SUSTAINABLE ALGAE BIOREFINERY FOR AGRICULTURE AND AQUACULTURE

SABANA

Sustainable Algae Biorefinery for Agriculture aNd Aquaculture

HORIZON 2020
European Union Funding
for Research & Innovation

This project has received funding from the European Union's Horizon 2020 Research and Innovation program under the Grant Agreement No.727874

3rd e-bulletin of SABANA Project

The general objective of the SABANA project is to demonstrate the technical, environmental and social feasibility of producing valuable products for agriculture and aquaculture by using only marine water and wastewater as nutrients source.

IMPROVEMENT OF LARGE-SCALE PRODUCTION TECHNOLOGY

DEVELOPMENT OF INTEGRAL UTILIZATION OF BIOMASS PROCESSES

SCALE-UP AND DEMONSTRATION OF THE DEVELOPED TECHNOLOGY

SABANA e-bulletin No.3, July 2018

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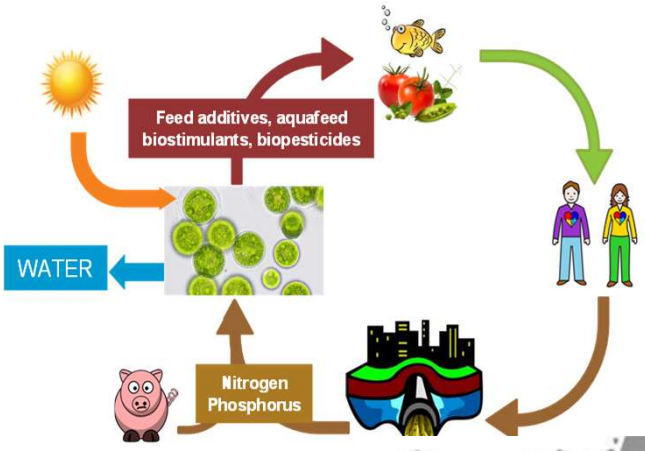
3rd e-bulletin of SABANA PROJECT

Introduction

Welcome to the 3rd e-bulletin of SABANA summarizing the achievements after 18 months of progress of the project. This project was approved by the European Union's Horizon 2020 Research and Innovation program, under the topic H2020-BG-2016-2017 Blue Growth: Demonstrating an ocean of opportunities, under the Grant Agreement No. 727874. The challenge is to build and operate a demonstration facility for producing biofertilizers/biopesticides and aquafeed at 5 ha scale. It provides a solution for three current key issues in the EU:

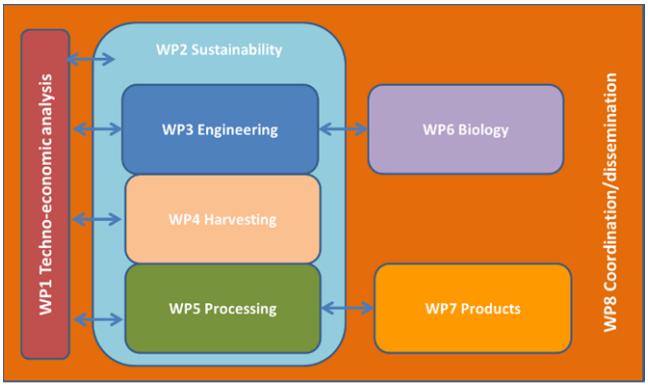
- Improvement of the safety and sustainability of food production in agriculture and aquaculture
- Contamination problems resulting from nutrients dissemination and scarcity (phosphorous)
- Minimization of greenhouse gas emissions from wastes (wastewater and flue gases)



You can find a video about the project at:
https://youtu.be/2kpEyevr38E

Partners

The project is led by the University of Almeria but major actors are the companies involved into the project (FCC Aqualia, GEA Westfalia, A.I.A. S.p.A., Biorizon Biotech) in addition to high reputation research centers at EU level (Karlsruhe Institute of Technology, Mikrobiologicky Ustav, Universita Degli Studi Di Milano, Univ. Las Palmas de Gran Canaria, Szechenyi Istvan University, Consorzio Italiano Biogas e Gassificazione). In addition to 11 partners from 5 EU countries , Fundacion Cajamar and IFAPA also collaborate in this project.



Work packages:

The work plan is divided in eight work packages combining scientific/technical research and innovation with market development and techno-economic and sustainability analysis.

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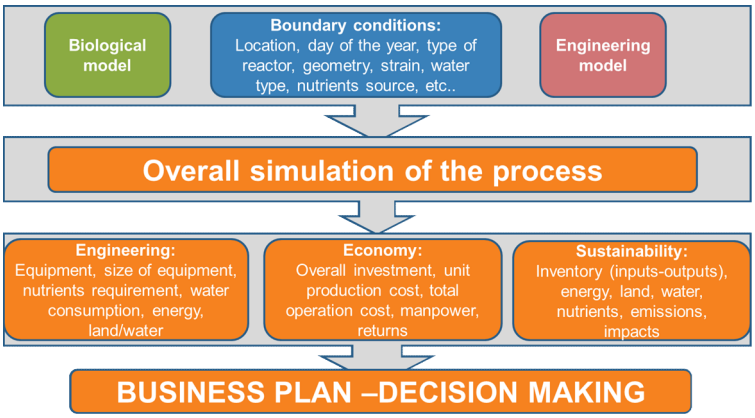
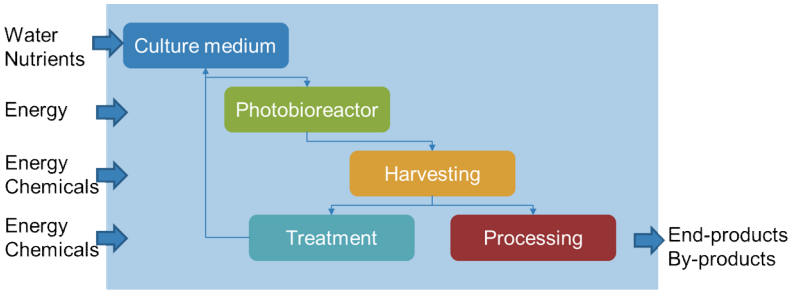
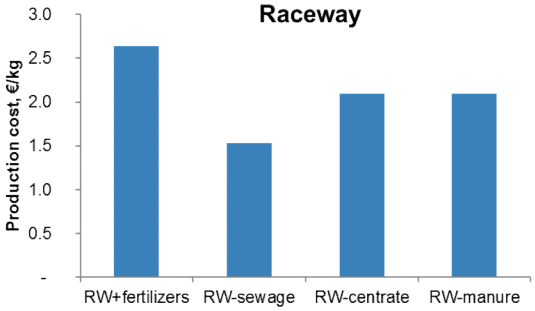
WP1 Techno-economic analysis

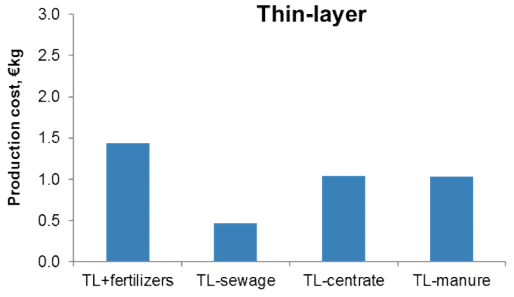
An Integrated Simulation Tool (IST) has been developed allowing to integrate the biological, engineering and boundary conditions into an overall analysis tool to obtain valuable data about the reliability, profitability and sustainability of planned activities. This tool is being used in SABANA project to estimate the biomass production cost and required equipment at different scenarios. Moreover, this tool also provide valuable information to perform Life Cycle Analysis, then analysis the sustainability of the different processes.





To complete the business plan two complete market analysis studies were previously developed, one focusing in agriculture and other in aquaculture applications of microalgae. Results confirm the reliability of releasing microalgae-based products on these fields. It was concluded that for agriculture the required price of the biomass is much higher, up to 10 €/kg and the production capacity lower, up to 20 tn/year, than for aquaculture. On aquaculture field the price of microalgae biomass is lower than 2 €/kg whereas the required production capacity overpasses 100 tn/year.





Techno-economic analysis confirm that it is possible to achieve biomass production cost below 2 €/kg when using nutrients from wastewater. The production cost is largely a function of biomass productivity, thus it being lower from thin-layer reactors than from raceway reactors. Thin-layer reactors demonstrated to be highly efficient in producing biomass per surface unit, almost doubling the productivity of raceway reactors. However, the scale-up of thin-layer reactors has not been still completed, larger studies about its performance and scale-up criteria being required. Today, the safer scenario for industrial scale is to use improved raceway reactors.

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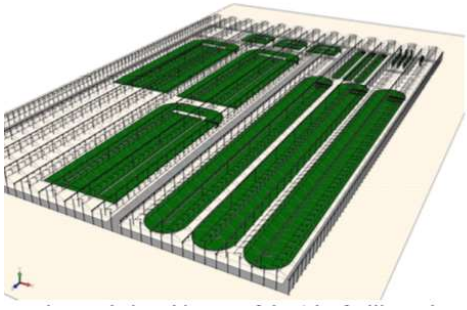
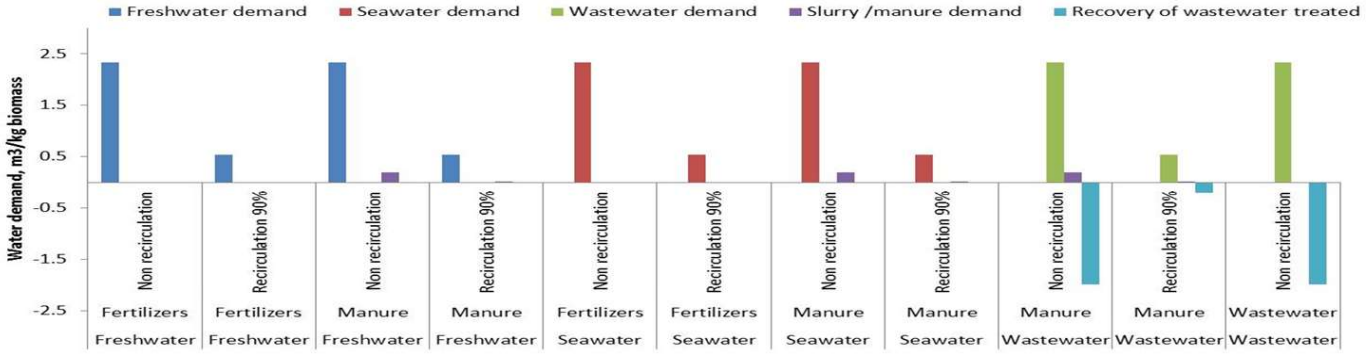
WP2 Sustainability

Complete life Cycle Analysis of planned DEMO5 facility has been performed, on the basis of results being obtained at DEMO1 R&D facility. At this scale open raceway reactors are used to produce microalgae biomass at different scenarios mainly involving the utilization of different water qualities (freshwater, wastewater, seawater), nutrients source (fertilizers, manure, wastewater), and CO_2 source (pure CO2, flue gases. In some cases the recirculation of the supernatant after recovery of the biomass is also considered. The end product considered is the production of biofertilizers by enzymatic hydrolysis.

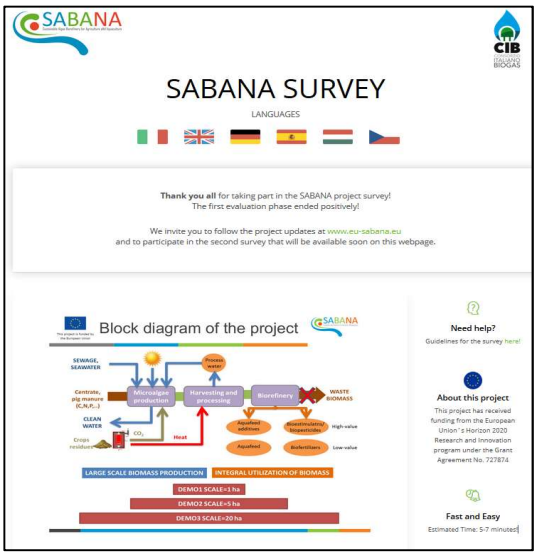


Analysis of water demand demonstrated as the consumption of water is much lower when recirculating the supernatant, but more interesting, when using wastewater the process is releasing clean water instead of consuming it. In this case no recirculation is required and the process allows to produce up to 1.5 m^3 of regenerated water per kg of produced microalgae biomass. When using seawater the water consumption can be also considered as null because no freshwater is consumed.



Social impact and acceptability

An important point included into SABANA project is to evaluate the social impact and acceptability of microalgae-based processes. A survey has been prepared and uploaded to SABANA website to obtain responses from the audience. Till now more than 500 responses has been obtained. Within the questionnaire, several questions were asked to test citizens' acceptance about the possible construction of microalgae and biorefinery plants for the production of DMA. The questions were organized, in a similar way, in a structure that went from the general to the specific. The answers were, in all cases, extremely favourable: on average only 6 individuals (out of a sample of 191 for these questions) answered negatively to any question



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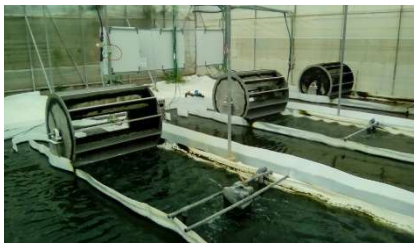
WP3 Engineering

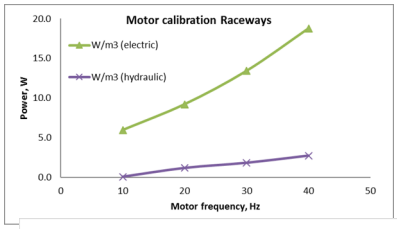
DEMO R&D facility has been completed and it is in operation from January 2018. The facility includes nine 100 L bubble column reactors, three 3.0 m^3 tubular photobioreactors, three 100 m^2 raceway reactors, two 80 m^2 and 160 m^2 thin-layer reactors, and one large 650 m^2 raceway reactor. All of them are installed at IFAPA center just attached to the University of Almeria. The plant is fully automated.

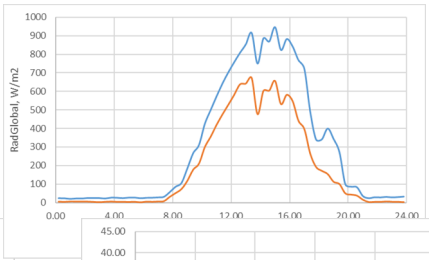


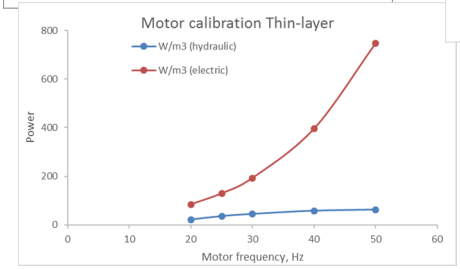


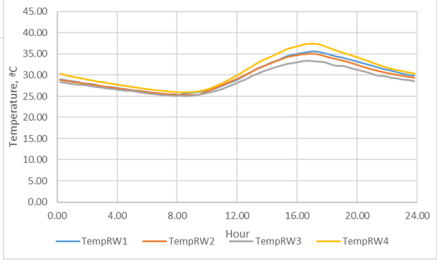


DEMO R&D facility is being operated in continuous mode, evaluating the performance of different reactors and strains, the influence of operational and environmental conditions, the reliability of different operation modes, water/nutrients/CO_2 sources, etc.. The objective is to determine the optimal conditions for the next larger facilities (DEMO1 and DEMO5) and the real values of biomass production and uptake of resources to complete the overall techno-economic and sustainability analysis. This DEMO R&D facility is also providing valuable biomass for optimization of downstream processing and evaluation in agriculture and aquaculture fields of end products obtained.









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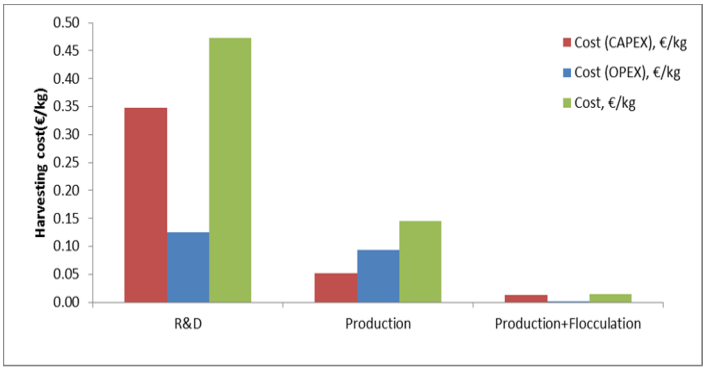
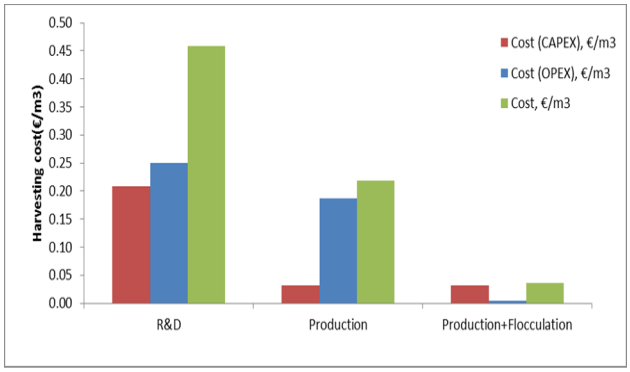
WP4 Harvesting

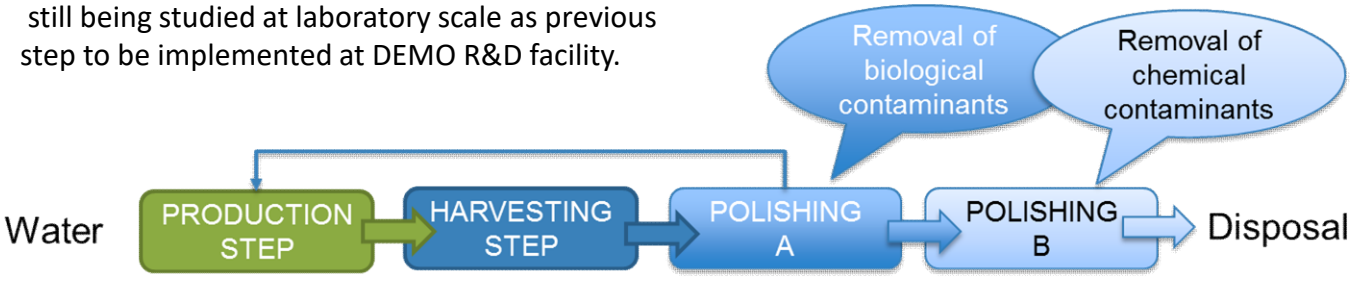
DEMO1 R&D facility is also providing enough volume of microalgae culture to evaluate different alternatives about harvesting of the biomass at pilot scale (1 m^3/h) . A complete analysis of technologies currently used has been performed, the most relevant being essayed as part of SABANA project. Data confirm the relevance of biomass concentration and characteristics of the cell on the design of adequate harvesting processes, it being mandatory at large scale to perform a pre-concentration and dewatering steps.

Although harvesting cost has been reclaimed to largely contribute to the microalgae biomass production cost, results from SABANA project refuse this fact. If adequately designed/managed the contribution of harvesting step to biomass production cost at large scale (5 ha) can be reduced till 0.15 €/kg only using centrifugation, and including below 0.05 €/kg if combining pre-concentration and dewatering steps. For that the utilization of nozzle separators from GEA Westfalia is recommended. When considering the cost per unit of water results are equivalent, but because wastewater treatment imposes to operate at costs lower than 0.2 $€/m^3$ the utilization of pre-concentration and dewatering step is the only option.





In addition to the recovery of microalgae biomass harvesting also includes the adequate polishing of supernatant to be recirculated or adequately released to the environment. Different scenarios/technologies are being studied, their performance still being studied at laboratory scale as previous step to be implemented at DEMO R&D facility.



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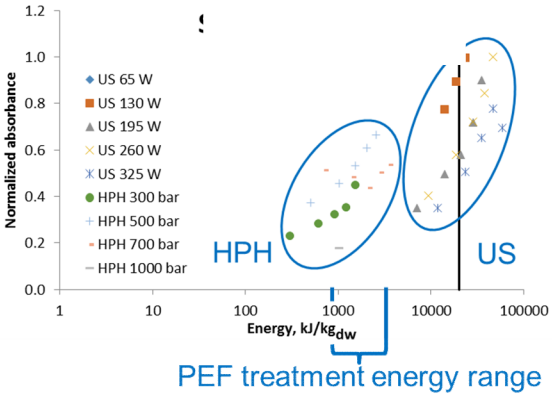
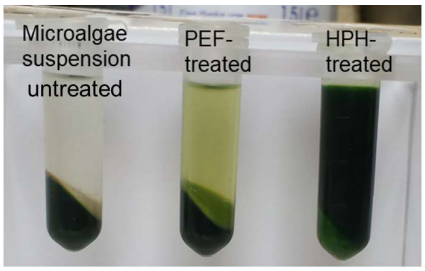
WP5 Processing

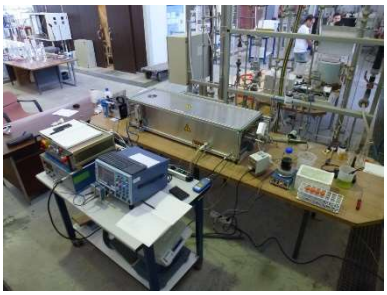
A large effort has been focused in identifying the most suitable methods to process the biomass. A cell disruption step is mandatory to ensure the adequate performance of whatever extraction or enzymatic hydrolysis step. From the portfolio of existing technologies the most suitable were UltraSounds (US), Pulse Electric Fields (PEF) and High Pressure Homogenization (HPH).

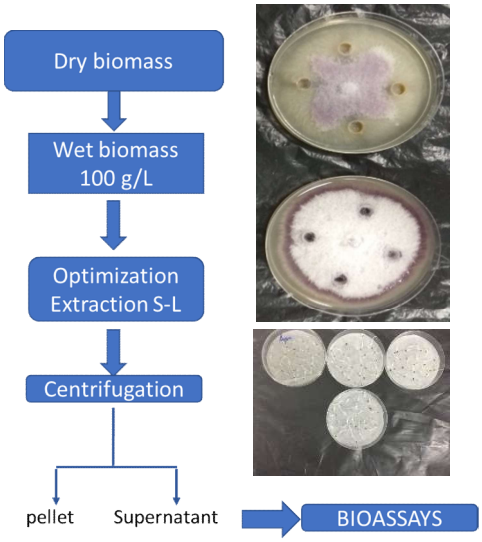


PEF and HPH demonstrated to consume much less energy than US, both of them achieving enough cell disruption. Energy consumption of both PEF and HPH are assumable in comparison with the energy content of the biomass, but at this moment the reliability of HPH at pilot scale is higher, although still experiments using a PEF pilot scale unit are pending.

Experiments are being performed at pilot scale at DEMO R&D facility to compare the performance of different pilot scale units. In addition to PEF and HPH a nannocavitation unit is currently under evaluation. An important factor to be considered is the modification of properties of disrupted cells for further processing steps, e.g. biomass recovery after cell disruption.







Different extraction protocols are being performed to determine the optimal method to produce valuable biostimulants and biopesticides. Biocompatible solvents and soft conditions are being used to achieve friendly processes. Quality of end products obtained is evaluated by bioassays, latter it being planned to analyze the compounds providing the positive effects observed at bioassays.

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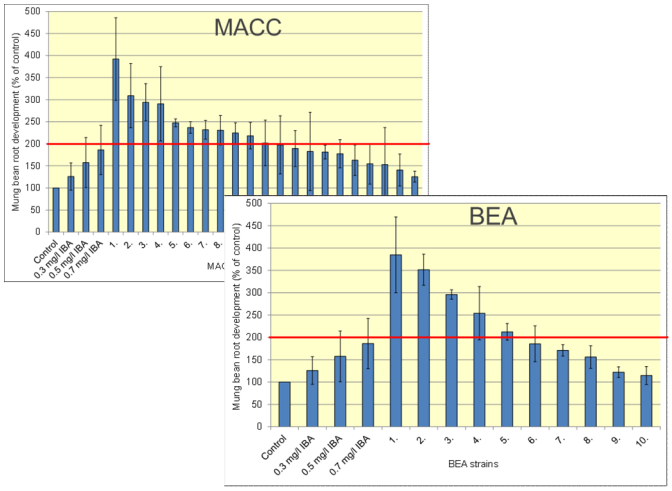
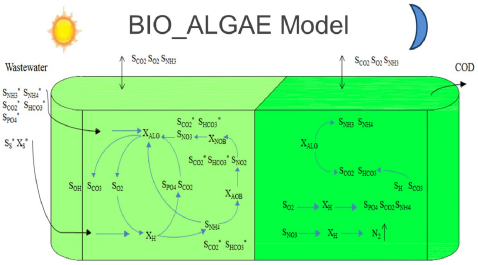
WP6 Biology

Four microalgae strains with large biostimulant activity, in addition to other four strains with high biopesticide activity has been selected from a list of more than 100 strains finally evaluated. These strains are provided by the MACC - Mosonmagyarovar Algal Culture Collection and BEA – Spanish Bank of Algae. The performance of selected strains was evaluated at laboratory, but also at pilot scale, also the capacity of selected strains to be produced using wastewater or manure being confirmed. These results confirm the reliability of microalgae to produce valuable compounds for agriculture, thus offering a large portfolio of potential valuable products on this field.



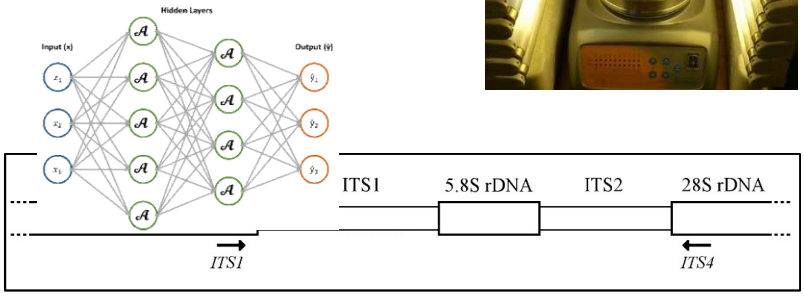
Modelling

For large scale production adequate models of the biological systems are required. The previously developed BIO_ALGAE model is being improved as part of SABANA project, to be used to simulate the evolution of different microalgae/bacteria consortia as a function of operation and environmental conditions.



To determine the values of characteristics parameters of the model photosynthesis and respiration rates are determined at laboratory conditions. On the basis of these measurements a complete biological model is being developed, it including the influence of culture conditions (pH, T, DO_2) on the performance of different microorganisms.

Colorimetric measurements, neural networks, molecular biology and other methods are being also used to evaluate the composition and performance of microalgae cultures. Fast monitoring methods are also required for large scale processes.



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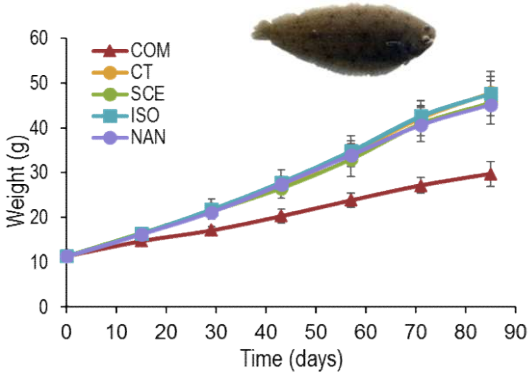
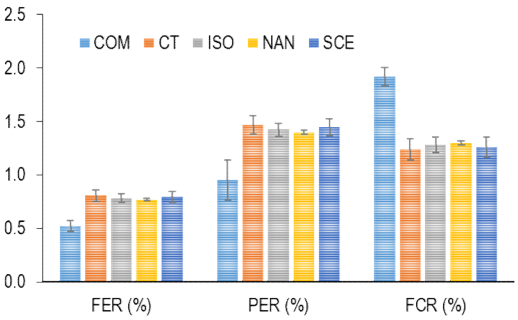
WP6 Biology

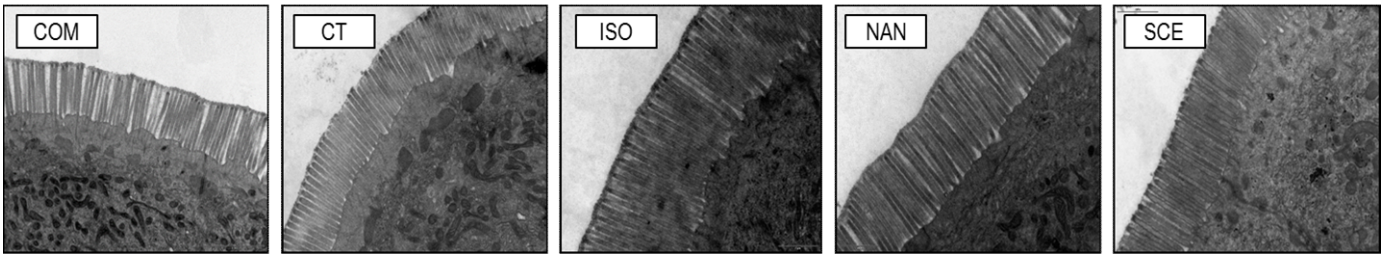
DEMO R&D is producing biomass samples of selected strains to be evaluated as supplement in aquafeeds. Experiments performed using Senegalese sole demonstrate a higher performance of aquafeed supplemented with microalgae, both in the time course variation of body weight and the nutrient utilization parameters. Inclusion of microalgae biomass up to 15% did not cause adverse effects.





However, the most relevant fact was the increase in microvilli length and microvilli absorption surface of fish fed with aquafeed supplemented with microalgae. Biomasses of T-ISO and *Nannochloropsis gaditana* show the best performance. Increase of microvilli has relevant advantages for improving the efficiency of the fish for nutrient absorption and as prebiotic to enhance the health of individuals.

Transmision electron microscopy (TEM) images



New fish trials are being performed using seabream juveniles and seabream larvae, also modifying the type of microalgae biomass and pre-treatment process. The objective is to determine the optimal biomass and processing method to maximize the quality of aquafeeds supplemented with microalgae at low percentage of biomass inclusion, dietary levels lower than 5%.

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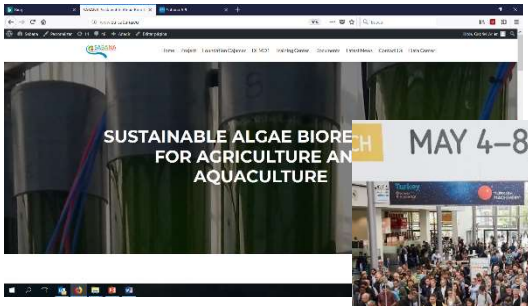
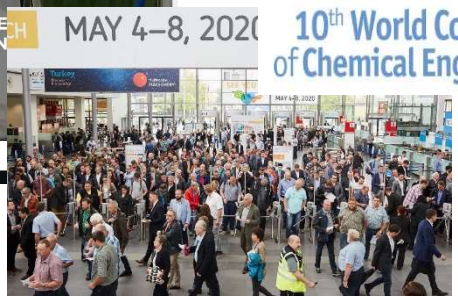
WP8 Dissemination

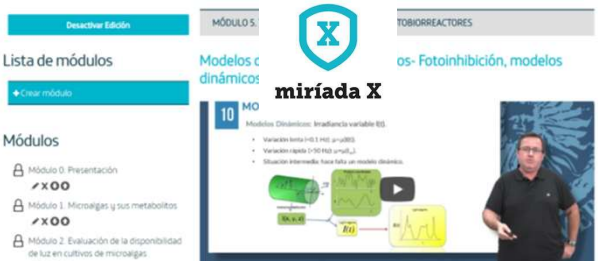
SABANA project participate in the most relevant events on microalgae field, in addition to other not typically related with microalgae but concerning nutrients recovery or bioeconomy. Information about dissemination activities performed is available at the new website.





Different videos about SABANA activities has been performed and they are available at the website, YouTube and related media.

SABANA project collaborate into the preparation of a Massive Online Open Course, soon available on MiridiaX platform. This course is free of charge and provide an excellent introduction to microalgae of biotechnology field.



https://www.youtube.com/watch?v=-eg_TyaMUNY

Data Center is also already available. Through the website access to some example files is provided. For full access to the results of the project please contact us.