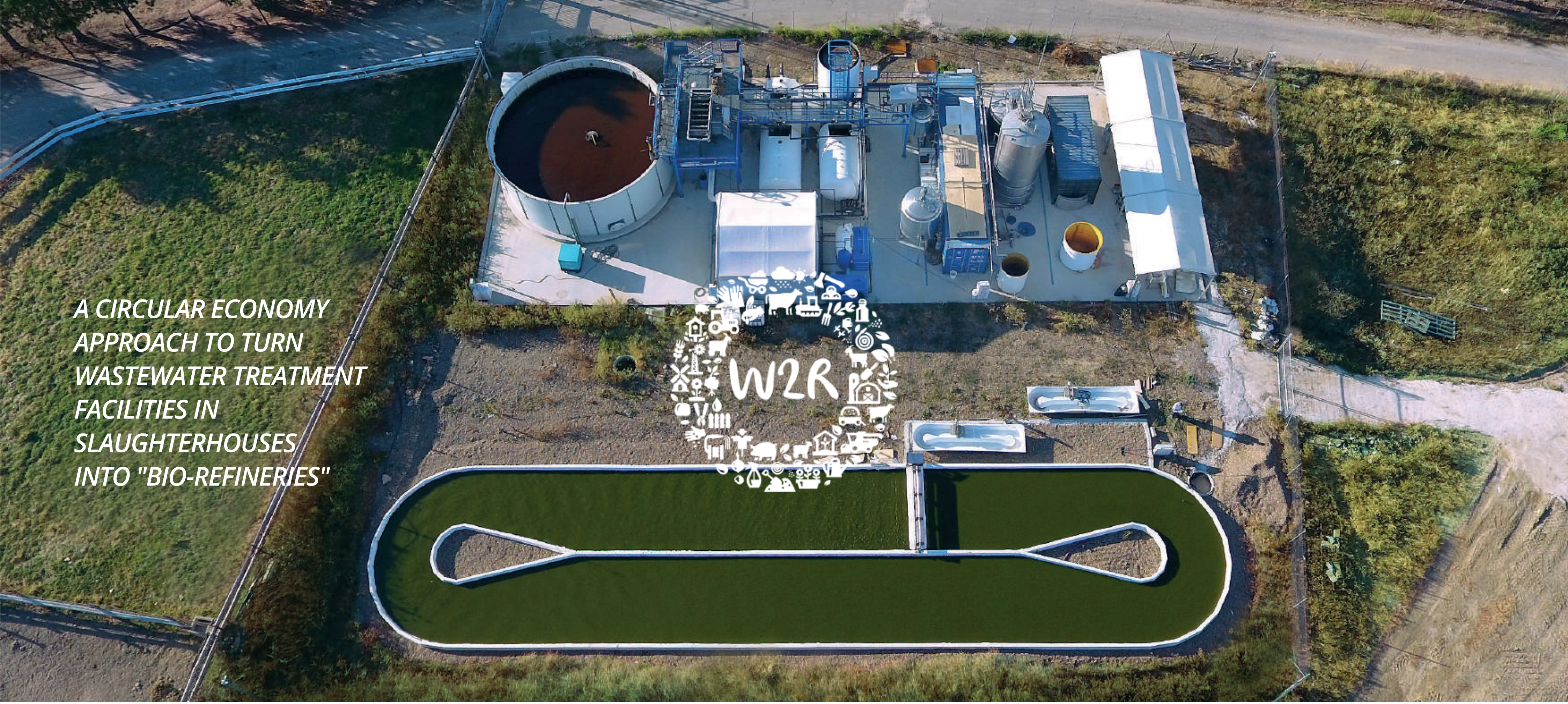


REcovery and REcycling of nutrients TURNing wasteWATER into added-value products for a circular economy in agriculture

Grant Agreement number: 730398
Water2REturn Project
Layman's Report
March, 2022

Water2REturn

This project is funded by European Union's H2020 Research & Innovation programme

Index

1. What is Horizon 2020?

Horizon 2020 (H2020) is a EU Framework Programme for research and innovation to make the economy grow. It has been the funding EU programme between 2014 – 2020, making the implementation of many projects possible to bring more ideas in the market, develop future & emerging technologies and create jobs.

By coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together and deliver innovation[1].

Water2REturn is an Innovation Action co-funded by the European Commission under its Horizon 2020 programme. It was submitted under the call "Industry 2020 in the Circular Economy" (call identifier H2020-IND- CE-2016- 17), topic "Water in the context of the circular economy" (topic identifier CIRC-02- 2016-2017). The objective of this topic was to implement large scale demonstration projects to tap the potential of nutrient recovery and encourage the use of these nutrients throughout Europe, including the active participation of the relevant industrial sectors, as well as SMEs.

2. Water2REturn project at a glance

15 partners

11 work packages

4 treatment lines

2* secondary raw materials

2* agronomic products

57 months | Duration: 01/07/2017 – 31/03/2022

€ 7,075,919.87 Total Budget | (EC contribution: € 5,871,895.76)

** Initially, three secondary raw materials (SRMs) were considered, but SRM1, nitrate concentrate, was ultimately not used to formulate an agronomic product. Wastewater from the slaughterhouse has a much lower Nitrogen concentration than expected, therefore there are not a great deal of nutrients to extract. It is not commercially feasible to formulate a product out of this raw material, but it could be used for direct fertilization in fields.*

3. What are the Water2REturn key findings?

- Up to 90 % of nutrients have been recovered from slaughterhouse wastewater and the discharge of low nutrient content of the reclaimed water has reduced the pollution of water bodies.

- Water2REturn has the potential to create new business opportunities and green jobs for the market based on nutrient recovery and recycling.

- Water2REturn reduces dependency on primary nutrient resources and increases supply security at a EU level.

4. Brief summary

Water2REturn proposes **an integrated solution** for slaughterhouse wastewater (SWW) treatment and nutrient recovery, as well as for **the recovery of valuable nutrients** with a high market value in the agriculture sector.

Water2REturn technology adopts **a circular economy approach** where **nutrients (and energy resources) present in wastewaters are safely and efficiently recycled** in different forms, then **injected back into the agricultural system as new raw materials.**

Wastewater is, therefore, **a source of nutrients, energy and water**, and **no longer a waste**; wastewater treatment facilities become **"bio-refineries"[2].** Water2REturn´s business model is based on **a viable, cross-sectoral and integrated perspective** for recovering resources from the water cycle, while considering the relevant **legal, societal and market challenges.**

Water2REturn aims to recover **three high-value agronomic products**; nitrate concentrate, a solid fraction of the fermented sludge which is composed by *Bacillus spp.* and algal biomass as well as energy production.

This project has received funding from the European Union's H2020 Research & Innovation program under grant agreement Nº 730398.

5. Introducing the problem

'The wastewater generated in the EU by the slaughtering industry: around 750,000 m^3/year.'

'The range of water consumption: between 1.5-40 m^3 per ton of animal processed[3].'

'Wastewater generation: typically, 80% of the water consumption[4].'

'High energy consumption in the meat industry: refrigeration: 90-1,094 kWh/t cattle, heating of water: 110-760 KWh/t pig[5].'

'Agricultural demand on chemical fertilizers: around 13.6 Mt/year, 9.1 billion expected in 2050[6].'

'Wastewater management costs: up to 25% of total production costs in the slaughtering industry.'

Agricultural demand for chemical fertilizers is increasing due to the rising world population. The importance of nutrient recycling is crucial in Europe, where the general absence of nutrients represents **a considerable threat to EU food security.** This tension between resource scarcity and growing demand will continue to **push the prices of nutrient resources higher in the near future.**

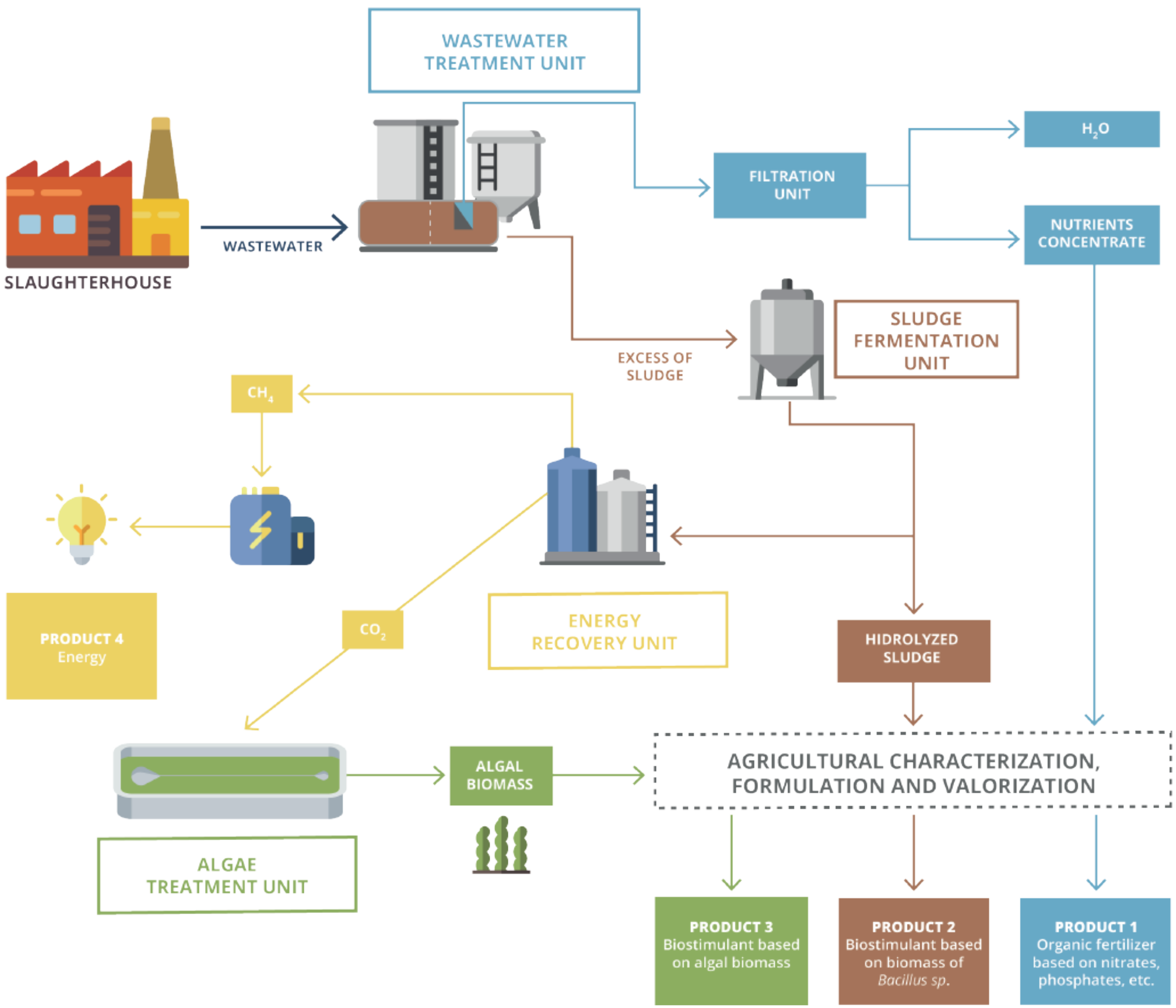
Chemical fertilizers can have negative effect on human health, especially when they contain nitrogen, potassium, phosphorus and heavy metals. These impacts can cause **cancer, Parkinson's disease, increase the risk of Alzheimer's disease and diabetes, neurological and reproductive effects[7].**

On the other hand, expansion in the animal production industry is resulting in the production of **nutrient rich wastewater and waste**, in addition to **high energy consumptions.** Pollution of water bodies and limited arable land for the disposal of solid waste increase environmental concern.

Large quantities of wastewater and waste are, consequently, emitted into the environment with a high content of easily methanizable organic matter and nutrients, that can potentially be transformed into energy, fertilizing and biostimulant products; but they are environmentally dangerous if discharged with no treatment.

The Ellen MacArthur Foundation[8] described **the circular economy concept**, as **a new economic model** which addresses mounting resource-related challenges for business and economies, and **could generate growth, create jobs, and reduce environmental impacts**, including carbon emissions. In line with this perspective, **the circular economy would avoid landfilling/emissions and try to extract maximum value from slaughterhouse wastes.**

6. Description of the project



W2R

Water2REturn proposes a full-scale demonstration process for integrated nutrient recovery from wastewater in the slaughterhouse industry using biochemical and physical technologies implemented in a real case study, the 'Matadero del Sur' slaughterhouse in Salteras, Spain. The Water2REturn system not only produces nitrates and phosphate concentrate to be used as organic fertilizer in agriculture, but its novelty lies in the use of an innovative fermentative process designed to exploit sludge, producing a hydrolyzed sludge (with a multiplied Biomethane Potential) and biostimultant products, with high added value in plant nutrition and agriculture.

Water line

Sludge line

Algae line

Energy line

6.1. Treatment lines

6.1.1. **Water** line

The water line consists of a wastewater treatment system. After removal of solid particles and fats in a preliminary treatment unit, wastewater is treated in a Sequential Batch Reactor (SBR). Then the reclaimed water is discharged to the receiving environment, in accordance with national regulations.
The first secondary raw material (SRM1) obtained after this treatment is a nitrate concentrate. However, it is not commercially feasible to formulate a product out of SRM1, due to a low Nitrogen concentration in slaughterhouse wastewater. But this could be a good candidate for the direct fertilization of local fields near the slaughterhouses.

6.1.2 . **Sludge** line

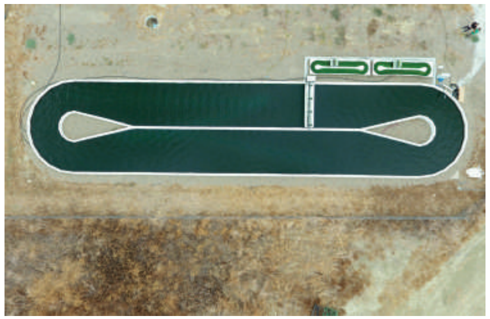
The sludge resulting from the water line goes through a first pre-treatment process where pathogenic microorganisms are eliminated. Subsequently, it enters the fermentation unit, where the sludge is fermented with *Bacillus spp*. As a result, **a hydrolyzed sludge is obtained, which is the secondary raw material (SRM2).** The second agronomic product (AP2) is formulated and manufactured from this raw material: **a biostimulant.**

6.1.3 . **Energy** line

The liquid fraction of fermented sludge from the previous treatment line **is upgraded in the energy line through an anaerobic digestion process.** In this process, organic matter is transformed into biogas, composed mainly of CH_4 and CO_2. **The biogas is turned into energy** in a cogeneration unit. **The energy generated can be used to either power the slaughterhouse or the system itself.**

6.1.4. **Algae** line

The AlgaBioGas (AGB) technology used in this algae treatment process, is based on **an algae ponds system.** The digestate from the energy line contributes to algal biomass growth in the algae line. **The third secondary raw material (SRM3) obtained after this treatment is an algal biomass.** Eventually, the third agronomic product (AP3) is formulated and manufactured from this raw material: **a second biostimulant.**



7. Project overview: objectives and structure

Objectives

Develop a demonstrative application for SWW treatment and large-scale nutrient recovery,

Produce organic-source fertilizers (nitrate concentrate) and biostimulants (*Bacillus spp.* and microalgae),

Reduce the adverse effects of nutrient emissions on the environment,

Reduce nutrient content in wastewater discharged to the environment by 90%, producing nitrate concentrate and high quality reclaimed water complying with regulations for reclaimed water discharge,

Energy savings from slaughterhouses wastewater treatment plant (WWTP) via biogas upgrading and subsequent valorization in cogeneration units (CHP).

The Water2REturn Structure

WP1
Ethics Requirements

WP2
Nitrates and Phosphates recovery from SWW

WP3
Sludge valorisation through fermentative process for biostimulant production

WP4
Multiplied energy production through hydrolysed sludge biogas upgrading

WP5
CO_2 fixation and nutrients recovery from anaerobic digestate by algae cultivation

WP6
Building full-scale demonstrator in the slaughter industry

WP7
Product valorisation for agronomic use

WP8
Environmental, Economic and Risk Assessment of biofertilizers and biostimulants recovery

WP9
End user needs and market update of WW technology and recycled products at EU level

WP10
Communication, dissemination and training activities

WP11
Project management and coordination

8. Results of the project

8.1. Benefits

BENEFITS IN MARKETS / INTEREST GROUPS

Slaughterhouses industry (early adopters) and meat processing industry

- reduce landfilled waste and energy saving
- reduce the environmental impact of food production
- lower wastewater and sludge treatment costs
- energy recovery
- nutrient recovery

Bio-agronomic product distributors and agricultural sector; conventional & organic farmers

- a new market opportunity for the bio-agronomic product sector
- maximize land use efficiency, decreasing the agricultural demand on imported chemical fertilizers by providing new solutions
- reduce the environmental impact of food production, promote synergies among key industrial sectors (e.g. agriculture, food processing and water treatment)

BENEFITS IN IMPACT

- Promote synergies among key industrial sectors (e.g. agriculture, food processing and water treatment)
- maximize land use efficiency
- reduce the environmental impact of food production
- replace conventional fertilizers with biostimulants:
  - reduction of pollution in the fields
  - reduction of negative effects on human health

BENEFITS IN THE EU LEVEL

- Decrease the dependency on primary nutrient resources and increasing the supply security at the EU level
- Reduce the adverse effects of nutrient emissions on water bodies and soil
- Close the water and nutrients cycles in the whole production and consumption value chain
- Improvement in the quality of data on nutrient flows, thus providing important information for investments into the recycling of recovered nutrients
- Create new green jobs and industries around nutrient recovery and recycling from water
- Create new business opportunities for industry and SMEs in the EU and improving the competitiveness of the EU enterprises in the global market
- Improvement in the policy and market conditions in the EU and globally for large scale deployment of innovative solutions for the Circular Economy
- Provide evidence-based knowledge regarding the enabling framework conditions (such as the regulatory or policy framework) that facilitate a broader transition to a Circular Economy in the EU

8.2. Environmental, economic and social impact of the project

A full-scale demonstration slaughterhouse wastewater (SWW) treatment plant has been set up at the ‘Matadero del Sur’, a slaughterhouse in Salteras, Spain. As the amount of wastewater produced by an average slaughterhouse is much higher, the environmental, economic and social assessments considered two different scenarios.

The first scenario is based on the demonstrator for a treatment capacity of 54 m^3 SWW per day. The second scenario is an adaptation of the Water2REturn system for a treatment capacity of 162 m^3 SWW per day, as an average capacity of a slaughterhouse wastewater treatment plant.

- Life Cycle Assessment (LCA) is a well-known analytical tool used to assess the potential environmental impact of the entire life-cycle of a product, process or service. LCA has the “cradle to cradle” approach, analyzing each stage of the life cycle of a product, from raw material, transport, production, distribution, use phase to recycling or final disposal.

- Life Cycle Costing (LCC) is an economic assessment of all costs related to a product, process or service, over the entire life cycle, from raw materials, transport, production until use and disposal. The goal of LCC is to minimize overall costs, associated with all life cycle phases, providing economic benefits for all supply chain stakeholders.

- Social Life Cycle Assessment (S-LCA) is a methodology for the assessment of the social impacts of products and services, and complements LCA and LCC in the evaluation of sustainability.

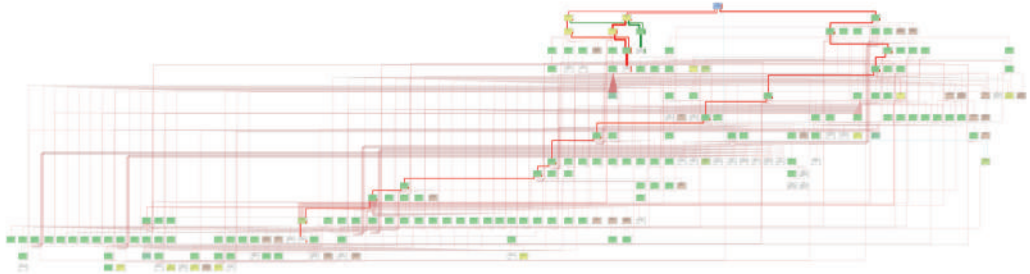
Comparative assessment:

LCA/LCC ⟶ a conventional wastewater treatment plant (WWTP) with energy recovery, but no nutrient recovery.

S-LCA ⟶ the system actually in place at Matadero del Sur before implementation of Water2REturn system.

Life Cycle Assessment (LCA) & Life Cycle Costing (LCC)

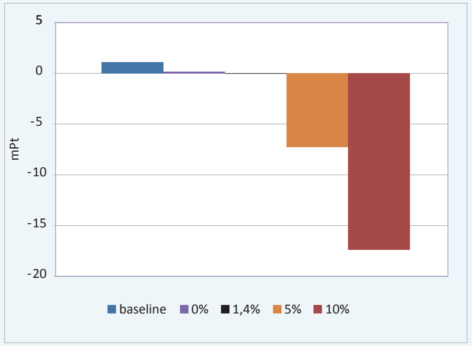
Flow diagram of Water2REturn model for the capacity of 54 m³ SWW/d with break-even point of LCA model, 1,4% reduction of the chemical fertilizer consumption (Climate change from EF 3.0 method, cut-off 0%).



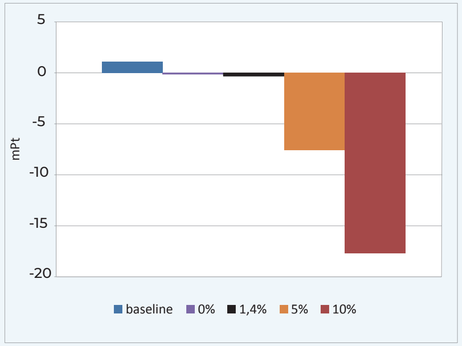
LCA and LCC models of Water2REturn are represented in the flow diagram. **Red arrows represent negative impacts while green arrows indicate benefits.** Impacts are accumulated along the four treatment lines, as well as for biostimulants in order to sum the total environmental impact and life cycle costs for the treatment of 1 m³ SWW.

Biostimulants are the products that cannot directly replace **chemical fertilizers** but they are useful for improving plant growth and reducing chemical fertilizer consumption. **Potential reduction of chemical fertilizers** is implemented in both LCA and LCC models to evaluate the contribution of biostimulants.

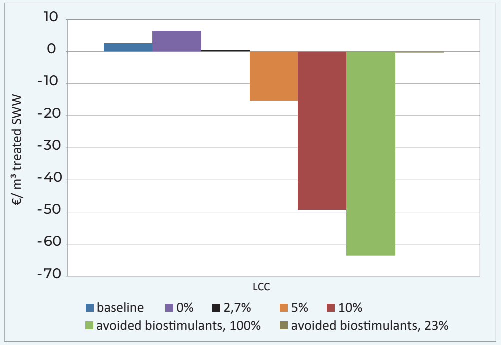
Different percentages of the chemical fertilizer reduction are investigated to have a broader perspective from worst to best case, including their break-even points, where the total environmental impact and total environmental benefit are equal for LCA and where the total cost and total revenue are equal for LCC. Additionally, in the LCC model, **biostimulants are also evaluated directly as avoided product.**



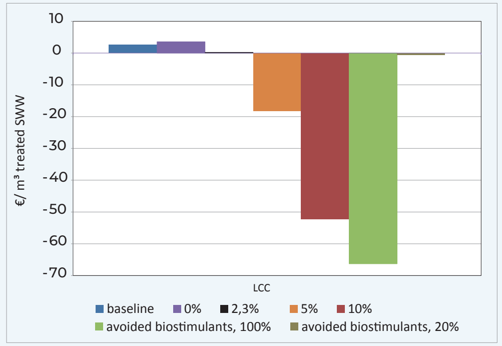
Graph.1: **Comparison between LCA of baseline and Water2REturn model (EF 3.0 method, single score), 33% capacity (54 m³/d).**



Graph.2: **Comparison between LCA of baseline and Water2REturn model (EF 3.0 method, single score), full capacity (162 m³/d).**



Graph.3: **Comparison between LCC of baseline and Water2REturn model, 33% capacity (54 m³/d).**

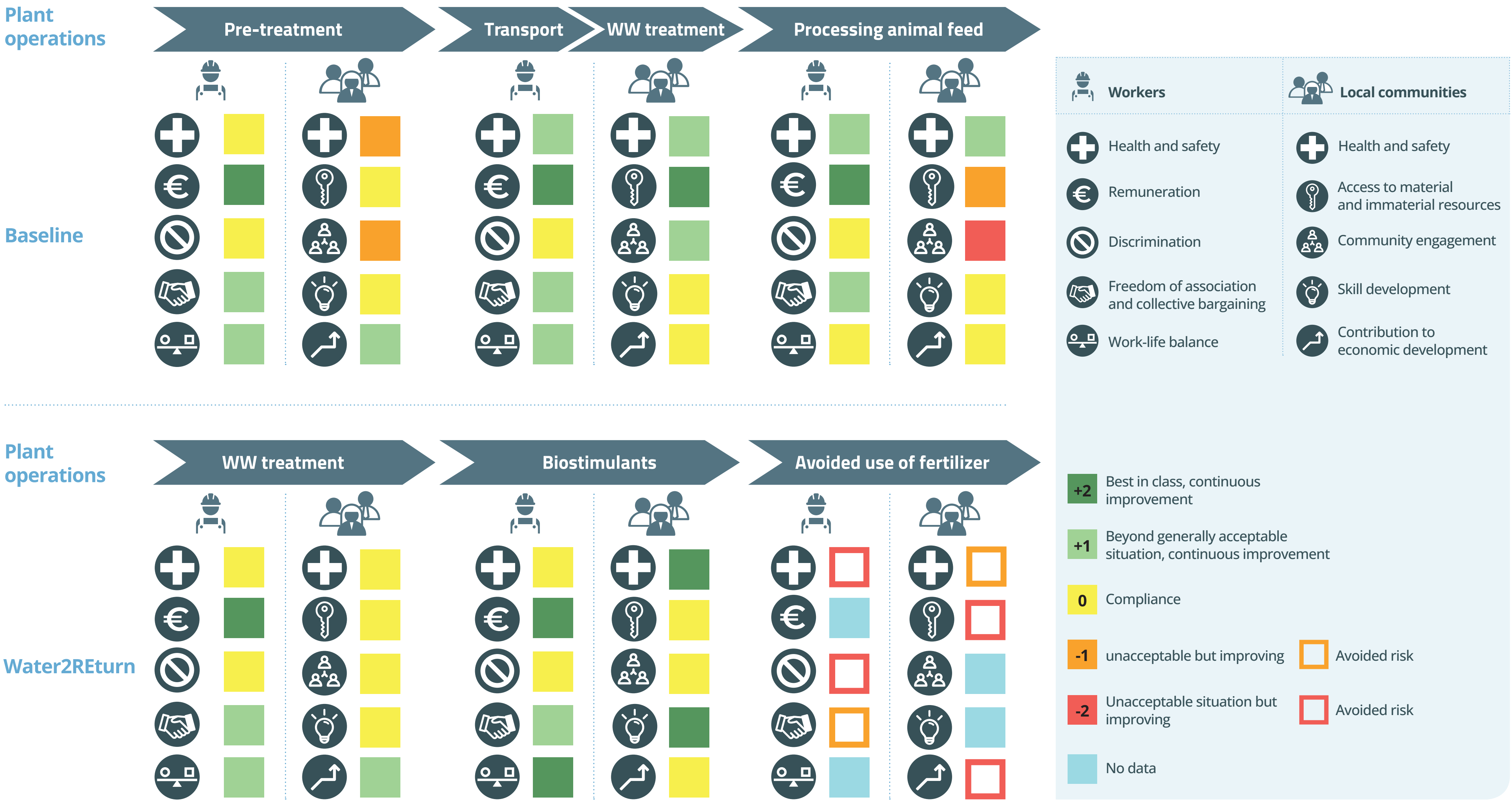


Graph.4: **Comparison between LCC of baseline and Water2REturn model, full capacity (162 m³/d).**

Different scenarios demonstrate that **the production of biostimulants** and **the chemical fertilizer reduction** have a significant role to determine the benefits of the Water2REturn system for both capacity scenarios. The Water2REturn system is beneficial:

- when the reduction rate is higher than 1.4% for both capacity scenarios**, in terms of environmental impact.**
- when the reduction rate is higher than 2.7% and 2.3% for 54 m³/d and 162 m³/d capacity scenarios, **in terms of life cycle costs.**

Social Life Cycle Assessment (S-LCA)



S-LCA follows the Product Social Impact Assessment Handbook – 2020. The Social Hotspot Database (SHDB) 2019 has been used to perform the hotspot analysis. In the baseline scenario, results show social risks relating to the local community, mainly for the social topic community engagement.
In the Water2REturn scenario the situation is compliant and the avoided use of fertilizers represents a reduction in risk for both workers and the local community

9. Key Exploitation Results (KERs)

Water2REturn process consists of different treatment lines based on biochemical and physical technologies. Four of the technologies implemented in the Water2REturn process can represent solutions that can be used separately for modular applications. These are **the cascade flash (C&F), sequencing batch reactor (SBR), secondary raw material 2 (SRM2) and secondary raw material 3 (SRM3).**

9.1. | Cascade Flash (C&F)

Cascade Flash (C&F) technology in the sludge line **converts sludge into a substrate that can be used directly as a fertilizer or to formulate biostimulants.** This technology is **less costly** than indirect competitive alternatives (composting, landfilling) and **results in value-added products.** Thanks to its small scale it can also be applied small sludge productions. Additionally, its small scale allows the possibility of coupling it to a renewable energy system reducing energetic costs.

9.2. | Sequencing batch reactor (SBR)

The Water2REturn Sequencing batch reactor (SBR) is an **efficient and competitive** wastewater treatment solution capable of removing organic carbon, nutrients, and suspended solids from wastewater in a single tank, with **low capital and operational costs while delivering an effluent in line with legal requirements.**

Water2REturn SBR makes it possible to **recover nutrients from wastewater and sludge** to be used for other purposes **in line with circular economy approaches.** SBR can be optimized as an **adequate solution for the removal (or concentration) of nutrients in a small area – single tank solution.**

9. Key Exploitation Results (KERs)

9.3. | Secondary raw material 2 (SRM2)

SRM2 is **a biostimulant product based on an innovative fermentative process** with an important concentration of biostimulant production, composed by high quality bacteria biomass, designed for sewage sludge valorization. It has **low development costs** and a **high added value in plant nutrition and agriculture.** It is **free of pathogens, heavy metals, and emerging pollutants.**

It is an environmentally sound product, **based on recycled products**, which brings **sustainability for organic farming** and covers **the demand for new recycled products as a nutrient source for agriculture.** Demonstrated by field testing, it enhances **agricultural production with the maximum guarantee at no additional cost.**

9.4. | Secondary raw material 3 (SRM3)

Algae hold great potential for stabilizing liquid digestate into biomass that **can easily be stored** with **multiple valorizations:** as an energetic substrate that can be processed in a biorefinery, or secondary raw material for low (biofuels, biomaterials, organic fertilizers) and high-added-value products (extracts for pharmacy, cosmetics, biostimulants, biopesticides).

SRM3 is a biostimulant product based on micro-algae biomass obtained from the algae line. Micro-algae contain **high levels of micronutrients and macronutrients essential for plant growth**, with a potential application as a biostimulant. Physico-chemical and biological composition of SRM3 is characterized and **efficiency in agricultural production has been proven by field testing.**

10. The market: target countries and customers

Target countries;

Before internationalization, these 10 countries in Europe are the first target markets; with the top 10 slaughterhouses in Europe, these 10 countries produce 86% of the total slaughtered meat in Europe; (Based on 2014 Eurostat data)[9]

Germany,
Spain,
France,
Poland,
UK,
Italy,
Denmark,
Belgium,
the Netherlands,
Ireland

Initial target customers;

Slaughterhouses industry (early adopters)

Meat processing industry

Bio-agronomic products' distributors

Agricultural sector; conventional & organic farmers

11. Dissemination activities

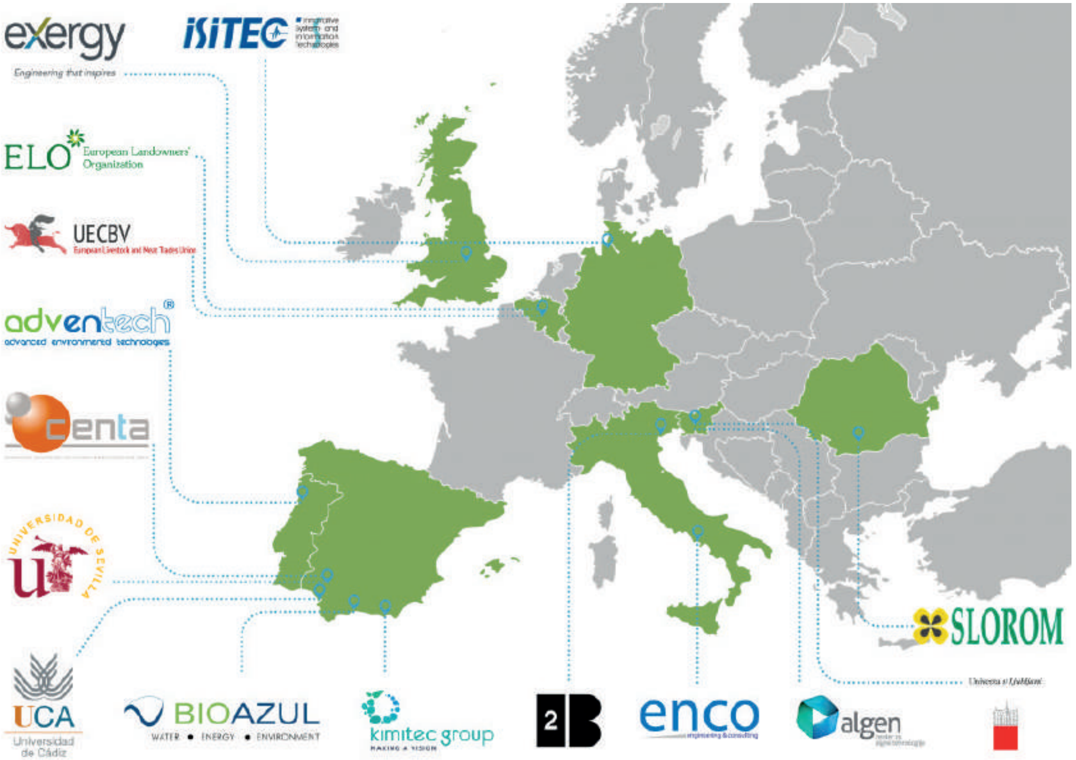
List of farmers workshops:

1. Spain
2. Italy
3. Belgium
4. Slovenia
5. Portugal

List of slaughter houses workshops:

1. Spain
2. Italy
3. Belgium
4. Slovenia

12. Partners involved



- Bioazul S.L. (BIOAZUL) Spain (www.bioazul.com)
- University of Seville (USE) Spain (www.us.es)
- University of Cadiz (UCA) Spain (www.tmagroup.es)
- Foundation Centre for the New Water Technologies (CENTA) Spain (www.centa.es)
- Agroindustrial Kimitec S.L. (KIMITEC) Spain (www.kimitec.es)
- Adventech, Advanced Environmental Technologies Lda
- (ADVENTECH) Portugal (www.adventech.pt)
- Algen, Algal Technology Centre (ALGEN) Slovenia (www.algen.si)
- University of Ljubljana (UL) Slovenia (www.uni-lj.si)
- SC Slorom Srl (SLOROM) Romania (www.slorom.ro)
- Enco Consulting Srl (ENCO) Italy (www.enco-consulting.it)
- 2B Srl (2B) Italy (www.to-be.it)
- European Livestock and Meat Trading Union (UECBV) Belgium (www.uecbv.eu)
- Isitec GmbH (ISITEC) Germany (www.isitec.de)
- Exergy Ltd (EXERGY) United Kingdom (www.exergy-global.com)*
- European Landowners Organisation (ELO) Belgium (www.elo.org)

* *until 28/09/2020*

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[9] http://ec.europa.eu/eurostat/statistics-explained/ index.php?title=Special:ListFiles&sort=img_timestamp&limit=50&user=Nrentzpa.

Water2REturn

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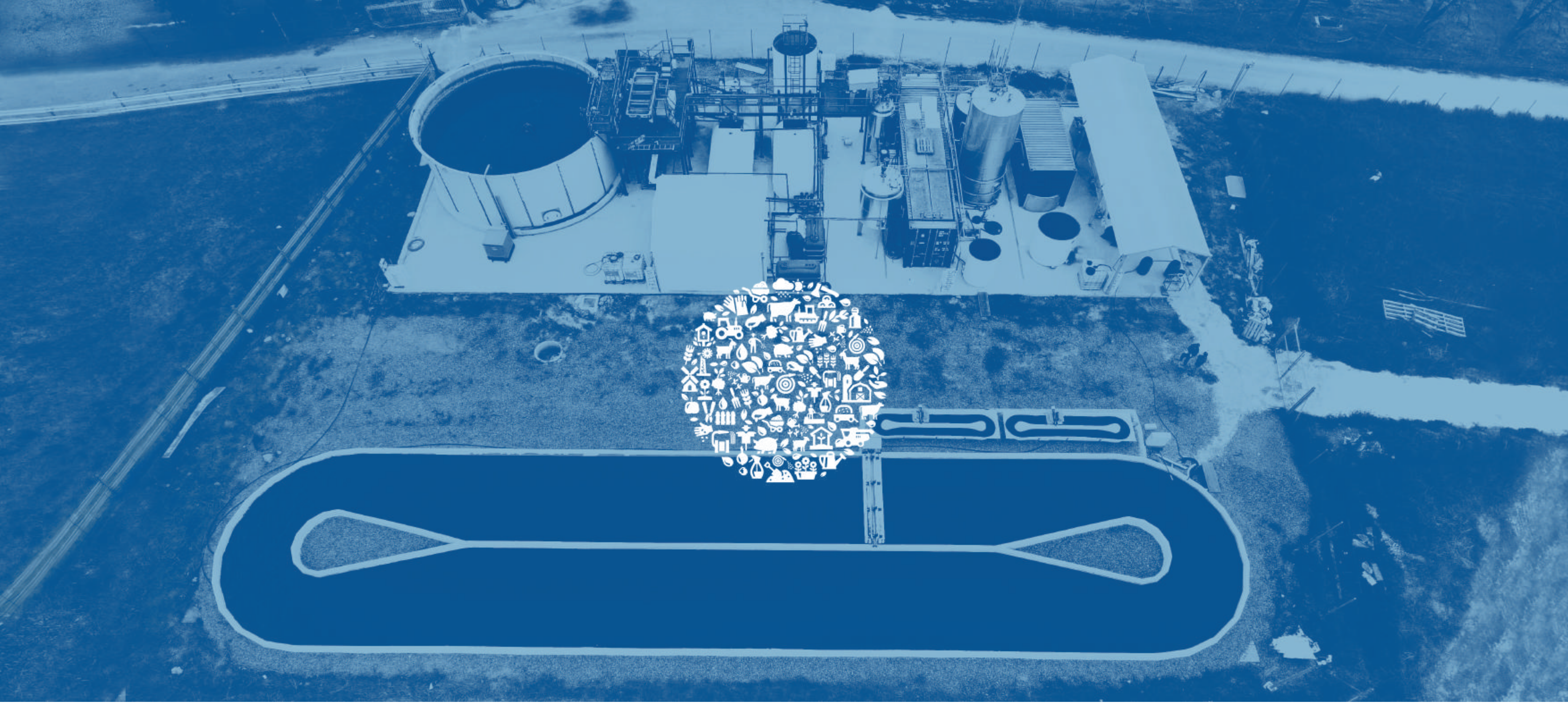

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