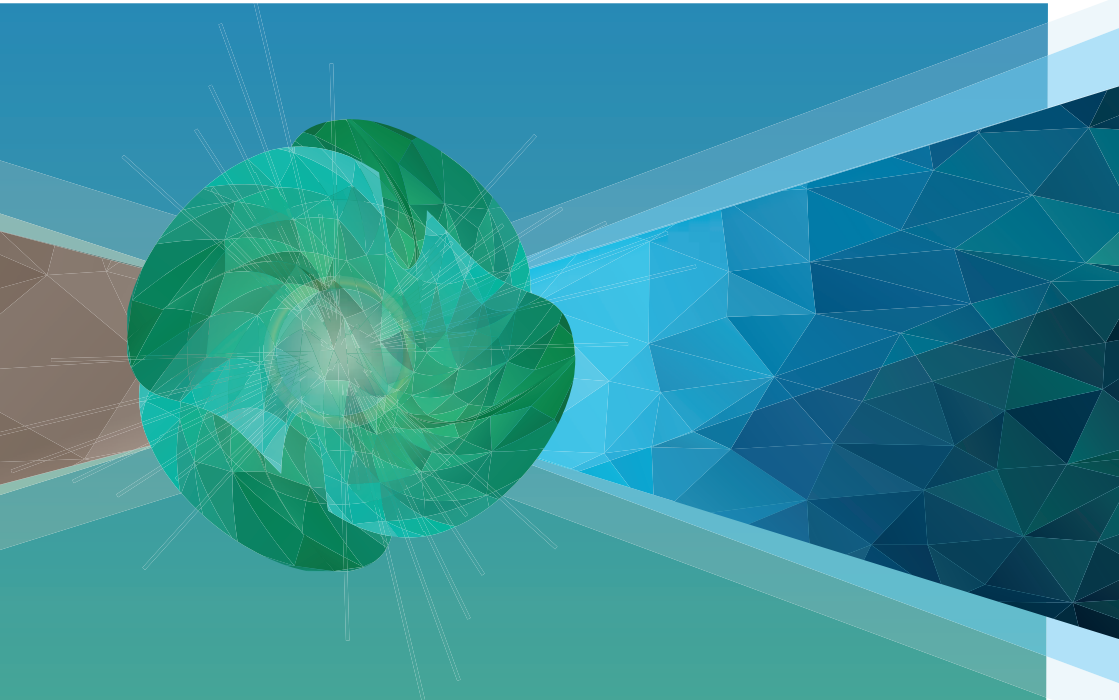


DEMONSTRATION PROJECT TO PROVE THE TECHNO-ECONOMIC FEASIBILITY OF USING ALGAE TO TREAT SALINE WASTEWATER FROM THE FOOD INDUSTRY.

SaltGae

algae to treat saline wastewater

*The information and views set out in this booklet are those of the authors and do not necessarily reflect the official opinion of the European Union. Neither the European Union institutions and bodies nor any person acting on their behalf may be held responsible for the use which may be made of the information contained therein.

EDITORIAL

The SaltGae project originates from the needs to provide a simpler and economically sustainable solution to the important problems of the treatment of saline waters with high organic load, such as, for example, the effluents of the Food and Drink industry. SaltGae implies the use of a combination of different technologies for the removal of pollutants and their recovery, an important aspect when proposing a sustainable solution. It has had to overcome scientific and technological barriers to move from the laboratory, through piloting, to reach a level of Demonstration development. For this later, three demo centres have been built up in different locations (Israel, Italy and Slovenia) with different climatic conditions and origins for the wastewater to be treated, which allows confirming its versatility, thanks to SaltGae modular design.

Experts from different areas: biology, genomic, desalination, anaerobic-digestion, water treatment, chemical transformation and sustainability studies, from both academy and industry collaborated during the project execution to develop the mentioned innovations in a complementary and effective way.

The SaltGae project is coming to an end (September 2019), it was a very successful project producing considerable scientific outputs that allow progress in the treatment of industrial wastewater exerting a dynamic effect within the different affected sectors to change the paradigm of “wastewater treatment” for a “potential source of resources to valorise”.

José I. Lozano

CONTEXT AND CHALLENGES

THE PROJECT

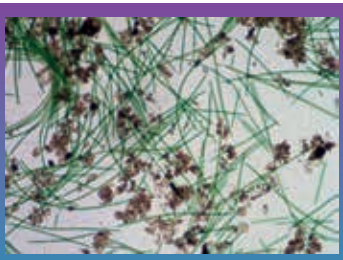
Water is an invaluable and essential resource for human life and for the environment, as well as an economic sector of growing importance for Europe. The aim of the project was to implement and demonstrate at large scale the long-term technological and economic feasibility of an innovative, sustainable and efficient solution for the treatment of high salinity wastewater from the Food and Beverage industry as conventional wastewater treatments have proven ineffective for this kind of wastewater. This kind of wastewater, with the high concentrations of biodegradable organic matter, suspended solids, nutrients (mainly nitrogen and phosphorus) and salt (concentrations up to 15%), is extremely difficult and expensive to treat, and its discharge represents a major threat to the environment.

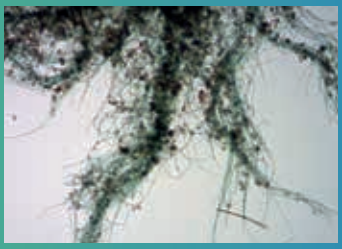
SaltGae addressed this market developing an innovative and cost effective solution for saline wastewater treatment using a combination of algal treatment, specially modified anaerobic digestion and desalination technologies to recycle energy, nutrients and produce valuable algae based products.

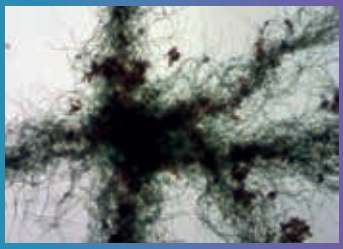
KEY RESULTS

THE PROJECT

- Business Visualization Toolkit
- Salt-tolerant anaerobic bacterial treatment
- Aerobic algal-bacterial treatment
- Biomass valorization:
  - Coatings
  - Animal Feed
  - Adhesives







ARCHIMEDE

DEMO SITE

Camporosso, ITALY

Archimede Ricerche s.r.l.

whey WW

Integrated technologies:

Dairy wastewater pre-treatment,
3000 m2 Algal phyto depuration system.
Biomass harvesting drying and storage.
Microfiltration and centrifugation.
Spirulina, Tetraselmis and Nannochloropsis biomass production

Demonstrator treatment capacity:

Cubic meters / day: 20m^3
Salinity levels: 2-30g/L
Organic matter: COD 5.000 mg O2/L, TKN 100 ppm
20kg/day of algal biomass

ARCHIMEDE

DEMO SITE

Following the tests carried out at ARCHIMEDE facilities; the *Spirulina* algae shows biomass purity above 99% when grown on medium prepared on dairy wastewater and ability to capture natural CO_2 from atmosphere. The Energy consumption was also measured at each step, with very competitive results.

The following results have been achieved at the end of the demonstration, with treated daily volume of 20m³:

- nitrogen content < 10 mg/L
- harvesting energy input < 0.8 kWh/kg
- overall energy balance more favourable than existing technology for dairy WWT
- better nutrient recovery than actual system (total N < 10mg/L and total P < 10mg/L)
- culture pond productivity >10 g/(m²*d)

KOTO

DEMO SITE

Ljubljana, SLOVENIA

KOTO D.O.O.

tannery WW

Integrated technologies:

Sieving

Two stage anaerobic digestion with granular anaerobic filters EGSB

100 m^2 Algal-bacterial wastewater treatment

Biomass Harvesting

Mix of different algae species as biomass

Demonstrator treatment capacity:

Cubic meters / day: 1 m^3

Salinity levels: up to 100 g/L NaCl

Organic matter: COD 10.000 mg O_2/L on the inflow to anaerobic treatment

KOTO

DEMO SITE

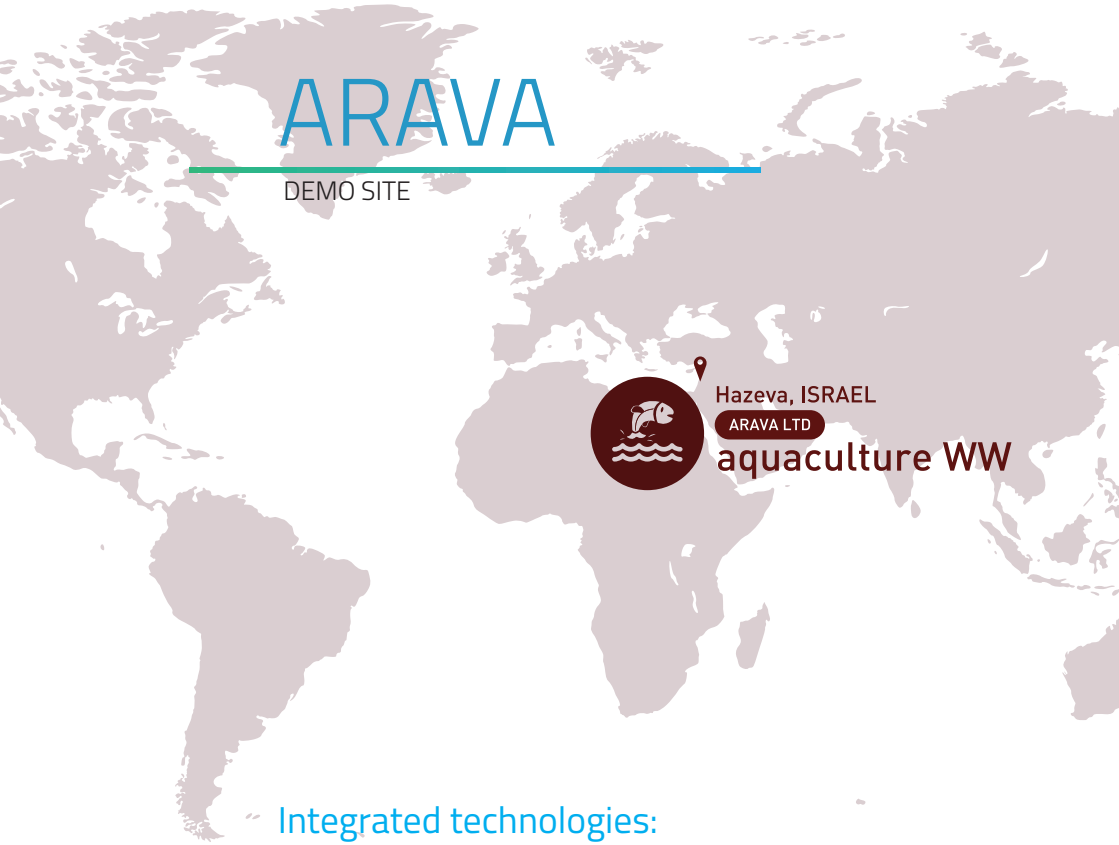
The Slovenian demo site has shown higher dissolved organic matter in the saline wastewater therefore it was the ideal candidate to test SaltGae anaerobic digestion module.

Treating a daily volume up to 1 m^3 of wastewater, the following results have been achieved:

- stable AD process at salinity up to 20 mg Na^+/L sodium with biogas production up to 380 L/h with high methane content 85,5 % CH_4
- contribution to electric energy = 9 kWh
- contribution to thermal energy = 18 kWh
- 9,3 m^3 CH_4/ m^3 waste water, maximally 23,4 m^3 CH_4/ m^3 wastewater
- harvested algal biomass (DM) = 6,9 kg/day
- output water (after filtration) = BOD5 < 50 mg/L and total $N^{average}$ <50 mg/L

ARAVA

DEMO SITE



Integrated technologies:

Water pre-treatment using Drum and Bio-Filter and DAF system
PBRs and HRAPs for large scale *Spirulina* cultivation
Harvesting and drying using vibration screen and solar oven
RO system

Demonstrator treatment capacity:

Cubic meters / day: 10 m^3 aquaculture waste water
Salinity levels: 2.5 g/L
Organic matter: COD 1.000 mg O_2/L
5-10 kg DW algal biomass/day

ARAVA

DEMO SITE

The demo site in Israel established a large scale HRAPs operation for algae biomass production (*Spirulina*) using aquaculture wastewater from fish production. The main focus of this pilot site was the demonstration of cost effective treatment of low salinity - low BOD - nutrient enriched fish waste water, used for algae biomass production and the re-use of desalinated algae harvest water within the algae system or for crop irrigation and increase of crop yield. The final performance at this demo sites are as follows:

- Continuous rearing of the selected fish and algae species in the system
- Demonstration of excess nutrient removal (N and P levels close to zero)
- Removal of sludge from waste water,
- Production of up to 60 g/m³/day of algal biomass and 5 kg/m³/month of fish
- Harvesting of algae biomass and recycling desalinated harvest water

Are you interested in SaltGae technology? Visitors are welcome, please notify us in advance. Send an email and book your visit at the ARAVA demo site!

yairk@arava.co.il

SALT-TOLERANT ANAEROBIC BACTERIAL TREATMENT

A salt-tolerant anaerobic digestion has been developed to remove in an efficient way the soluble organic matter presents in the highly saline wastewaters.
SaltGae innovation allows to convert organic matter into energy using the methanogenic Archaea; to guarantee their survival in elevated salinity levels the following steps has been followed: the separation of all other anaerobic digestion processes that are much less salinity sensitive from the methanogenesis. Progressively methanogens have been provided with granular substrates; finally the most performing species and variants have been selected.

AEROBIC ALGAL-BACTERIAL TREATMENT

SaltGae Project contributes to CO_2 reduction thus generating benefits on the environment. Usually wastewater is treated with bacteria using aerobic processes that imply the use of oxygen that needs to be externally supplied (usually by aeration). Bacteria convert these organic substances into CO_2 that is released into the atmosphere.
The use of algae in SaltGae process enable the consumption of CO_2 produced by bacteria converting it into their own biomass using solar light (photosynthesis). A side product of this process is oxygen, which replaces the need for aeration.
SaltGae not only eliminates the energy requirement of aeration but captures nitrogen and phosphorous from water partially embedding the carbon contained in wastewater into biomass which can then be valorised. As a result, the treatment is much cheaper due to the reduced costs of aeration, CO_2 is recycled and biomass can be further utilized and sold.

BIOMASS VALORIZATION

One of the key results of SaltGae was the biomass valorization to contribute to the reduction of CO_2 emissions.
Refinement of the studied algae allowed the obtainment of various fractions potentially interesting for a future valorization: a first one rich in proteins, a second one rich in lipids and finally the residue. These three products were the subject of extensive characterizations. Regarding the purity, the objective was reached for both proteins and lipids fractions.
The lipid product obtained is comparable to the algae oils in development with the aspect, the consistency and the colour comparable to an oleoresin. These fractions were then tested in the various targeted applications.

Microalgae biomass was added to materials derived from gluten, in order to obtain a compound from renewable sources that can be used for a sustainable industry. The addition of the microalgae increases the resistance of gluten to mechanical solicitations, increasing the stiffness and the strength without significantly changing its behaviour towards water and moisture.
The biomass was also included in ceramic pastes for 3D-printing, an innovative technique that aims to produce complex structures in clay, cement or other similar materials. Microalgae addition increases the peculiar properties that such viscous pastes must possess, increasing workability and reducing the number of defects during the printing process, without significantly reducing the final mechanical properties of the obtained parts.
In both cases, different types of biomass were used: apparently, best results are achieved with biomasses rich in proteins but both materials can be compounded with different biomasses and different fractions of algae.
According with the results obtained during this project, we can concluded that at least the 50% of fishmeal, that is included in the post-weaning diets of piglets, could be substituted by Spirulina meal. These results suppose an interesting source to look for alternative to animal byproducts inclusion in livestock feeding, making the piglet production more efficient, less depend of extractive fishing and consequently, more ecofriendly and sustainable.

SaltGae VISUALIZATION TOOLKIT

The SaltGae Visualization Toolkit aims at illustrating the economic and environmental potential of the SaltGae solution, addressing the variability in the most influential site-specific parameters - to present an economic and environmental profile of the SaltGae system performance in a wide range of scenarios.

The toolkit facilitates site-specific user interaction that allow potential stakeholders to understand how the system will perform for them by providing a selection of visual, easy to understand, system analysis outputs.
http://www.stakeholdersaltgae.eu/saltgae-tool/

CONSORTIUM

THE PROJECT

FUNDITEC

Archimede Ricerche Srl

European Desalination Society

RISE

EUBIA

FOOD+i CLUSTER

enco engineering & consulting

PTP SCIENCE PARK

EXTRACTIS the experts in plant biorefinery

OXIDINE Water Technology

DCU Oifigiúl Chathair Bhaile Átha Cliath Dublin City University

NOVA id FCT

KOTO

iBET Instituto de Biologia Experimental e Tecnológica

PRODUMIX Basemixes for piglets Núcleos para lechones

algen algal technology centre

Bibo Aqua

Central & Northern Araba-Tamar R&D

CONTACTS

www.saltgae.eu
info@saltgae.eu
www.stakeholdersaltgae.eu

José Ignacio Lozano
Project Coordinator
Foundation for Development and Technological Innovation (Spain)
jilozano@funditec.es

Robert Reinhardt
Technical Manager
ALGEN (Slovenia)
robert@algen.si

Marco de la Feld
Exploitation Manager
ENCO (Italy)
m.delafeld@enco-consulting.it

Silvio Mangini
Risk Manager
ARCHIMEDE (Italy)
mangini@archimedericerche.com

Are you interested in SaltGae technology? Visitors are welcome, please notify us in advance. Send an email and book your visit at the demo site!

ARAVA:
yairk@arava.co.il

info@saltgae.eu
www.saltgae.eu

H2020-WATER 1b-2015
GA n°689785

SaltGae project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N. 689785