Study of the anaerobic digestion of microalgae residues

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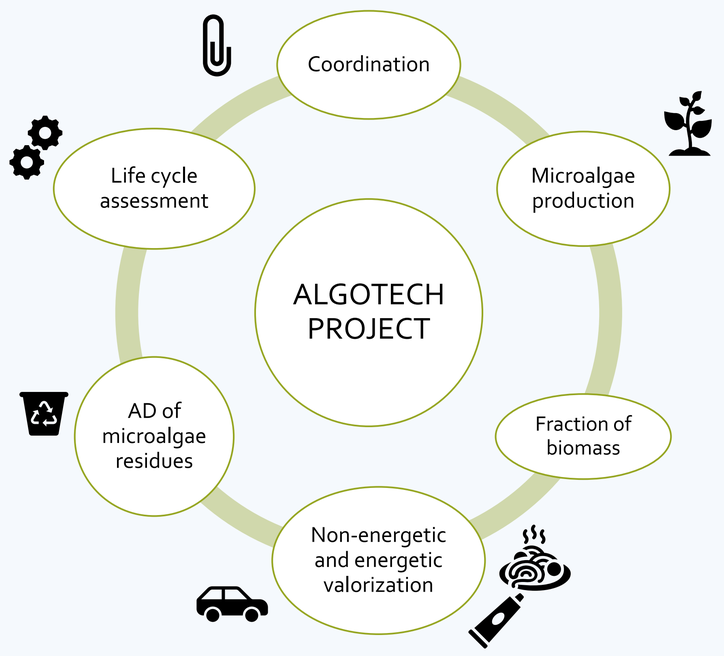
Problem Statement

Owing the current scenario of energy crisis, the study of alternative biomass as an efficient energy producing feedstock in terms of biomethane through anaerobic digestion (AD) process seems to congregate the future needs.

Besides biodiesel and high value-added compounds (such as proteins or vitamins) from microalgal biomass, the Algotech project, where this thesis research is part, is closing the loop to create a circular economy. Hence, anaerobic digestion of microlagae (with potentially co-substrates to improve biogas formation) is an auspicious approach to produce biogas and could be the solution for treating residues. Unfortunately, there are many challenges such as the biochemical composition variation and the occurrence of inhibitory phenomena during the fermentation stages. These locks make algal biofuels not yet economically profitable although they are more environment friendly than fossil fuels. To achieve such goals, in this work, microalgal residues will be utilised to produce energy (biomethane) and create more value.

Taking account of the low C/N ratio of the microalgae residues, rich-carbon substrates will be added.

The Algotech project



Co-digestion

Biochemical composition

Microalgae (unabridged/extracted)

Excess protein content

Low C/N (<10)

Toxicity

High NH_3 and/or H_2S concentration

Inhibition of acidogens/ methanogens

Volatil Fatty Acids accumulation

Digestion failure

Several Pretreatments

- Physical
- Chemical
- Biological
- Combined process

Co-digestion

Increasing C/N >20

Rich-carbon substrates

Biogas production enhanced

BMP Test

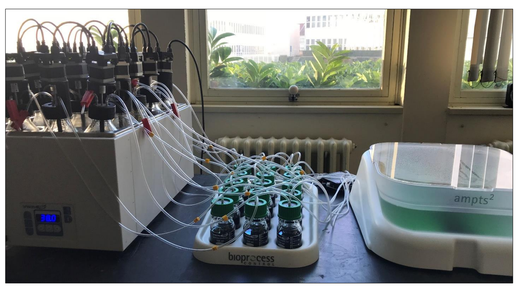
- ✓ The most relevant indicator for assessing AD.
- ✓ Estimation of the biomethane yields and biodegradability of the mix (Microalgae + co-substrates) : Helps to select the most suitable ratio.

Inoculum

Microalgae + co-substrate

CO_2 Capture

CH_4 measurement



Scale-up with the suitable co-substrate

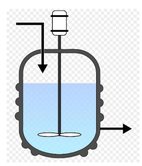
Examples of reactors configurations

Main objective

Lowest hydraulic retention time + Highest organic loading rates

CSTR: Continuous stirred-tank reactor

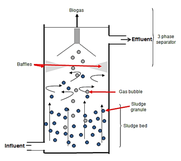
+ The most used for the digestion of microalgae



UASB: Upflow anaerobic sludge blanket

+ Ability to keep large amounts of the biomass for degradation

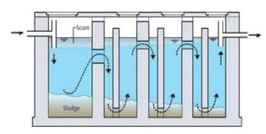
+ Effluent free of suspended solids



ABR: Anaerobic baffled reactors

+ Long sludge retention

+ Efficient reactor performance



Discussion

This thesis is focused on the utilization of the microalgae residues, after their extraction of lipids and carbohydrates, as feedstock to produce biogas in a circular economy. Therefore, AD of microalgae residues should be the most direct route and appropriate process even if it has three major critical points in the digestion of microalgal waste: a slow biodegradability depending on the biochemical composition of the microalgae, its protein content which may cause inhibition, and finally, the presence of sodium in some marine species that could affect the performance of digestion.

The initiation of anaerobic digestion is the most critical step. Physicochemical pretreatments, adequate co-substrate and control of the species' crude composition are strategies that would increase the methanogenic potential. Thus, attention should be paid to the economic balance. A need of returns of experience and monitoring on AD plants is important.

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Acknowlegments

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