life seacan

Reducing the pressure of fish canneries on the marine environment with novel effluent treatment and ecosystem monitoring

LAYMAN'S REPORT

ABOUT THE PROJECT

Project Life Seacan started in September 2015 and ended in October 2019. Its total budget was 1.7 M€, 60% of which was co-funded by the Life Programme of the European Commission.

Cetaqua, Water Technology Center, led the project and counted with the Universities of Santiago de Compostela (USC) and Vigo (UVigo) as partners.

LIFE14 ENV/ES/000852

PROJECT CONSORTIUM

Cetaqua

Cetaqua is a model of public-private collaboration created to ensure the sustainability and efficiency of the water cycle while taking regional needs into account.

USC

The University of Santiago de Compostela promotes new enterprising initiatives by sharing knowledge and leadership with the society.

UVigo

The University of Vigo has placed a particular emphasis on innovation by developing several projects through its own technical centres.

STAKEHOLDERS

LIFE SEACAN stakeholders played an important role in the development of the project: taking part in workshops and visits to the demonstrative plants, as well as giving technical support to the project consortium.

INDEX

Challenges for water treatment in the fish canning industry

The loss of ecosystem biodiversity is causing economic impacts affecting human welfare. Today as never before, pollution, climate change and biological invasions are major threats to our marine environment.

Galicia is home to one of the greatest marine ecosystems in the world, due to its biodiversity. This gives rise to a significant number of economic activities, which represent 3% of the regional Gross Domestic Product (European Commission, 2007), reaching the highest production of transformed sea food in Europe.

This industrial activity requires high levels of water consumption that, consequently, means a large disposal of wastewater, that it must be properly treated in order to ensure the preservation of the ecosystems and to meet the discharge limits imposed by the current legislation.

Drivers

- Treatment of complex wastewater (high salinity, organic matter, grease and fats)
- Compact treatment for industrial biodegradable wastewater
- High fluctuations in wastewater composition (depending on production)

ECONOMIC

- Low footprint for implementation / low CAPEX
- Low energy and chemicals required / low OPEX

ENVIRONMENTAL & SOCIAL

- Effluent with suitable characteristics (organic matter and nitrogen) for discharge to water bodies

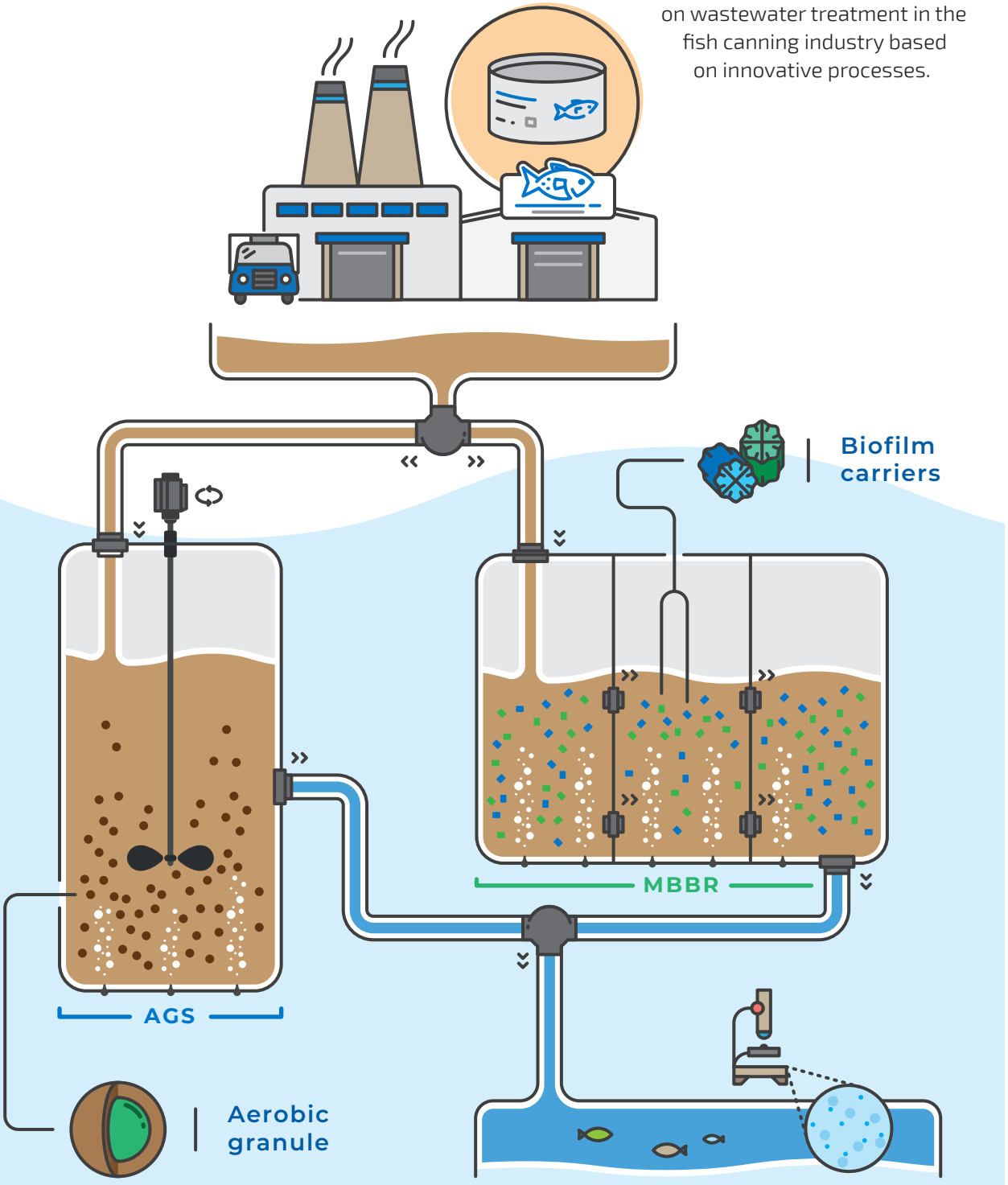
The idea

The overall objective of Life Seacan was to reduce the environmental pressure exerted by fish canneries' effluents in the marine ecosystem. In this sense, the project aimed at demonstrating the feasibility of biofilm-based wastewater treatment processes (carriers and granular sludge) in order to minimize the environmental impact of the industrial activity on the marine environment; and to monitor the benthonic ecosystem in order to determine the potential effects/changes of the industrial in the marine biodiversity.

Objectives

The goals of this project are to:

- Demonstrate the technical and environmental feasibility of using biofilm-based wastewater treatment systems.
- Optimize the current treatment systems in order to improve effluent quality.
- Monitor the benthonic ecosystem to assess the potential impact of the industrial activity on the marine biodiversity.
- Disseminate the main outcomes of the project in order to spread the use of this technology and implementing a good practice on wastewater treatment in the fish canning industry based on innovative processes.



Demonstration Sites

An important fish cannery factory situated in O Grove (Galicia) hosted MBBR and AGS prototype.

The wastewater produced in this fish canning industry is segregated in two differentiated currents:

- No mixed low strength wastewater. Water derived from cleaning processes, sterilization and washing of cans.
- No mixed strength wastewater. Water derived from defrosting, cooking and bleeding of fish.

A wastewater mixture of both streams was treated in the prototypes, with different % of each of them.

Monitoring of the benthonic ecosystem

The monitoring of the benthonic ecosystem was carried out near the effluent discharge point of two different fish canning factories and compared to areas not affected by the industrial effluents. The monitoring campaign was carried out during from March 2016 and March 2019.

Results

- Compared to areas not affected by the discharge of industrial effluents, the marine ecosystem near the effluent discharge points showed an impact.
- The physico-chemical properties of the sediment and the structure of the benthonic macrofauna are modified, there is a loose of the specific biodiversity and in general, less quality of the ecological and environmental status of the area affected.
- However, it was found that a high hydrodynamics in the discharge point of the effluents can disperse the negative effects.
- The current wastewater treatments need to be improved to minimize the potential negative impact of the industrial activity in the marine ecosystem.

Moving Bed Biofilm Reactor Prototype

In the MBBR (Moving Bed Biofilm Reactor) treatment system, the microorganisms form a biofilm which grows on the surface of external carriers. The system operates in continuous mode, in which the wastewater flows through several tanks operated under aerobic conditions. The reactors are aerated from the bottom, allowing the mixing and suspension of the carriers. For this study, the organic loading rate applied was 2 kg COD/m^3/d.

- Wastewater mixture – Low-strength: 96% no mixed low strength (from cleaning steps) and 4% no mixed high strength (from fish cooking)

Main operational conditions of MBBR prototype (Wastewater mixture – Low-strength)

Influent flow (m^3/day)	8.6
Influent COD (mg/L)	1380 (± 700)
Influent NH_4-N (mg N/L)	40 (± 15)
HRT (h)	8
Operation mode	Continuous

Results

- Good biofilm formation on the carriers
- COD removal efficiency higher than 70%
- Total nitrogen removal of 70%
- Grease, a problem factor of fish canning effluents, was removed by the system with an average removal efficiency of 89%
- Concentration of grease and fats admitted by the MBBR system (system operational limit) was 200 mg/L
- Compliance with current discharge limits

Aerobic Granular Sludge Prototype

In the AGS technology, the microorganisms grow in form of compact aggregates called granules. Anoxic and aerobic conditions are feasible inside and in the outer layer of the granules, allowing the simultaneous removal of organic matter and nitrogen in the same unit. The operation of the system occurs in sequencing batch mode: the reactor is fed with wastewater; then, the reaction takes place under aerobic conditions; in the following step, the aeration is stopped, and the granular biomass is decanted; in the end, the treated effluent is discharged, while the biomass is kept inside the system. The technology was tested by applying two different organic loading rates into the reactor. Firstly, the reactor was operated with a low-strength wastewater mixture (as in the MBBR technology) with 2-3 kg COD/m^3/d. Then, a high-strength wastewater mixture was applied to the system to assess its operational limit by using an influent organic loading of 5-7 kg COD/m^3/d.

- **Wastewater mixture – Low-strength:** 96% no mixed low strength (from cleaning steps) and 4% no mixed high strength (from fish cooking)
- **Wastewater mixture – High-strength:** 50% no mixed low strength (from cleaning steps) and 50% no mixed high strength (from fish cooking)

Main operational conditions of AGS prototype

	Wastewater mixture Low-strength	Wastewater mixture High-strength
Influent flow (m^3/day)	12	4
Influent COD (mg/L)	1380 (± 700)	3140 (± 1500)
Influent NH_4-N (mg N/L)	40 (± 15)	269 (± 150)
HRT (h)	6	18
Operation mode	Sequencing Batch	Sequencing Batch

Results

- The operational conditions (short feeding time, high air flow and low setting time) led to the selection of appropriate organisms to form compact aggregates with good settling properties.
- The feast-famine regime was stablished in both operational stages (wastewater mixture low-strength and wastewater mixture high-strength).

Wastewater mixture Low-strength

- COD removal efficiency of 70 – 80%
- Total nitrogen removal efficiency up to 90%
- Fast formation of aggregates (30 days)
- Compliance with current discharge limits

Wastewater mixture High-strength

- High and stable COD removal efficiency of 80 – 90% (higher than the ones obtained from the test with low-strength wastewater)
- Total nitrogen removal efficiencies between 30% and 40% due to the high nitrogen concentration of this type of high wastewater

Technical, environmental and economic assessment

A complete environmental analysis was conducted in order to study the performance of the two biofilm-based treatment technologies proposed in the project. In addition to that both innovative systems were compared to conventional treatment options, currently in use in fish canning industries. Life Cycle Assessment (LCA) was the selected methodology used to calculate the environmental burdens cause by each treatment process, by means of a set of impact categories selected in accordance to the specific context and focus of the study.

The following scenarios have been considered for technical, environmental and economic assessment:

- Scenario 0a - baseline: Treatment of the Wastewater mixture – Low strength (LSmix) in the actual physiochemical treatment plant installed at the fish canning factory;
- Scenario 0b – baseline: Treatment of the Wastewater mixture – High strength (HSmix) in a conventional activated sludge (CAS) system, based on external data;
- Scenario 1a: Treatment of the LSmix by the AGS prototype;
- Scenario 1b: Treatment of the HSmix by the AGS prototype;
- Scenario 2: Treatment of the LSmix by the MBBR prototype

Figure 1 depicts the results found for the **comparison of the scenarios treating** LSmix wastewater. Five impact categories from the ReCiPe Midpoint (H) LCIA Methodology were selected for the study. This selection was carried out based on the experience of previous studies dealing with the environmental analysis of wastewater treatment systems found in literature. One impact category related with energy use global warming potential (GWP), two categories related with eutrophication marine (MEP) and freshwater (FEP) eutrophication potential and two final categories associated with toxicity; human (HTP) and terrestrial ecotoxicity (TTP) composed the final selection.

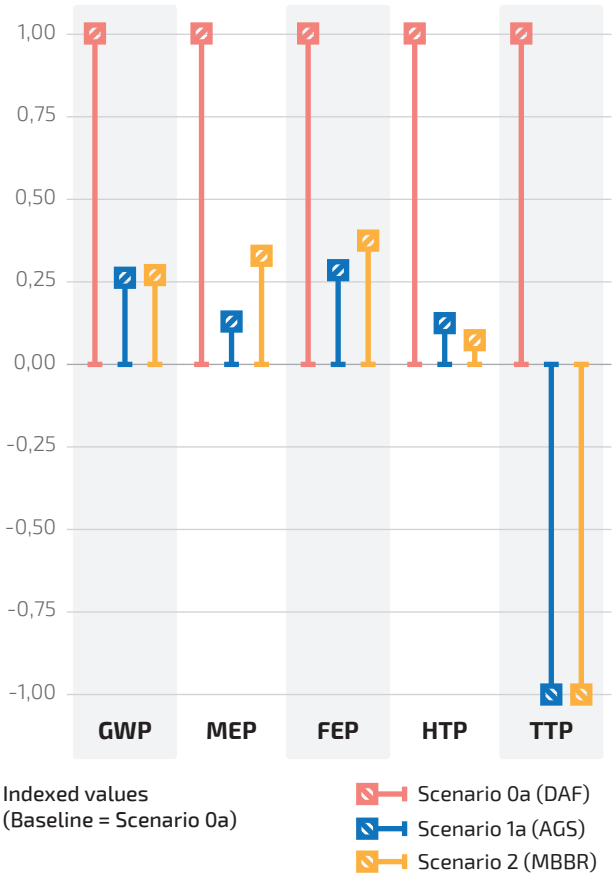


Figure 1:
Comparative environmental performance of scenarios for LSmix.

Considering the level of accuracy that can be allocated to the results obtained from the present LCA, based on pilot scale systems, the conclusions that can be derived have to be considered as preliminary. In any case and having said that, it can be confirmed the improved performance of the two technologies tested and validated within the LIFE SEACAN project for all the impact categories under study (Figure 1). The unique exception of a slightly higher impact for the AGS prototype working with high loaded influent (HSmix) was found for the MEP and TTP, probably due to underestimations in the CAS system scenario operated with this high load influent.

The **economic analysis** carried out follows the **cost-benefit analysis (CBA)** methodology, commonly applied to measure and compare socio-economic and environmental impacts of different alternatives for a project. The benefits presented are in terms of the welfare economics considered with a positive impact to society.

In the LIFE SEACAN context, the environmental indicators monetized are emissions to water bodies, emissions from energy consumption, and valorization of the biological sludge for agricultural fertilizer use, which avoids manufacturing new fertilizer. In addition, operation and maintenance costs (OPEX) and initial investments (CAPEX) for the alternative scenarios were estimated. Both cost lines are annualized through the study period set at 20 years, to make a comparative of the full picture of costs. Benefits, understood as avoided damages, and costs are added up to obtain the net benefit of each scenario.

The **results of the CBA for** LSmix are presented in Figure 2, displaying positive net benefit for the AGS (Sc1a), where 98% of the benefits arise from the avoided water pollution. For the MBBR technology (Sc2), the environmental benefits do not exceed the expected costs, although reducing the costs 51% compared to the current scenario (Sc0a).

The **comparison of AGS and CAS technologies for** HSmix (the most challenging wastewater) is further described. The space required for the AGS technology implementation resulted in 81% lower than for CAS implantation. The CAPEX of AGS would be 20-50% lower, since the high dimensions of the CAS to treat this type of high strength wastewater.

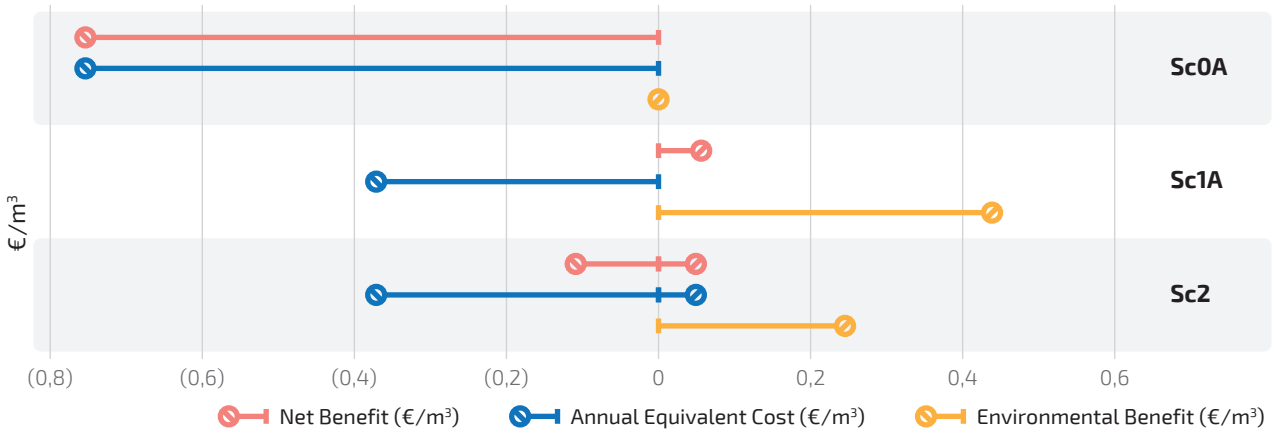


Figure 2: Estimated CBA results for scenarios in LSmix (€/m³)

Technology's Transferability

Taking into consideration the main places where waterbodies are suffering from pressure related to cannery wastewater releases, it could be said that the LIFE SEACAN schemes would be suitable to zones such as the countries bathed by the Mediterranean Sea and by the Baltic Sea (in Europe). In terms of world transferability, Thailand, Cambodia, the Carribean Countries and Vietnam were bounded as potential market niches for the LIFE SEACAN technology, as well as those placed on the coast of South America.

Apart from the fish canning industries, dairy factories and slaughterhouses were detected as priority activities of interest for LIFE SEACAN technology in the industrial field. But generally, the biofilm-based technologies demonstrated in the project could be applied to other activities in the Food & Beverage (biodegradable wastewater with high concentrations of organic matter).

Conclusions

The LIFE SEACAN project demonstrated the feasibility of biofilm-based processes for the treatment of effluents generated in the fish canning industry. Biofilm-based treatment solutions consisted of an aerobic granular sludge (AGS) and an aerobic film biomass (MBBR). COD and N were successfully eliminated in the two prototypes, allowing to improve effluent quality and therefore to reduce the environmental impact on the marine ecosystem.

The technologies have accomplished the indicators listed below:

- Organic matter removal up to 90% and 70% for nitrogen removal
- 80% reduction of footprint for the technology implementation, i.e compact treatment systems compared to conventional treatments, such as a conventional activated sludge (CAS).
- AGS CAPEX resulted 20-50% lower than CAS for the treatment of high strength wastewater.
- Total costs savings calculated for AGS and MBBR prototypes ranged between 49-51%, compared to the current DAF technology, including the additional investment required to renovate the plant. If only OPEX is considered, savings reach 72%.
- Important reduction in estimated environmental welfare damage in both biofilm-based technologies for the case of eutrophication.
  - AGS decrease up to 74% the expected value of damage to river ecosystem and nearly 90% in the case of marine ecosystems
  - MBBR decrease 65% expected value of damage to river ecosystem and 70% in the case of marine ecosystems

The monitoring of the benthonic ecosystem demonstrated the need to implement sustainable and effective technologies for the treatment of complex fish canning wastewaters.

Biofilm-based technologies are suitable and efficient alternative systems for the treatment of biodegradable industrial wastewaters, including fish canning wastewater, dairy industry and other effluents from the food and beverage sector.

Project Communication and Dissemination

Online Activities

01 Website

5.612 Visits to the website

80 Tweets and mentions about the project

Media

05 Press releases

57 Articles in general and specialized media

Visual Communication

02 Brochures

04 Poster at the partners' headquarters

01 Notice Board at the demonstration site

01 Video

02 Newsletters

Networking and dissemination

01 Webinar

05 Workshops organized

07 Networking events

53 People visited the pilot plants

18 Oral and poster presentations at conferences

01 Master's thesis carried out in the framework of the project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