish and 100 in English, given priority to digital format*).**	07/2021	09/2021
Deliverable: Project video	07/2021	09/2021
Deliverable: Layman's Report	09/2021	09/2021
Additional deliverables (not foreseen): **Project video (midterm)** **Spot for workshop** **Spot for dissemination**	 - - -	 03/2019 10/2019 06/2020

This action was programmed to be implemented throughout the life of the project. It started in September 2017 and will continue beyond the end of the project in terms of disseminating the Layman report, project video, networking and updating news on the website. The action **has been carried out as planned**, with all the expected deliverables completed, although some of them have suffered small delays that have been resolved.

Sub-action D1.1. *Dissemination planning and development of the dissemination pack* has been implemented as scheduled. While the CB has been responsible for implementation of this action, all the partners have been involved in it.

The first step consisted of the drafting of a **Communication Plan** (Annex III.1) designed to identify the target audience, definition of the information to be disseminated, identification of the corresponding communication channels, and planning of the communication activities and the corresponding budgets. Implementation of the Communication Plan was subsequently carried out.

The first step was the design of an identifying image, or **logo**, for the project. Estimates were requested from four companies, the least expensive selected, and the design completed in January of 2018. The manual on the use of the Life Ecogranularwater project logo is available in Annex III.2.

Estimates for **website** design were requested from six companies, with the bid offering the best value for money and the most attractive design selected. Then, contracts were signed with the selected company for web maintenance and updates. The website was designed and launched in February of 2018 and consists of the following sections: Home Page; The Project (Key aspects of Life Ecogranularwater, Objectives, Expected results, Actions and Timetable and Videos of the Project); Participants (Project Partnership and Stakeholders); Networking (Life Projects and Other Projects of interest); News; Publications/Downloads (Newsletters, Layman Report, Workshop's presentations); Contact; About Life. Project advances and the more significant activities, from a communications perspective, are periodically posted in the News section and deliverables are uploaded and available in the Publications/Download section.

While the home page is available in English, Spanish and Finnish, the remainder of the content is only available in English and Spanish, English being widely used in Finland, especially in professional circles. The website is the project's most important communications tool. By November 2021, it had 9,189 individual users and 28,448 pages visited. (Screenshots in Annex III.3).

An informative leaflet was designed in the first stage of the project and 500 copies were printed in Spanish and 500 in English (Annex III.5). These were distributed throughout the municipality of Torre Cardela - in the Advanced School of Civil Engineering, Faculty of Pharmacy, and Water Institute of Granada University, in the Department of Built Environment of Aalto University, in the 90 municipalities integrated in GRAMAS Network and among contacts in Construcciones Otero. It is also available in electronic format on the website and has been sent, as part of the newsletter, to stakeholders and subscribers.

In the final stage of the Project, **an informative brochure** has been designed including the results achieved (Annex III.6.). The brochure is in digital format, available on the website and 300 copies have been printed in Spanish and 100 in English. They were distributed at the final technical workshop of the project and among the municipalities of the GRAMAS Network. Fewer copies have been printed because the impact of documentation in digital format is increasing.

Five notice boards (Annex III.7) were produced and installed in the main offices of the four entities integrated in the project and in the Torre Cardela Town Hall in January of 2018. These are updated with the same information relating to project advances that is available on the website. In addition, a roll-up (Annex III.13) has been produced for use at meetings and events. After a new partner joined, it was necessary to print another roll-up banner to include the Gedar logo.

A **FB page** and a **profile in LI** were also created for the project and are used for the dissemination of website updates and news relating to water issues. The Facebook page has 85 followers and the LinkedIn profile has 370 contacts. Annex III.4 shows the impact of a number of news updates and the number of people reached by the same. Some entries have reached more than 750 people.

At the same time, a **list of stakeholders**, related entities, people responsible and contact information has been compiled. The list contains a total of 172 contacts grouped into different categories:

- Local, Sub-provincial, Provincial, Regional and National public administrations.
- Local Networks of Municipalities.
- Research Organizations.
- Professional bodies.
- Universities.
- Environmental Associations.
- Water Management Organizations.
- Water Management Companies.
- Rural Development Groups.

Ten Informative Newsletters (Annex III.8) have been produced and sent to subscribers and stakeholders identified for the project: April (no 1), July (no 2) and November (no 3) of 2018, March (no 4), June (no 5) and October (no 6) of 2019, April (no 7) and September (no 8) of 2020 and April (no 9) and September (no 10) of 2021. A newsletter containing relevant updates is produced and sent to the aforementioned recipients. The newsletter is also available in the Publications/Downloads section of the website, where it can be downloaded from. To date, there are 95 subscribers. The 10 newsletters have reported a total of 50 news items on developments.

In the audiovisual field, **two documentary videos and two informative spots** have been produced although only one was foreseen. The first documentary was made by the communication department of the Provincial Council of Granada, with its own means. The final video, which includes the results of the project, was produced through an open contract. The video was produced in Spanish with English subtitles. Both have been disseminated through the institution's YouTube channel, creating links from ecogranularwater's website, Facebook and LinkedIn. In addition, two informative spots have been produced, one coinciding with the first technical seminar and the other in the last year of the project. The audiovisuals are attached in Annex III.14.

The **Layman's Report** has been designed in English and Spanish. 150 units have been printed in Spanish and the digital version is available on the website. It is attached as Annex III.15.

Regarding sub-action D1.2. *Networking with other projects*, the following activities have been carried out:

- Presentation of Life Ecogranularwater project at the GRAMAS Network Assembly held on the 27th of April, 2018. Representatives from **41 municipalities** were present. The GRAMAS Network is made up of 126 municipalities in 2021 and progress has been presented to them through newsletters and working group meetings. They know the technology and some of them have shown direct interest.
- Contact with 14 related LIFE projects addressing a range of water issues: drinking water, wastewater treatments, removal of nitrates from water bodies, etc. In addition to the contacting and dissemination of these projects on the web, as a result, six LIFE projects have participated in the Ecogranularwater dissemination days, which meant they could be disseminated and allowed for an exchange of experiences: InSitrate,

Libernitrate, Alchemia, Nirvana, Spot and Desirows. The LIFE ECOGRANULARWATER project was also presented during two days held within the framework of the LIFE Alchemia project (June 17 and September 30, 2021).

Dissemination activities have developed according to plan and even ahead of schedule.

Action D2. Technical dissemination of the project and promotion of the replicability of the project results.

	EXPECTED	ACTUAL
Start date:	09/2017	03/2018
End date:	09/2021	09/2021
Milestone: Holding of the First Technical Workshop about purification techniques for nitrate and pesticide pollution groundwater.	03/2019	10/2019
Milestone: Holding of the Second Technical Workshop about purification techniques for nitrate and pesticide pollution groundwater.	09/2021	09/2021
Deliverable: Technical guide for the installation of a purification plant in areas with polluted groundwater with aerobic granular technology	09/2021	09/2021

The start of this action required the general launch of the Project and other more technical actions that enabled the project's objectives and the main advances to begin being announced.

In relation to sub-action *D2.1. Attendance at meetings, conferences and seminars on environmental issues in general and on groundwater pollution in particular*, the partners have participated in most of the events scheduled in the proposal.

On behalf of **Aalto University,** Mr. Riku Vahala participated in two water-management-related events targeting Scandinavian countries, where LIFE ECOGRANULARWATER was presented and made contact with other related projects. No costs have been allocated to the project for these events; and the programmes can be consulted in Annex IV.1. a) y b) These events were:

- World Water Day, held on the 22nd of March, 2018, in Helsinki. About 100 attendees.
- National Water Services Days (Vesihuoltopäivät) held on the 24th and 25th of May, 2018, in Rauha (Finland). About 700 attendees.

The **Granada Provincial Council** presented the LIFE ECOGRANULARWATER at the following events:

- 10th SIAGA (Symposium on Water in Andalusia), held in Huelva from the 24th to the 27th of October, 2018. The event laid the groundwork for current and future water research, the role to be played by education and citizen participation, the impact of the economy on water management, and all aspects relating to the proper use of water. LIFE ECOGRANULARWATER was presented on the 25th of October by Francisco Javier García Martínez, the project coordinator. A technical communication (Annex III.10) was sent in advance for publication in the minutes of the symposium and a PowerPoint presentation was designed especially for this purpose. About 30 people attended the oral communication.
- 14th CONAMA (National Environmental Congress), held in Madrid from the 26th to the 29th of November, 2018. This is the most important environmental conference on a

national level and takes places every two years. A technical communication (Annex III.10) was sent for publication in the minutes of the conference and a poster (Annex III.12 sent for display during the event. 7,900 attendees visited the Congress.

- <u>MITECO Workshop on Nature-based Solutions for Water Management in Spain,</u> held in Madrid on March 22, 2019. Fco. Javier García Martínez, taking part as an attendee, took the opportunity to hand out informative brochures and present the project to other administrations. Some 35 people attended.
- <u>Two online seminars of the LIFE ALCHEMIA project,</u> held on June 17, and on September 30, 2021. A presentation on the project was made. Annex IV.1. contains the programmes for the day. Some 86 people attended the first one.

The **<u>UGR</u>** has made presentations of the project, either as oral communications or with posters at the following events:

- **EWA (European Water Association) Spring Conference**, held on May 9 in Copenhagen, Denmark. Bárbara Muñoz made a presentation to an audience of about 120 people.
- **8th Congress of European Microbiologists**, held July 7-11, 2019 in Glasgow, Scotland. Barbara Muñoz presented a poster. An estimated 80-100 people attended the poster session.
- **International Congress on Nitrogen Fixation**, held July 10-12, 2019 in Madrid. Miguel Hurtado, Belén Rodelas and Jesús González participated in the poster session. Approximately 150 people attended.
- **46th IAH (International Association of Hydrogeologist) Congress**, held in Malaga from 22 to 27 September 2019. A poster of the results of Action A1 was presented by Virginia Robles, in a session with an estimated attendance of 100 people.
- **2nd Bioremediation Congress** held in Porto in October 2019. Alejandro González from UGR gave an oral presentation entitled "Organic carbon source effect over the performance and the microbial community in a groundwater denitrifying granular sludge bioreactor" and Belén Rodelas and Jesús González presented a poster entitled: "Physico-chemical performance and microbial characterization of a granular sludge system for groundwater denitrification".
- **EU Water Innovation Conference**, held in December 2019 in Zaragoza. Barbara Muñoz presented the Ecogranularwater project during a networking day to share the experiences and trajectories of research on water management and treatment framed in LIFE projects. 30 people participated in the event.

In addition**, 4 scientific articles** have been published and are attached in Annex III.11.

Regarding sub-action <u>*D2.2. Holding technical workshops to transfer the results obtained to other territories with groundwater pollution problems*</u>, two technical workshops have been held. The first day was held on October 10, 2019, and the second day took place on September 28, 2021. In both days, the progress of the project so far has been presented and a round table of experiences has been organized with the participation of other LIFE projects related to the improvement of drinking water quality. The first was a visit to the Torre Cardela pilot plant. There were 130 participants on the first day, which was held in person, and 113 in the second, 78 in person and 35 through Zoom, with the recording available on the Diputación de Granada's YouTube channel. Annex III.9. contains the programme for the workshops, as well as the materials handed out to the attendees, which consisted of a programme booklet for each day and a pen. A document with images of the conference is also included.

The sub-action "*D2.3. Edition and publication of a technical guide*" consisted of the drafting, layout and printing of a document aimed at water service managers who will use this technology. The guide has been written in English and Spanish and 250 units have been printed in Spanish and 200 units in English. The digital version is available on the project website and attached in Annex II.9.

The objectives envisaged in the proposal to present the project at events of various related themes have been met despite the difficulties imposed by the pandemic.

Action E1. Project management.

	EXPECTED	ACTUAL
Start date:	09/2017	09/2017
End date:	09/2021	09/2021
Milestone: Setting-up of the Steering Committee.	11/2017	11/2017
Milestone: Setting-up of the management team.	11/2017	11/2017
Milestone: Mid-term report dispatch.	01/2019	01/2019
Milestone: Progress report dispatch.	01/2020	01/2020
Milestone: Progress report nº 2 dispatch.	05/2021	05/2021
Milestone: Final report dispatch.	12/2021	01/2022
Deliverable: Partnership agreement.	02/2018	05/2018
Deliverable: After-LIFE Plan	09/2021	09/2021

The aim of this action is to fulfil the obligations established under the Grant Agreement Model in terms of project management and coordination. From the outset, the following tasks required for suitable management of the project have been carried out:

- Assignment of internal personnel for the project - October, 2017 (Mª Caridad Ruiz as Project Manager and Fco. Javier García as coordinator).
- Setting up of the cost centre. Approved in September, 2017 (2017/3/WATER/1/40).
- Transfers to the associated beneficiaries, as established in the Grant Agreement and in the Internal Agreement of partners.
- Attendance at the kick-off meeting held in Brussels in October, 2017 (Mª Caridad Ruiz and Fco. Javier García).
- Constitution of the Steering Committee on the 8th March 2018. It is made up of the members indicated in point 5 of this report.
- Recruitment of external personnel (financial management) - From January 2018 to February 2018, from March 2018 to June 2019 and from July 2021 until the end of the project. The details of the contracts are described below.
- Setting up the management team consisting of the Project Coordinator (Fco. Javier García Martínez), the Project Manager (Mª Caridad Ruiz Valero) and the Financial Manager (Remedios Ortigosa Rubio, Cristina Rodríguez Ramírez and Beatriz Rodríguez Centeno).
- Drafting and negotiation of the internal agreement, signed in May, 2018 in Granada, and the two subsequent modifications aligned with the main amendments to the AG.
- Organization and coordination of fourteen meetings with the beneficiaries in order to address technical, administrative and financial issues (dates mentioned in point 5).
- Administrative tasks for the tendering of services and supplies needed for the development of the project.

- Request and filing of supporting documentation, on a quarterly basis, to the associated beneficiaries.
- Drafting of the technical mid-term report, progress report no. 1 and no. 2 and final report, including the contributions of each partner.
- Preparation of the financial report based on contributions of each partner.
- Maintaining continuous contact with the external monitor, Borja Domínguez. Organization of the four annual visits carried out and the online visit of the project manager of CINEA in September 2021.
- Preparation of a draft of the After-LIFE Plan (annex II.10.), to establish the continuity of actions after the end of the project. The deployment of the business plan and the transferability of the project have been considered as a collaboration scheme between the partners to encourage the installation of new plants in other territories. The maintenance of operations of the biological plant installed in Torre Cardela, its monitoring and control will continue to be supported by the partners. The completion of the procedures for obtaining health permits, the patentability of the granules and the dissemination of the project and its results will also be continued.

Recruitment of a project financial technician could not be undertaken at the start of the project for several reasons:

- Prior to the recruitment of additional personnel, the cost centre had to be approved by the plenary session of the Granada Provincial Council.
- According to existing law, recruitment of personnel for specific programmes may not exceed a period of three years. Adding to the total project development period the additional three months that will be dedicated to the drafting of the final report meant that the entire project lifespan initially came to a total of 41 months; in other words 5 months more the stipulated three year period. As a result, it was impossible to recruit a technician for the entire lifespan of the project. DIPGRA considered it more important to hire a financial technician for the final stage of the project rather than from the beginning as, in the latter case, the project would find itself without a financial technician in the final crucial months when project justification would be required. As a result, recruitment was carried out in such a way as to ensure the presence of the technician during the three months following project completion.
- Given these circumstances, we considered the possibility of hiring a management technician for a short period of time (one month) in order to assist the project manager with internal processing of the signing of the partnership agreement and for the tendering of services. Finally, a management technician was recruited from the 8th of January, 2018 to the 7th of February, 2018 (Remedios Ortigosa).
- Continuing with the initial approach outlined above, a Financial Technician (Cristina Rodriguez) was later hired on a part-time basis, with the idea that she would remain until the end of the project, but finally her assignment to the project lasted from March 2018 to June 2019. After that date, this person resigned from the contract, although she has continued to provide services to the Provincial Council through other projects, which has allowed her to continue providing support to the LIFE ECOGRANULARWATER project, although without charging expenses.

  It should be noted that this has been the most appropriate way to provide coverage for the economic development of the project until the incorporation of a full-time financial technician in the last stage of the project. This was due to the restrictions on the hiring of personnel in the public sector and to the paralysis of activity caused by the health crisis caused by Covid-19, which made it difficult to plan, as it was necessary to extend the duration of the project.

- Finally, as we have already mentioned, for the final phase of the project, from July to December 2021 (the last 6 months, maximum time allowed to public administrations for the hiring of personnel due to accumulation of tasks), another financial technician (Beatriz Rodríguez) was hired to take charge of the financial closure of the project and the preparation of the final report.

The conclusion is that none of the related circumstances have prevented or hindered the proper development of the project's financial management.

6.2.Main deviations, problems and corrective actions implemented.

The main **difficulties** encountered in the project have been related to the following issues:

- with the construction and operation of the prototype, which involved modifications to the initial design and was divided into two phases, causing delays for full-scale commissioning and optimization of operational cycles;
- with the need to include a new partner in the consortium due to the financial difficulties of the company Construcciones Otero in the middle of the development of the project;
- with the pandemic caused by Covid-19, which has led to delays in the completion of the second phase of the prototype.
- with malfunctions in the bioreactors, which have been solved on the fly but have increased the delays in start-up and monitoring.

It should also be noted that the health permits required for the introduction of treated water into the supply network are still being processed after completion of the project.

a) Construction of the prototype in two phases.

Firstly, when designing the full-scale prototype, a series of errors were detected in the sizing of the bioreactor which, as planned, did not reach the target of supplying a population of 500 inhabitants to be met due to the sequential operation of the SBRs and the minimum times of each operating cycle.

On September 25, 2018, a report was sent to EASME on the need to establish two phases in the construction of the prototype (Annex I.4.): a first phase in which a methacrylate bioreactor of specific dimensions would be installed and a second phase in which, once the first bioreactor had been monitored and its efficiency and performance in nitrate removal had been demonstrated, a larger number of PVC bioreactors could be installed to achieve a volume of drinking water suitable for supplying a population of 500 inhabitants.

In February 2019, the first phase of the bioreactor was installed and, following the relevant mechanical operating tests, the UGR started the commissioning phase in March 2019. The bioreactor was commissioned in two phases. The deliverable entitled "Monitoring Report I" describes how each of these phases was carried out. The first phase was carried out using activated sludge from the Baza wastewater treatment plant (province of Granada). After a period, no positive trend was observed in terms of granulation, biomass concentration and nitrate and organic matter removal. It was therefore decided, in a second phase, to inoculate the bioreactor with mature granules from the laboratory.

Granulation difficulties encountered after inoculation with sewage sludge at the start-up of the biological system meant that the monitoring of the biological system’s performance was delayed until May 2019.

b) Change in the organization of the consortium.

On the other hand, in September 2019, the company Construcciones Otero SL informed DIPGRA of its entry into insolvency proceedings. For some time, the consortium was monitoring the company's movements to see if the possible solution to be adopted would allow the workers assigned to the project to continue.

After some time, it was decided to look for another possible partner who could enter the consortium and assume the commitment adopted by Otero Construction in the Grant Agreement and who could continue the actions from the point where the company had left them. The company willing to embark on the project was Gedar S.L., which became part of the consortium on 1 December 2019, although the amendment to the Grant Agreement was requested later. All these delays also led to a request for a 6-month extension of the project completion date. Amendment No. 3 to the Grant Agreement was signed on May 27, 2020 by EASME and on June 3, 2020 by DIPGRA.

c) Covid-19 pandemic.

Soon after Gedar's entry, the Covid-19 pandemic occurred. As explained in the request for amendment No. 4, the pandemic did not lead to a stoppage of the project works, since Gedar is a company dedicated to a basic services such as water management. However, there were delays caused by the closure of some suppliers and by the ERTE (temporary labour force adjustment programme) that the company needed to carry out for a few months.

d) Difficulties in the installation, inoculation and start-up of the new bioreactors.

As was also described in the request for amendment No. 4, the installation and start-up of the new bioreactors by the new company involved solving small difficulties related to the pumps, the electrical system, the probes and the adaptation and programming of the new bioreactors in the PCL. In addition to all this, an accident occurred in November 2020 in which all granules from the methacrylate bioreactor were lost before the new bioreactors had been inoculated. This meant that the University had to put all its systems into operation to produce granules in order to inoculate the bioreactor again (on 31 December, 2020 the first one, in January the second one and in February 2021 the third one). All this further delayed the start-up of the prototype as a whole, since the inoculation was done in phases. The need to carry out a minimum monitoring period of the plant operating in its entirety meant that an additional 5 months were requested to run the project, which moved the project completion date to September 30, 2021.

e) Delays in obtaining health permits.

In February 2021 the first contacts were made with the health authority to request the mandatory health report required by law on the quality of water intended for human consumption in Andalusia. The actions to obtain the permits is summarized in the following table:

Table 2. Timeline for the processing of health permits.

ACTION FOR OBTAINING THE PERMIT	Date
First contact with the Provincial Health Delegation.	February 2021
Inspection visit	**14 March 2021**
Request for a report to the Provincial Health Delegation by the Town Council	22 March 2021

Response and request for correction of documentation by the health authority	**30 June 2021**
Substantiation of the application by the Town Council	22 July 2021
Response and request for correction of documentation by the health authority	**28 July 2021**
Substantiation of the application by the Town Council.	In progress

Two of the points that are hindering and delaying the procedure for obtaining the permits are the completion of a complete analysis of the water treated with the biological system, as well as the designation of a head technician for the DWTP by the supply manager. It is not easy for a small municipality to appoint a head technician because of the financial costs involved. In this regard, the council has requested technical support from the Provincial Council, which is processing a dossier to provide a short-term solution for the first year of operation of the plant. On the other hand, it has been necessary to repeat the complete analysis of the treated water because of high biological contamination detected due to a possible contamination of the sand filter after the accident where the granules left the bioreactor on November 2020.
The project partners continue to work on the processing of the Health Report outside the project development period, and we are optimistic about obtaining the permits as soon as possible.

f) Impossibility of patenting the prototype.

Advised by a patent expert from the UGR, it became clear that it was impossible to patent the system because a lot of information, both oral and written, had been made public about EGW technology.

6.3. Evaluation of Project Implementation.

The following is a step-by-step summary of the objectives and expected results set out in the initial proposal, a description of what has been achieved and an evaluation of the coincidences and differences between the two extremes.

The results of the project linked to the design and construction of the prototype have had a short-term effect, as it is a corrective project linked to a technology that works immediately. However, the efforts made in the dissemination and promotion of the commercialisation and replication of the project will have an effect in the medium to long term.

Action A1. Groundwater characterization.	
Predicted in the revised proposal	Objectives: To carry out a comprehensive hydrochemical characterization of the groundwater body responsible for the drinking water supply. Expected results: To corroborate the presence of nitrate pollution in the groundwater body and to determine whether or not it is affected by pesticides.
Achieved	An extensive characterization of the groundwater body intended for human consumption in Torre Cardela has been carried out (nitrate concentration has been determined in 40 samples). Pollution by nitrates has been confirmed but data reveals that nitrate concentrations vary over time and depend on agricultural practices and rainfall events (infiltration rates). There is no contamination caused by pesticides.

Evaluation	The action took longer than planned, but has enabled the gathering of valuable information about the behaviour of nitrate concentration in the groundwater body and confirm that this does not remain stable. Since the plant is based on a biological process, it would be necessary to adjust the operational conditions to input concentration.
Action A.2. Selection and evaluation of the organic carbon source and selection of the bacterial inoculum and the operational conditions of the aerobic granular system, amended with or without pesticide compounds.	
Predicted in the revised proposal	Objectives: To determine the best combination of factors for operating the biological system for removing nitrates and other pollutants from the groundwater. Expected results: Definition of the best group of inoculating bacteria in the bioreactor, the optimum carbon source and concentration of the same, and the optimal operational conditions. Assessment of the system behaviour and removal performance in the presence of pesticides.
Achieved	After the studies carried out, it was concluded that the quickest and most efficient method of starting up this type of system is inoculation with activated sludge, operating under aerobic conditions and fed with methanol as a carbon source.
Evaluation	Full-scale start-up has subsequently demonstrated that inoculation with pre-formed granules (instead of activated sludge) and using sodium acetate as a carbon source (cheaper than methanol), allows for rapid start-up of the bioreactors.
Action B.1. Design of the full-scale purification plant.	
Predicted in the revised proposal	Objectives: Design of all the components that will form part of the full-scale groundwater treatment plant before its construction, paying attention to the components required to make the plant energetically self-sufficient Expected results: Design of a full-scale plant able to supply drinking water to a population of 500-1000 inhabitants, including all the components to be taken into account in the construction phase.
Achieved	A water treatment plant based on two-stage biological methods has been designed to supply a population of 500 inhabitants. In a first phase, a small methacrylate bioreactor was designed in order to observe the functioning of its interior, and in a second phase, two more polyester bioreactors of larger volume were added, all integrated into a single system.
Evaluation	The design allows us to deduce that the plant is scalable and that the dimensions of the bioreactors are not unique, but that they accept a certain flexibility in their diameter-height ratio. This flexibility allows the design of plants adapted to the size of population to be supplied.
Action B.2. Construction and maintenance of the full-scale purification plant and sludge treatment.	
Predicted in the revised proposal	Objectives: To construct the prototype according to the design established in Action B1 and install it in the Torre Cardela facilities. Plant maintenance will be carried out over the lifespan of the project Expected results: To have a full-scale, energetically self-sufficient plant installed in Torre Cardela, operating to purify the water polluted by nitrates and agrochemical products.
Achieved	The full-scale plant has been built and installed in Torre Cardela with all the necessary elements to supply 500 inhabitants. To promote the use of renewable energy, photovoltaic solar panels and storage batteries have been

	installed. A small artificial wetland has been constructed to purify the water runoff from washing the sand filter. During the life of the project, all necessary repairs and maintenance tasks have been carried out to ensure proper operation. Health permits have not been obtained within the project development period, although the application file is open.
Evaluation	The objective of installing a biological plant, self-sufficient in energy for a large part of the year, has been achieved. One of the project's weak points has been the failure to obtain the health permit prior to completion. However, the consortium remains committed to resolving all the observations indicated by the health authority in the shortest possible amount of time in order to obtain the health permit for this biological DWTP.
Action B.3. Promotion of the transferability and replicability of the project.	
Predicted in the revised proposal	<u>Objectives</u>: To promote the transferability and replicability of the technology proposed in the project in other EU areas facing groundwater pollution problems. <u>Expected results:</u> The identification of areas most affected by the problem and with the greatest potential for replication of the technology, the drafting of a business plan and the commitment of 15 entities to replication of the technology.
Achieved	All deliverables foreseen in the proposal have been completed. A business plan has been designed jointly by the University of Granada and GEDAR, which combines economic theories for commercialization with the practical experience and knowledge of the market provided by the company. The cost of setting up an EGW plant has been calculated according to the number of inhabitants and taking into account different criteria.
Evaluation	The actual commercialization phase did not begin during the life of the project due to the absence of health permits and the limited time available for the monitoring phase of its operation and the preparation of economic and environmental studies of the technology, the positive results of which have been provided in the final phase of the project. However, an ambitious yet feasible business plan has been designed, which will begin to be implemented once the health permits are in place. The results of this action will take effect in the medium to long term, when the business plan and the replicability plan start to be implemented.
Action C.1. Monitoring of the impacts of the full-scale purification plant.	
Predicted in the revised proposal	<u>Objectives</u>: To monitor the impacts of the full-scale plant after its construction and start up. <u>Expected results</u>: installation of a fully operational biological plant for the treatment of nitrate-contaminated groundwater intended for human consumption.
Achieved	The installation has been fully commissioned and monitored to ensure correct operation, establishing the operational parameters and nutrient addition for correct operation. All analytical and control systems have been implemented to ensure the correct operation of the facility. The monitoring periods have been: - Phase 1 (methacrylate bioreactor): From 1 April 2019 to 1 November 2020. - Phase 2 (3 bioreactors together): From 1 March to 31 August 2021.
Evaluation	The plant is now fully completed and operational, having adjusted and optimized the operating cycles and nutrient addition to the maximum.

Action C.2. Analysis of socio-economic and environmental sustainability: cost-benefit analysis and of the carbon and environmental footprint.	
Predicted in the revised proposal	Objectives: To demonstrate that the new water purification plant is a superior cost-benefit solution and has a lower environmental impact than other alternatives, such as reverse osmosis. Expected results: To obtain information relating to the price of the treatment of 1 m^3 of drinking water, the Product Carbon Footprint, Product Environmental Footprint, and LCA of both systems (RO and EGW).
Achieved	A cost-effectiveness analysis was performed to compare the cost of producing 1 m^3 of water with the RO plant and with the EGW plant and a contingent valuation analysis. In addition, the impact of putting the demonstration plant into operation on the water utility's budget was analyzed. The LCA was prepared with SimaPro software.
Evaluation	As regards the financial costs study, the methodology employed has been appropriate to demonstrate that the EGW plant represents a better solution in financial and economic terms than the RO plant. This methodology is used in the River Basin Management Plans to prioritize measures in the action programmes and is consistent with the recommendation to use economic instruments for decision making provided for in the WFD. The result is that, in **financial** terms, the new plant makes it possible to produce 1 m^3 of water with a cost saving of 30%. In **economic** terms, the cost savings are 45%. The EGW plant will allow the water service cost recovery rate to increase from 60% to 85%. With regard to the study of environmental impacts and LCA, as extensively described in deliverable II.7, it has been shown that in the treatment of 1 m^3 of water, EGW technology has a lower carbon footprint and environmental footprint than RO, mainly because biological technology consumes less electricity. The impact of the plant's operation phase plus the infrastructure phase is reduced by an average of 60% in the EGW plant compared to the RO, both analyzing the carbon footprint and the environmental footprint in the different impact categories measured.
Action C.3. Monitoring of the LIFE Programme Indicators.	
Predicted in the revised proposal	Objectives: To monitor the indicators established by the LIFE Programme and selected during the project, on project completion, and three years after project completion. Expected results: To gain information relating to the impact of the project in relation to natural resources, energy, waste, persons involved, dissemination and costs.
Achieved	The context and specific context, according to the framework established by the Life Programme, were defined, and selection of the indicators to be measured at the end of the project and three years after completion of the same, were made. The values of the indicators were estimated at the beginning, at the end of the project and three years later. Once the project was completed, the indicators were recalculated according to the results obtained.
Evaluation	Initially, values were defined according to the expected objectives in terms of resource consumption, emissions, waste production, entities involved or impacts on the dissemination of the project. These data could not be recalculated until the final results of the economic and environmental studies were available. The values of the indicators have changed, but they are close

<table>
<tr><td></td><td>the real figures. Those related to the replicability of the project after 3 years have also been adapted to the results provided by the business plan, which foresees, in an intermediate scenario, the installation of a larger number of plants than initially foreseen.
On the other hand, the values of the indicators related to the impacts of project dissemination have been lower than initially expected, perhaps because they were overestimated.</td></tr>
<tr><td colspan="2">Action D.1. Dissemination Planning, Development of the Dissemination Pack, and Networking.</td></tr>
<tr><td>Predicted in the revised proposal</td><td><u>Objectives:</u> To disseminate the project among target groups, stakeholders and the general public.
<u>Expected results</u>: Communications plan, dissemination tools (website, Facebook page, notice boards, leaflets, newsletters, video, Layman's report, etc.), impact of the dissemination on the recipients (water management professionals, municipalities, water management companies, researchers, etc.).</td></tr>
<tr><td>Achieved</td><td>All planned deliverables have been completed and all communication tools foreseen in the proposal have been used to publicise progress and results throughout the life of the project.
The web page has been used as the central tool, where other deliverables such as 2 brochures, 50 news, 10 periodical Newsletters, 2 videos and 2 spots of the project, registration form, Layman Report, etc., have been posted in different sections. In addition, all information is in both Spanish and English.
Networking activities have also been carried out, mainly with other LIFE projects related to the elimination of nitrates and other sources of contamination of water for human consumption. 6 of them have involved participation in a round table of experiences during the two informative workshop days organized within the framework of the project.</td></tr>
<tr><td>Evaluation</td><td>The objectives foreseen in the proposal have been achieved and a wide variety of communication resources have been used to raise awareness of the project, both in digital and paper format. Other projects have been identified that are working on the elimination of nitrates from water using different technologies, and contact will be maintained with them to exchange experiences. 2 documentary videos, 2 spots, 2 technical seminars, 2 brochures, 10 regular newsletters and meetings with companies have made it possible to explain the technology at different levels and to different audiences.</td></tr>
<tr><td colspan="2">Action D.2. Technical dissemination of the project and promotion of the replicability of the project results.</td></tr>
<tr><td>Predicted in the revised proposal</td><td><u>Objectives:</u> To communicate the project among the scientific community and among entities involved in water management.
<u>Expected results</u>: Attendance, throughout the lifespan of the project, at important events relating to the areas of environment and water in an effort to disseminate the project in technical circles. Organization of 2 technical workshops targeting water managers and researchers. Publication of a technical guide.</td></tr>
<tr><td>Achieved</td><td>The LIFE EGW project has been presented at 13 events (Congresses, Conferences, and Symposiums) of a technical nature and on diverse topics: the environment in general, water management, specific microbiology, hydrogeology, nitrogen fixation, etc. Oral, poster and written communications</td></tr>
</table>

	were presented. On the other hand, 4 scientific articles have been published in high impact journals. Likewise, the two technical workshops planned for raising awareness of the LIFE EGW project have been held and the technical guide has been published in both English and Spanish.
Evaluation	The objectives foreseen in the action in relation to the technical dissemination of the project have been met. During the pandemic period, this type of event was suspended and later recovered in a combined online format.
Action E.1. Project management.	
Predicted in the revised proposal	<u>Objectives</u>: To fulfil the obligations established under the Grant Agreement in terms of project management and coordination. <u>Expected results</u>: Consolidation of a compact, coordinated work team; presentation of quality reports; adherence to schedule.
Achieved	DIPGRA formed a management team. The person in charge of financial management has changed during the lifetime of the project. An internal agreement was signed between the partners that has had addenda due to changes in the consortium and the project completion date. DIPGRA has also processed the amendments to the AG with EASME and CINEA, due to the causes described in the report. Coordination and SC meetings were held on a quarterly basis, approximately. A total of 14 SC meetings were held, plus other coordination meetings. There was direct communication between the coordinator and the associates, as well as between the coordinator and the external monitor. There was an annual visit from the external monitor and a visit from CINEA in the final phase of the project. At the reporting level, two progress reports have been sent, the interim report with a request for payment and the final report with a request for payment. To date, the two scheduled payments have been received and the corresponding portion has been transferred to each of the partners.
Evaluation	Project management has been carried out correctly, ensuring compliance with the guidelines established by the LIFE Programme, such as the compilation of all technical and financial documentation that supports the actions carried out and the expenses incurred, and the submission of the relevant reports in due time and form. Likewise, the coordination of the project has allowed the continuous sharing of the progress of the project and its difficulties, the search for solutions to the problems that have arisen, the processing of the administrative documentation necessary to adjust the changes adopted, etc.

The project has progressed as expected, although <u>two amendments to the GA</u> were necessary. On the one hand, the company Gedar joining has been essential to continue the work assigned to Construcciones Otero and to be able to complete the construction, installation and maintenance of the prototype. Also, extending the duration of the project by 11 months has provided an essential margin of time to solve the operating problems that have occurred and to be able to properly monitor the effectiveness and performance of the system.

However, there was not enough time to complete the <u>processing of the Health Report</u> with the provincial health authority. At the date of project completion, the necessary permit is not available to introduce the water treated with the biological system into the municipality's supply network. However, the partners are still working to correct the deficiencies detected by the health inspector and to complete all the information requested.

The work carried out to analyze the economic and environmental cost of the technology has revealed the water service management problems suffered by small municipalities, with a lack of technical means, human and economic resources to adequately provide a basic service such as domestic water supply. The impossibility of applying economies of scale, the non-separation of water service accounting, the poor condition of some old infrastructures, the absence of qualified technical staff or staff with the necessary dedication to water service, the low rate of cost recovery and the high amount of unregistered water are some of the most important weaknesses that are repeated in many small municipalities that carry out direct management of water service.

In terms of replicability, the UGR has worked intensively, hand in hand with GEDAR, in the drafting of a business plan to reflect an ambitious and at the same time viable strategy for the commercialization of the technology, which the company itself considers realistic and within its reach. The situation caused by the pandemic, the need for dedication to the project during the last months of implementation, the positive economic and environmental results obtained in the final phase of the project, and the fact that the plant is not in operation at the municipal supply level (due to the lack of health permits), have slowed down the development of marketing and promotion activities for the technology during the life of the project.

Thanks to the dissemination activities, several municipalities such as Humilladero in Malaga, Lojilla (Montefrio) in Granada, as well as water management companies, have shown direct interest in the technology, contacting the partners directly, as they have supplies affected by nitrate problems. More municipalities and companies have learned about the technology through their participation in the technical conferences, subscription to the newsletter, etc. Part of the future work of the partners, once the health permit has been obtained, is to continue promoting the technology which, in the case of the Provincial Council, can be financially supported in municipalities of the province through the Works and Services Plans.

During the development of the project, there has been a regulatory change at the European level in relation to the regulations concerning the quality of water for human consumption, with the approval of Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption. With respect to the previous Directive, the limit established for the presence of nitrates in drinking water, which cannot exceed 50 mg/l, has not been modified. Although the EGW technology and the results of the project do not represent changes that could affect drinking water policies and regulations, it does make a new technology available and within the reach of water supply managers, with better economic and environmental conditions than conventional technologies to deal with this contamination problem.

6.4. Analysis of benefits.

The replication of this project in other regions will achieve economic, social and environmental benefits for different stakeholders.

1. Environmental benefits.

The new EGW technology contributes to the reduction of energy consumption in the process of purification of water contaminated by nitrates compared to other traditional systems such as RO. In units of m^3 of water produced, the EGW plant consumes 0.37 Kwh/m^3 while the RO consumes 2.05 Kwh/m^3.

Another aspect that has been highlighted and is of great importance, especially in areas with Mediterranean climates, semi-arid climates or areas with water scarcity, is the reduction of additional water consumption in the drinking water production process. Studies have shown that to produce 1 m^3 of water, RO uses 1.42 m^3 while the EGW plant only requires 1.02 m^3. In other words, for every m^3 of water treated with osmosis, 0.42 m^3 of water is rejected, while with the EGW plant, the rejection is reduced to 0.02 m^3.

In terms of carbon footprint, the EGW plant, each m^3 of water produced, emits 0.38 KgCO2eq, while the RO plant emits 1.02 KgCO_2eq. Therefore, EGW technology reports a CO_2eq reduction of 62.75% compared to RO.

In the case of the environmental footprint, as in the carbon footprint, the EGW plant represents an average reduction of 66.42% in the different impact categories analyzed, as shown in the following table:

Table 3. Impacts per m^3 of purification water.

Impacts per m^3 purification water	Unit	EGW	RO
Carbon footprint	kg CO_2 eq	3.98E-01	1.02E+00
Photochemical ozone formation	kg NMVOC eq	1.38E-03	3.27E-03
Acidification	mol H^+ eq	2.67E-03	8.17E-03
Freshwater eutrophication	kg P eq	1.07E-04	3.35E-04
Freshwater ecotoxicity	CTUe	5.31E+00	2.41E+01

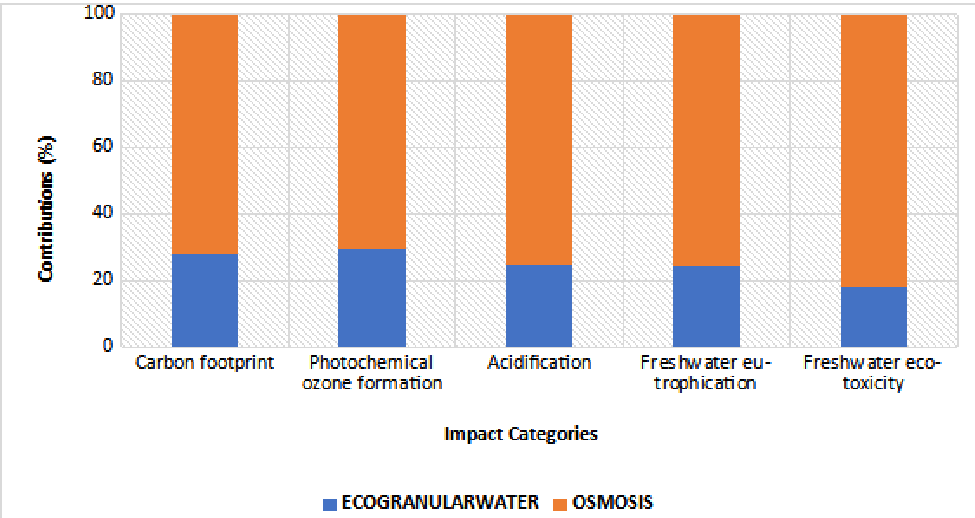


Figure 16. Comparison of the environmental footprint between both systems.

In general, the RO plant has a higher impact in all the categories analyzed compared to the EGW plant, due to higher resource use and a greater negative impact on the environment.

High water consumption by the RO generates more stress on water resources in areas where water resources are scarce. In addition to the stress caused, it is very important to note that RO only removes nitrate in a part of the urban water cycle that is destined for human consumption, but does not make it disappear from the basin. The brine produced in the RO process generates a cumulative nitrate effect that will persist forever in the supply zone. On the contrary, the EGW plant reduces nitrate to nitrogen gas (N2) which is returned to the atmosphere without producing any polluting effect, eliminating it from the supply area.

With the passage of time, if the nitrate input to the aquifer is reduced, this parameter could reach suitable levels, while the use of RO, by discharging the nitrate-concentrated brine in the same area or nearby, only maintains or displaces the contamination problem, but does not improve the suitability of the water resource.

2. Economic benefits.

From the economic point of view, investments will be encouraged in the sector related to the integral water cycle, which will make it possible to reduce operating costs and free up economic resources that can be used for other purposes. The analysis of economic and financial costs also corroborates that the cost of making water drinkable with the EGW system is 45% cheaper than with RO. The councils of small municipalities will be one of the parties that will benefit most from the implementation of EGW technology, since they usually have budget deficits in the drinking water supply service. In the case of Torre Cardela, it has been estimated that the cost recovery of the water service could be increased from 60% to 85% by replacing the RO with an EGW treatment plant.

In addition, the business sector will obtain financial profits from investing in this new technology through different channels.

- On the one hand, the companies managing the complete water cycle could reduce the costs of drinking water production in the treatment plants they manage, gaining a competitive edge in the market on the competition.
- On the other hand, companies that develop production processes with high water consumption can benefit from a technology that can be installed individually in their facilities, allowing them to eliminate nitrates present in the water at a low cost, both in the incoming water, from their own catchments, and in the effluents they generate, avoiding the discharge of contaminated water into the environment.

The investments that will be made in the construction of new water treatment plants with this technology and their subsequent maintenance are bound to generate an economic impact on multiple sectors and/or branches of activity. First, there will be **direct effects on production and employment** in the "Water supply; sanitation, waste management and decontamination activities" branch, which is the branch to which the companies in charge of designing and installing EGW plants, and providing maintenance, technical assistance or water production services belong.

Secondly, **indirect effects** will be generated **in other productive branches**, as a consequence of the purchase of intermediate goods and services by upstream companies from other suppliers, which will also lead to in an increase in turnover and employment. Among the industries that will benefit the most, indirectly, are "Electric power, gas, steam and water", "Manufacture of metal products" and "Metallurgy". Within services, the "Trade", "Transportation and warehousing", and "Technical and professional services" branches will be boosted.

The sum of the direct and indirect effects estimated in each demand scenario, represents very significant economic benefits for the business sector and also for the Public Administrations, which will collect more taxes and social security contributions as a result of the increase in turnover and employment recorded by the companies. According to forecasts, if the intermediate demand scenario were to be fulfilled, the direct and indirect production of goods and services, driven by the business sector, would amount to 9.51 MEUR during the first five years.

3. Social benefits.

Likewise, the production of goods generates income that is received, on the one hand, by workers in the form of wages and salaries and, on the other hand, by the owners of capital in the form of business profits and interest, and by the public administrations through taxes. In the period analyzed, it is estimated that the income generated, in the case of the intermediate scenario, would exceed 5 million euros, with workers receiving close to 50% of this income in the form of wages and salaries. For their part, public administrations would collect around 20% of the income received by workers and owners of capital.

In terms of employment, the commercialization of EGW technology will allow the creation, in the intermediate demand scenario, of approximately 30 new full-time equivalent jobs in the fifth year, of which 20 would be direct and 10 indirect. In addition, an average of 19 jobs would be created annually during the first five years. In the best case demand scenario, jobs created in the fifth year would rise to more than 40, while in the worst case scenario, they would fall to 18 jobs in the last year. The average annual number of direct and indirect jobs in the first five years is estimated at 31 for the most favourable demand scenario and 9 for the pessimistic scenario.

It should also be noted that, as described in action C2, the use of EGW technology in the provision of water services at the local level will allow the water supply manager, the municipality itself in small municipalities, to increase the water service cost recovery rate. This means that the local administration will have more financial resources to allocate to other social activities in the municipality.

4. Replicability, transferability, cooperation.

As described in the **Replication and Transferability Plan**, three stages have been projected to carry out the commercialization of the new technology. The first one, which coincides with the technology introduction phase, covers the first three years, and targets the Andalusia region, due to its proximity to the Torre Cardela pilot plant and the possibility of exploiting the demonstration effect in other municipalities. In a second stage, which lasts between 4 and 6 years, it will seek to grow in the rest of Spain and Portugal. Finally, in the long term (7-10 years), it is expected to open new markets in other Mediterranean countries of the EU.

The sales or installation targets for EGW plants have been defined for each of the projected stages, considering three demand scenarios. Thus, in the worst-case scenario, 20 plants would be installed in the medium term and 50 plants after 10 years. In the intermediate scenario, 40 plants are expected to be installed in 5 years and 90 plants in 10 years. Finally, in the most favorable scenario, 60 plants are expected to be installed in the fifth year and 125 plants in the tenth year.

The technology developed in this LIFE project has a high potential for transferability and replicability, due to the fact that its main recipients would be small municipalities, which usually have the backing of supra-municipal entities in their investments in infrastructure and equipment. This would be the case of the Provincial Council of Granada which, in exercising its responsibility for economic assistance and cooperation towards its towns, applies the *Provincial Cooperation Plan for Works and Services of Municipal Competence* on a biannual basis. This plan includes, as preferential actions, investments aimed at improving water supply and sanitation, which would allow municipalities to finance up to 70% of the installation of EGW technology.

Moreover, the LIFE EGW project fits perfectly within the objectives set by the EU's Next Generation funds, consisting of large-scale financial support for public investments and in areas related to green and digital projects. These funds will be invested in various programmes and distributed to EU countries and beneficiaries through grants (407,500 MEUR) and loans (385,800 MEUR). Spain may receive up to 140,000 MEUR, of which 72,000 MEUR would be in direct aid.

The main weaknesses and threats that may affect this project stem from the uncertainty about the economic recovery after the COVID-19 pandemic, which may condition the purchasing capacity of potential customers, as well as the risk that the health authorities may not approve the implementation of this biological technology in certain areas of the EU, or that they may require control mechanisms or additional water treatments, which may increase operating costs.

From an economic and financial point of view, the LIFE EGW project is feasible according to the analysis carried out. In order to ensure the medium and long-term viability of the company promoting the project, it is essential that it promotes investment strategies in human capital and R&D&I, to continue innovating in the improvement and study of new applications of EGW technology, as well as promoting the implementation of an integral quality system, promoting collaboration and the establishment of alliances with other companies to reach more markets and seek leadership in environmentally sustainable development.

To reinforce the transferability and replicability of the project in the EU, it is essential that there is a strong involvement of the Public Administrations in the development of policies that promote investment in environmentally friendly technologies, such as the one developed in this project, by financially assisting local entities that are responsible for drinking water supply, in the installation and maintenance of plants with EGW technology.

5. Best Practice lessons.

First of all, it should be noted that the consortium formed for the implementation of this innovative project in the water sector has been very successful, taking into account the profile of each of the partners, their competencies and their scope of action:

- The Provincial Council of Granada is a public body, a local authority, which provides technical and financial support to the municipalities of the province, especially to those with fewer than 20,000 inhabitants. DIPGRA has the Integral Water Cycle Service within its organizational structure, to manage various water management programmes and, specifically, the Urban Water Cycle Exploitation Section. It manages various programmes, including "Other supplies for the integral water cycle", "Implementation of remote management of the integral water cycle" and "Water Quality Control". The Provincial authority also has the Provincial Cooperation Plan for works and services at municipal level, which provides financial support for works and services in the area of urban water cycle management. This role has been vital on the one hand in the coordination and management of the project and, for the future, to promote the technology in the towns of the province of Granada
- The Universities of Granada and Aalto are represented in the project through different departments, mainly from the fields of water, microbiology and economics. These are institutions with renowned capacity for research and knowledge, and extensive experience and participation in research, development and innovation projects. Their role in the design, operation and adjustments of the innovative biological technology have been vital, as well as their role in monitoring the impacts and leading all economic, environmental and biosafety studies of the demonstrated system.
- The companies OTERO and GEDAR have a long history in the construction of technologies for the water sector, as well as in the maintenance of water services. Both companies have been responsible for transferring all the knowledge from the laboratory to a real scale, designing, building, installing and maintaining the pilot plant.

On the other hand, the development of the pilot plant in several phases has allowed us to make decisions on small adjustments in the design and operational conditions that have allowed us to demonstrate that it is a very versatile system due to the following:

- It is a scalable system, capable of adapting to the size of the population and the space of existing facilities. Bioreactors of various sizes, with different diameter-height ratios, have been installed and operated and it has been demonstrated that the aeration achieved in all cases enables the correct formation of granules, as well as the efficiency of the system in the elimination of nitrates.

- The hydraulic retention time of the process can be reduced with respect to what was initially planned, allowing for shorter cycles and a greater volume of treated water. Adjustments must be made to achieve a balance between the nitrate concentration at the inlet and outlet and the need for mixing with raw water, to ensure that the final nitrate concentration is within the limits established by law. However, this technology, as designed, cannot operate continuously. This would be the subject of further research.
- The nutrient supply can be adjusted to the nitrate concentration of the inlet water, thus optimizing operating costs.

Finally, we must emphasize that the difficulties encountered in obtaining health permits are not exclusively due to the installation of an innovative and pioneering biological technology in Andalusia, but are also directly related to the limitations and complexities faced by small municipalities in the management of water services, largely caused by the shortage of technical and economic resources to provide the service in accordance with legal requirements. The improvement of water services in small municipalities is a pending issue, both in the province of Granada and national level, which has also become evident over the course of this project.

6. **Innovation and demonstration value:**

The use of the aerobic granular system for the removal of nitrates in groundwater is a new low-cost biological technology that enables not only the treatment of polluted groundwater but at the same time it enables lower costs when compared to other technologies. Furthermore, the EGW technology represents a self-sufficient alternative in terms of energy, with very low environmental impact by generating no waste and being able to be considered as a biofactory concept.

7. **Policy implications.**

During the lifetime of the project, the EU passed Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption. As regards the limits established for nitrates, the value of 50 mg/l has been maintained as the limit for the suitability of water for human consumption. At national level, work is underway on the draft Royal Decree establishing the technical and health criteria for the supply and quality control of drinking water, which will incorporate the requirements of the new Directive.

As already mentioned, although the results of the project will not modify the parameters and limits established in the regulations regarding nitrates, they do provide an innovative solution, with a smaller environmental footprint and a lower economic cost than other conventional technologies. The technology has proven to be effective in the elimination of nitrates, enabling water polluted by nitrates to be made drinkable. It is therefore a viable solution to ensure compliance with legislation in supply areas with this contamination problem.

On the other hand, the economic and environmental studies carried out in Torre Cardela's water service have revealed a latent reality in many of the small municipalities that carry out the direct management of the service. High water consumption accompanied by a high level of unregistered water and a low cost recovery rate have been detected.

Some of the unregistered water is thought to be leaks, due to the fact that the infrastructures are old and little investment is made in improving them. But another important part is suspected to be fraud. In terms of improving water management, it would be desirable for managers to carry out diagnoses of the service situation, infrastructures, economic balance, etc., in order to be aware of the magnitude of the problem and identify the areas where it is a priority to make improvements.

7. Key Project-level Indicators

Initially, indicators were defined based on the forecasts established in the proposal, which can be summarized in the following points. More details on the calculation of the indicators can be found in the annex II.8.

- At the end of the Project, the EGW plant was expected to be in operation, with permits obtained and integrated into the Torre Cardela DWTS. This would result in a reduction in the operation of RO.
- Three years after the end of the project, 10 new plants were to be installed in municipalities of approximately 1,000 inhabitants. 7 jobs would be created and the cost per plant was estimated at €105,000.
- Water reduction values were estimated considering the replication targets described above, that the entire volume of treated water passes through osmosis and that 40% of the water is rejected as brine.
- In terms of lower energy consumption, a reduction of 87% of electricity consumption, with 100% of it coming from renewable sources were considered.
- In relation to the indicators regarding the dissemination of the project, very ambitious objectives were set, such as 32,000 individuals on the website or 320,000 unique visits.

In order to determine the final values of the selected indicators, it was necessary to have the results of actions C1 and C2. It was first necessary to demonstrate the efficiency of the technology in the purification of water contaminated by nitrates. Subsequently, economic, financial and life cycle analysis studies of the technology have confirmed the initial hypotheses (better cost-effectiveness and lower environmental footprint than other conventional systems), as well as refining its calculation. These results have determined the definition of the three scenarios described in the business plan for the replicability of the project over a time horizon. In an intermediate scenario (neither the most pessimistic nor the most optimistic), replicability expectations are foreseen within 3 years above those initially defined in the proposal. These forecasts are summarized in the following points:

- At the end of the Project, it has been considered the real capacity of the EGW plant to treat water.
- After 3 years, considering an intermediate scenario, 18 new plants are expected to be installed in towns of around 1,000 inhabitants. The plant is expected to create 19 jobs and cost €97,605 without chemical control (and €214,296 with chemical control).
- Water reduction values are lower than initially expected. It has been taken into account that the treated water (both with the EGW system and with the RO) can be mixed with raw water in a 1:1 ratio to achieve final nitrate values within those permitted by law. This means that the water savings of the approximately 40% that osmosis rejects more than the biological plant, would only apply to half of the volume of water consumed.
- As for the reduction of electricity consumption, a final value of 82% has been determined. Water treatment with the RO plant has a consume of 2.05 kwh per m^3 while the treatment with the EGW system has 0.37 kwh per m^3.

- The consumption of electricity from renewable sources by the biological system is not 100% every day of the year. There are sporadic weather situations that force the system to draw power from the grid.
- Finally, in terms of the impact of the website on the dissemination of the project, it has reached 9,189 individuals, 12,514 sessions and 28,448 pages visited. Probably the initial values included in 2018 were overestimated and overambitious.
- Greenhouse gas emission values have been calculated according to the results of the life cycle analysis, carbon footprint and environmental footprint. Both systems have been considered as consuming electricity from the grid in order to compare the CO_2 emissions.

Finally, the specific context "Drinking water supply sector" has been removed as it refers to ecosystem services and was mistakenly included in the initial forecast.

8. Comments on the financial report

8.1. Summary of Costs Incurred.

The following table presents the project costs incurred until the end of the project:

PROJECT COSTS INCURRED				
	Cost category	Budget according to the grant agreement in €*	Costs incurred within the reporting period in €	%**
1.	Personnel	579,816 €	581,217.62 €	100.24%
2.	Travel and subsistence	54,125 €	16,522.50 €	30.53%
3.	External assistance	74,922 €	40,563.72 €	54.14%
4.	Durables goods: total non-depreciated cost	166.014 €	99,561.01 €	59.97%
	- *Infrastructure sub-tot.*	-	-	-
	- *Equipment sub-tot.*	2,075 €	0.00 €	0.00%
	- *Prototype sub-tot.*	163,939 €	99,561.01 €	60.73%
5.	Consumables	27,999 €	17,969.12 €	64.18%
6.	Other costs	27,100 €	16,736.62 €	61.76%
7.	Overheads	65,024 €	54,079.94 €	83.17%
	TOTAL	**995,000 €**	**826,650.53 €**	**83.08%**

In general terms, 83.08% of the project budget has been executed, which has enabled the overall achievement of the objectives set out in the project in an adequate and sufficient manner.

Despite reaching the end of the project, the beneficiaries have continued to dedicate their own resources, both personal and material, in order to ensure its continuity.

The following are the most important details of the comparison between the initial budget and the expenditure actually made:

- **Personnel**: In order to *comply with the 2% rule*, the beneficiary public agencies listed below have not imputed hours worked on the project in accordance with the following:

DIPGRA

	Year 2019		Year 2020		Year 2021		Total adjustment of hours worked on the project	Total personnel costs not claimed for the project
Category/Role in the Project	**Hourly rate**	**Adj of hours**	**Hourly rate**	**Adj of hours**	**Hourly rate**	**Adj of hours**		
Head of Service/Project Coordinator	44,22	-74,5	44,29	-128	47,31	-85	-287,5	-12.984,88
Environmental technician/Project Manager	47,71	0	32,92	0	31,89	-363,5	-363,5	-11.590,49
							-651	**-24.575,37**

In the case of the project coordinator (Fco. Javier García), the hours worked on the project from August 2019 to the end of the project have not been imputed, while in the case of the project manager (Caridad Ruiz), the hours worked on the project from May 2021 to the end of the project have not been imputed.

In general terms, the personnel costs necessary to continue with the deployment of the project during the eleven months in which it has been extended have been financed with the entity's own resources, amounting to €24,585.37 plus the indirect costs that would have corresponded proportionally.

AALTO

	Year 2017		Year 2018		Total adjustment of hours worked on the project	Total personnel costs not claimed for the project
Category/Role in the Project	**Hourly rate**	**Adj of hours**	**Hourly rate**	**Adj of hours**		
Professor	0,00	0,00	57,30	-66,15	-66,15	-3.790,07
Postdoctoral Researcher	28,83	-530,00	28,25	-308,70	-838,70	-23.999,43
					-934,85	**-27.789,49**

In the case of the professor (Riku Vahala), the hours spent on the project in 2018 have not been imputed, while in case of the researcher (Alejandro Gonzalez), the hours worked on the project in 2017 (partially) and 2018 have not been imputed.

This drastic adjustment stems from Mid-term Report observation that pointed out that Alejandro González should be considered “non-additional” in accordance with Article II.19.2 of the General Conditions.

In other areas, in accordance with the guidelines provided in the response to the fifth follow-up visit, we have reported the personnel costs for any single employee in one line in a given year, considering as daily working hours the weighted average of the year.

In the case of Gedar, the division into multiple lines was due to variations in the percentage of the working day of the majority of the company's workforce as a result of the Temporary Furlough (ERTE) which the company applied during the pandemic.

- **Travel and subsistence**: The main reason for the level of expenditure for this item, which reached 30.53%, was the health crisis caused by Covid-19. Mobility restrictions have limited in-person attendance at events, as well as increased online participation, resulting in a lower cost associated with action D.2.

  In line with the above, the cost charged to action B.2 by Gedar was also significantly lower than budgeted. Despite the fact that 120 trips were made to Torre Cardela, compared to the 143 budgeted, for the installation, maintenance and monitoring of the plant, only two people went simultaneously for 18 days, which resulted in the imputed expenditure being reduced by half.

  For its part, Otero, despite having made the required trips to the plant, has not passed on any costs to the project.

- **External assistance**: For this item, the 54.14% of expenditure is motivated by the efficiency in the allocation of resources by all beneficiaries, who received more competitive prices that allowed them to implement the actions effectively with an overall saving of €34,358.28.

  For example, in the case of DIPGRA, the cost item "design, hosting and maintenance of the web page", initially budgeted at €20,495, amounted to €8,712.

  On the other hand, the UGR has carried out with its own personnel both the microbiological analyses and the translations foreseen for this expense, budgeted at €11,250, with only the purchase of consumables for carrying out the analyses being charged to the corresponding item.

  On the part of Otero and Gedar, the plant start-up costs were 59% lower than budgeted.

  Finally, it should be noted that, despite not being included in the budget, in order to ensure continuity of appropriate monitoring of the water treatment plant, it has been necessary to transfer the remote control to the remote management system of the DIPGRA, the cost of the service being assumed by said partner (€7,498.43).

- **Equipment costs**: Finally, it has not been necessary to acquire the SCADA software license because Gedar already had it, so that the Internet connection the only related cost that has been imputed to the project, since it is necessary for the correct operation of the remote control.

- **Prototype**: It should be noted that certain expenses initially budgeted have not been necessary in the development of the project, such as the metal frame with the necessary measures for storage and transport of equipment, the multifilamento mesh for flexible gabions or the irrigation system for maintenance of plants phytodepuration. In addition, due to the capacity of private companies to directly undertake the work contemplated in this item, it has not been necessary to outsource services as initially planned, for example the assembly of the SBR bioreactor, which has resulted in a lower expenditure in this item.

- **Consumables**: Having reached an execution level of 64.18%, we must refer to the circumstance mentioned above regarding Aalto University, which accounted for more than half of the allocation of this item. Therefore, the UGR has assumed most of this type of costs, as well as, to a lesser extent, DIPGRA and Gedar.

- **Other costs**: For the reasons explained in the technical part (action B.3 and section 6.2), the expenditure associated with the acquisition of the patent has not occurred.

  The expenses associated with action D.2 on the part of DIPGRA were also lower because the speakers at the two technical seminars held were not paid for this. The catering and merchandising expenses were also significantly lower because the prices were more competitive and it was not possible to provide this service at the final technical seminar due to the security measures adopted by Covid-19.

  Likewise, expenses for translations have finally been lower than initially foreseen.

  Where appropriate for the project, the UGR has attended congresses that had not initially been foreseen, and the corresponding registration costs have been charged to this item.

  Likewise, within the framework of Action C.2, it was necessary to acquire translation services that had not been budgeted for (€1,390.71).

  In contrast, while the acquisition of graphic design software and a fully comprehensive insurance were initially budgeted, in the end these proved to be unnecessary.

Finally, it is necessary to point out that the Financial Statement of Aalto has been signed by Mr. Gary Marquis, Dean of the School Engineering, who is enabled to represent the beneficiary legally/financially.

8.2. Accounting system.

➢ **Accounting systems employed:**

DIPGRA: The **Provincial Council of Granada** uses an accounting information system designed for the management of general budgets for local public administrations known as "*SicalWin*". For specific projects affected by external funding, an "expenditure project" is created within the application and identified with a code.

For the LIFE ECOGRANULARWATER project this code is 2017/3/WATER/1 and all incomes, expenditures and transfers relating to the project are registered in this cost centre, with the exception of personnel costs of permanent staff and overheads.

UGR: The accounting system used by the **University of Granada** is *UNIVERSITAS XXI*. Project accounting is separated by means of expenditure centres created for each project. All expenditures should be authorized by the person responsible for the expenditure centre, usually the principal investigator. The code of the expenditure centre is 2017-30B1631601 – LIFE16 ENV.ES.000196.GONZÁLEZ LÓPEZ, JESÚS.

The accounting system employed, as with all current accounting systems, only allows an invoice to be associated with one expenditure centre.

OTERO: Construcciones Otero S.L. uses an integrated accounting system implemented in its ERP-Enterprise Resource Planning *(iVECTOR Integra*), so all company activities are separated by project within the system.

In each project, or cost centre, costs relating to personnel assigned to the project in question are registered according to their level of commitment, as are costs relating to project purchases (supplier invoices, equipment rental, etc.). This LIFE Ecogranularwater project number is O17040046.

AALTO: **AALTO University** internal accounting is project based, each project bearing its own code (Ecogranularwater: T2 School of ENG/T213 Built Environment/604424). This ensures that each project can be individually handled, monitored and reported on. All actions take place within a nominated project. The accounting system consists of a number of subsystems interconnected via Aalto DW (Data Warehouse, overnight updates), the most significant individual project management systems being:

- Halli for work time reporting.
- M2 travel management system.
- Rondo for invoice processing and management.
- QlikView for financial management and reporting.

GEDAR: GEDAR S.L. has two software programs for managing its activity: FactuSOL for the logistics area (warehouse, purchases, receipt and shipment of merchandise, fabrications and repairs...), sales area (budgets for clients, dispatch notes, invoicing...) and accounting area (collections, payments...) and ContaSOL for accounting management and taxes.

For the LIFE ECOGRANULARWATER project, a specific cost center was created with code 8514.

- **Cost approval procedure:**

DIPGRA: The Provincial Council of Granada is subject to Public Sector Contracts Law 9/2017, which establishes the limit for services procurement for minor contracts at 15,000 €.

In the interests of transparency and good practises, the Environment Service usually sends a tender to several companies for the procurement of services with a value under this limit.

The usual procedure is:

- Confirmation of the existence of an available budget in the "registered cost centre".
- Drafting of a document of technical requirements of the service to be contracted.
- Tendering of a services provision offer to 3-6 companies.
- Assessment and selection of the proposal offering the best value for money.
- Drafting and signature of a minor contract with the selected contractor.

In cases where the amount of the service exceeds €15.000 or the duration of the service is greater than one year, the open contract procedure is used.

UGR: The University of Granada applies Contract Law 9/2017 for the public sector and its amendment through law 6/2018.

The amendment to this law affects the contracting of services on behalf of public agents of the National System of Science, Technology and Innovation, among which the University of Granada can be found. This amendment influences a raise in the limit for minor contracts of less than €50,000, with regards to research contracts.

OTERO: The purchasing procedure is defined in internal document PROC05 ed08 of October, 2017, updated by PROCO05 ed09 of April 2018.

For each project, there is a "money pouch" of €1.500 per month for small purchases that do not exceed this amount. In these cases, purchases can be done by direct award.

For quantities exceeding this value, it is necessary to ask for several offers. Once offers have been compiled, the Site Manager draws up a Comparative or Purchase Request in the ERP system with the following conditions: It must include offers by at least three suppliers / subcontractors. The comparative should always include the total amounts, i.e. measurement and prices.

Approval of the comparative requires the following levels of authorization, bearing in mind the following amounts:

- Less than or equal to €3000: Approval by the Site Manager.
- Equal to or greater than €3000: Approved by the Technical Director.
- All: Approval by the Purchasing Manager.

In any case, a company that does not comply with the requirements set out in this procedure will not be contracted, so the comparative must be authorized by the administrator responsible for controlling subcontractors following the revision of the compliance conditions relating to labour and taxes.

Sometimes, the materials or equipment are very specific and there are not enough suppliers to compile three offers. In these cases, it will be justified the procedure with less than three offers.

AALTO: Procurement includes the ordering, acquisition and rental of goods and services as well as all other similar activities, and the procedures defined in the Public Procurement Act must be followed. Each separate unit has the authority and responsibility for approving the procurement of goods and services according to AALTO guidelines, approved budget and available funding. All purchase orders and agreements must be approved in advance.

Procurements that do not exceed the national threshold value, i.e. minor-value procurements (€60.000 in procurements of goods, services and design contests), are not governed by the Public Procurement Act. For minor procurements, university procurement policy must be complied with and the economic benefit for the university as a whole must be ensured.

For externally funded projects, the funding terms of each programme are followed. For example, with regards to the European Structural Funds, the limit is currently set at €4,000. Tenders for consultancy services are always required.

GEDAR: The purchasing procedure for new products or exceptional purchases is as follows:

- Selection of several suppliers (maximum 3 and minimum 2), submission of technical specifications and request for quotation.
- Evaluation of the bids received and selection of the most advantageous bid based on the following criteria: compliance with technical specifications, price, quality, delivery time and method of payment.
- Confirmation of the purchase.

When the purchasing department receives a formal request for a duly authorized purchase, it must select a source of supply. In general, this department maintains a list of suppliers for each type of material and suppliers are selected following an invitation to bid.

The contract is awarded to the bidder offering the highest quality at the lowest price and giving due consideration to the delivery date and other purchase terms. Once the supplier is selected, a purchase order is prepared.

There are reliable sources of supply and strict ethical standards are maintained in the negotiation process with suppliers.

Suppliers are evaluated on a regular basis. Regular suppliers are compared with new suppliers that offer more favorable purchasing conditions or products with better performance.

- **Time recording system:**

DIPGRA: Staff assigned to the project, both permanent stall assigned to the project and additional staff recruited for it have completed timesheets to declare the time dedicated to the project.

UGR: Additional staff employed exclusively for the LIFE Project, either in a full- or part-time capacity, have not been required to complete timesheets.

On the other hand, permanent university staff allocated to the project, and possessing assignment certificates defining the percentage of time allocated, have been required to complete timesheets.

OTERO: Permanent staff allocated to the project, with assignment sheets defining the percentage of time allocated, have completed timesheets.

AALTO: The personnel assigned to the project have declared their time of dedication to it through the internal working time management system of the University of Aalto, in which the employee's daily working time is recorded and then validated by a superior.

GEDAR: Permanent staff allocated to the project, with assignment sheets defining the percentage of time allocated, have completed timesheets.

- **<u>Registration, submission and approval procedure/routines for the time registration system:</u>**

Monthly timesheets have been completed and signed by each staff member and their supervisor at the beginning of the month subsequent to which they refer. It applies to all beneficiaries.

- **<u>Reference to the LIFE project:</u>**

Life Project personnel responsible for ordering, purchasing and rental of goods and services and other similar activities will take care to remind providers/subcontractors to include clear references to the LIFE project (Project ID or acronym) on all communications, e.g. procurement procedures, incoming invoices, staff expenses, etc.

However, if the invoices do not include the above references, a stamp with the project number is affixed. It should also be considered that the expenses incurred within the framework of the project are linked to the cost center specifically created for the project by each of the beneficiaries in the cost accounting system.

8.3.Partnership arrangements.

On May 22, 2018, the *Partnership Agreement concerning LIFE ECOGRANULARWATER PROJECT* was signed, the purpose of the document being to supplement the Grant Agreement and specify the relationship among the Parties, in particular the organisation of work assignments, project management and the rights and obligations of the parties.

On October 14, 2019, a first amendment to the Partnership Agreement was signed, due to the waiver by Aalto University, after completing the A1 activity "Groundwater characterisation" of the project, for part of the budget allocated by this entity’s project and not consumed during the activity, concluded in December 2018, in favor of the rest of the activities and the rest of the partner entities.

On August 21, 2020, the second amendment to the internal partners' agreement was signed, which includes the integration of GEDAR as a partner in the project as of December 1, 2019, and the termination by Construcciones Otero SL of its activities in the project on the same date.

Payments to the associated beneficiaries have been made by the coordinating beneficiary according to the terms set out in Art.17 of the Partnership Agreement, modified by the amendment no. 2:

- *With regard to **Aalto University:***
    - *A **<u>first payment</u>** was made, equivalent to 30 % of the Union contribution according with the approved budget (18,254.10 €).*

- *Given that Aalto decided not to declare any more expenses in the project, a second payment has not been done.*
- *The **payment of the balance** will be made once CINEA approves the Final Report and makes the final transfer to the coordinating beneficiary.*

— *With regard to **Granada University:***

- *A **first payment** was made, at the beginning of the project, equivalent to 30 % of the Union contribution according with the approved budget (46,181.40 €).*
- *A **second payment** was made once the coordinating beneficiary receives the intermediate payment after the acceptance of the Mid-term report by EASME. The amount was 61.575,20 €, equivalent to 40 % of the Union contribution.*
- *A **third payment** was made after the signature of this amendment and having agreed a new distribution of the budget among the partners to develop its actions. The amount was 12,601.61 €.*
- *The **payment of the balance** will be made once CINEA approves the Final Report and makes the final transfer to the coordinating beneficiary. The maximum amount will be equivalent to 30 % of the Union contribution to Granada University.*

— *With regard to **Construcciones Otero,***

- *A **first payment** was made on May 2019, after delivering to the coordinating beneficiary all the supporting documents related to the declared costs for the development of the actions. The amount was 44.415,45 €.*
- *A **second payment** was made, once the review, by the coordinating beneficiary, of all the supporting documents related to the declared costs for the development of the actions. The amount was 23.425,51€.*
- *The **payment of the balance** will be made once CINEA approves the Final Report and makes the final transfer to the coordinating beneficiary. The maximum amount will be equivalent to 30 % of the Union contribution to Construcciones Otero.*

— *With regard to **Gedar,***

- *A **first payment** was made on July 2021, after delivering to the coordinating beneficiary all the supporting documents related to the declared costs for the development of the actions. The amount was 54.007,70 €.*
- *A **second payment** was made on October 2021, once the review, by the coordinating beneficiary, of all the supporting documents related to the declared costs for the development of the actions. The amount was 23.425,51€.*
- *The **payment of the balance** will be made once CINEA approves the Final Report and makes the final transfer to the coordinating beneficiary. The maximum amount will be equivalent to 30 % of the Union contribution to Gedar.*

Each beneficiary shall be solely responsible for carrying out its tasks in the Project and for complying with any obligations imposed on it under this Agreement. (…)

Below is a summary table of the payments distributed to members, made in accordance with the above:

	1st payment		**2nd payment**		**3rd payment**	
	Amount distributed	**Date of payment**	**Amount distributed**	**Date of payment**	**Amount distributed**	**Date of payment**
DIPGRA	35.740,20	10/07/2017	47.653,60	18/06/2019		
AALTO	18.254,10	21/12/2017				
UGR	46.181,40	21/12/2017	61.575,20	27/06/2019	12.601,71	15/02/2021
OTERO	44.415,45	20/05/2019	23.425,51	21/07/2020		
GEDAR	54.007,70	21/07/2021	2.817,21	20/10/2021		
	198.598,85		**135.471,52**		**12.601,71**	

Regarding financial reporting by each beneficiary and how consolidated cost statement are prepared, the Provincial Council of Granada, as Coordinating Beneficiary of the LIFE Project, have provided technical advice to the partners during the Steering Committee meetings, by phone and by email.

Quarterly, each associated beneficiary has sent a report to the CB including a description of the work done in the last three months, a declaration of the expenditures incurred as well as the supporting documents (timesheets, invoices, proofs of payment, etc.).

For activity reports foreseen in the proposal, each partner has completed their financial report and send it to the CB along with the financial documents required for justification of costs incurred at least 40 days before the agreed deadline.

The Provincial Council of Granada has been responsible for collecting and evaluating all documents and for completing the "Consolidated Financial Report", which includes the financial information relating to each partner.

The Provincial Council of Granada has been responsible for signing the Financial and Technical Report and sending it to the Commission.

8.4. Certificate on the financial statement.

In accordance with Art II. 23.2. d) none of the partners involved in the LIFE ECOGRANULARWATER project will be obliged to carry out external auditing.

8.5. Estimation of person-days used per action.

Action type	Budgeted person	Number of days	Estimated % of person-days spent
Action A: Preparatory actions	56.470,00 €	260	66%
Action B: Implementation actions	167.852,00 €	990	122%
Action C: Monitoring of the impact of the project action	107.061,00 €	792	101%
Action D: Public awareness/communication and dissemination of results	85.748,00 €	364	73%
Action E: Project management	162.685,00 €	850	104%
TOTAL	**579.816,00 €**	**3.256**	**100%**

The estimated percentage of person-days spent related to action A is 66% due to the adjustment of hours worked on the project made in Aalto's personnel. If this adjustment is not taken into consideration, the percentage would have reached 111%.

Likewise, the 73% in action D is motivated by the cut of hours worked on the project made in DIPGRA's personnel. Without this adjustment, the action would have reached 82%. Furthermore, the health crisis caused by Covid-19 and mobility restrictions have also caused an impact on the final result.

In relation to action B, the level of person-days spent is higher than initially foreseen due to a further assignment of resources to the action B.3 by the University of Granada and to the action B.2 by the private companies.

9. Timetable of the Project.