www.disat.unimib.it

Sustainable agriculture: integration of algae in agricultural biomethane plants to produce biostimulants

Valeria Mezzanotte

Università degli Studi di Milano Bicocca, Piazza della Scienza, 1,

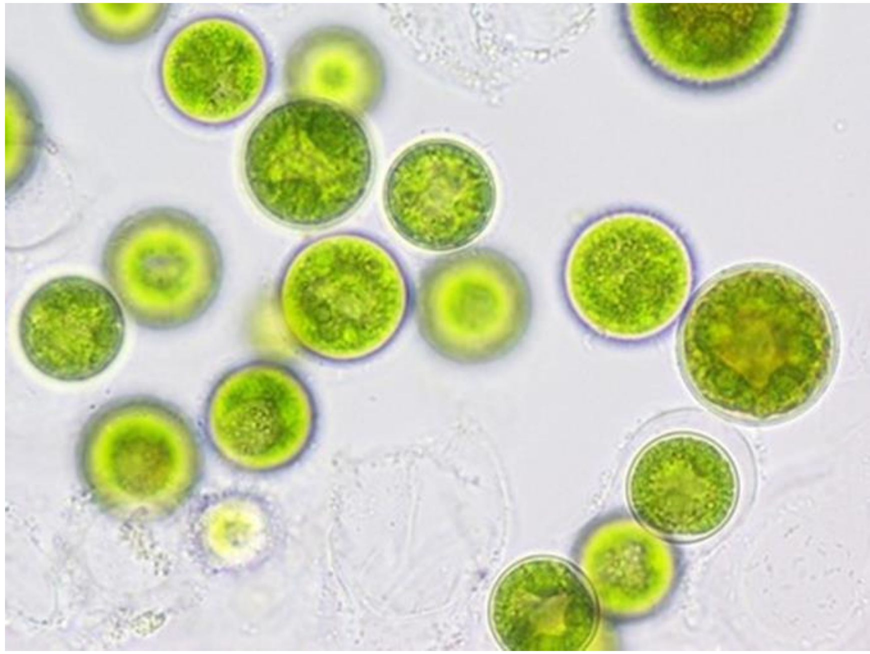
20126 Milano, Italy

Valeria.mezzanotte@unimib.it

UNIVERSITA' DEGLI STUDI DI MILANO BICOCCA

DIPARTIMENTO DI SCIENZE DELL'AMBIENTE E DELLA TERRA

Algae are autotrophic organisms, but can also perform mixotrophic or heterotrophic metabolism
They can remove nutrients and COD from wastewaters and digestates
They can produce lipids, pharmaceutically active compounds, lipids to be used to produce biofuels, bioplastics, etc.
They have important nutritional value, and can be used to integrate feed and food
They can be used for cosmetic preparations
They can act as natural pesticides and **biostimulants**
…….



Their cultivation is not always economically sustainable, especially where the weather conditions are not optimal

Their cultivation can become convenient if the growth medium is unexpensive and the final valorization of biomass allows for economic income

Biogas plants are a smart way to dispose excess agrowastes and animal sewage

BUT

MORE BIOGAS MEANS MORE RENEWABLE ENERGY **BUT ALSO MORE DIGESTATE**

The solid fraction can be applied to soil as amendment, but the liquid fraction must be treated and can be a good substrate for algal growth

↓

PHYCOREMEDIATION

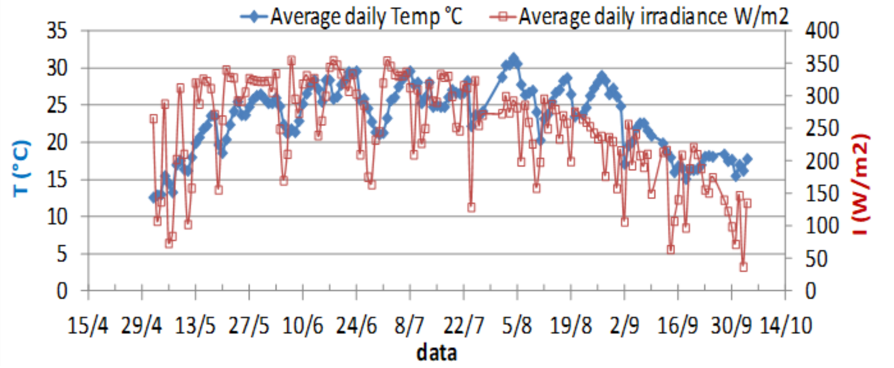
PILOT SCALE EXPERIENCE WITH DIGESTATE FROM A PIGGERY FARM UNDER SUB-OPTIMAL CLIMATIC CONDITIONS (200 days)

Raceway

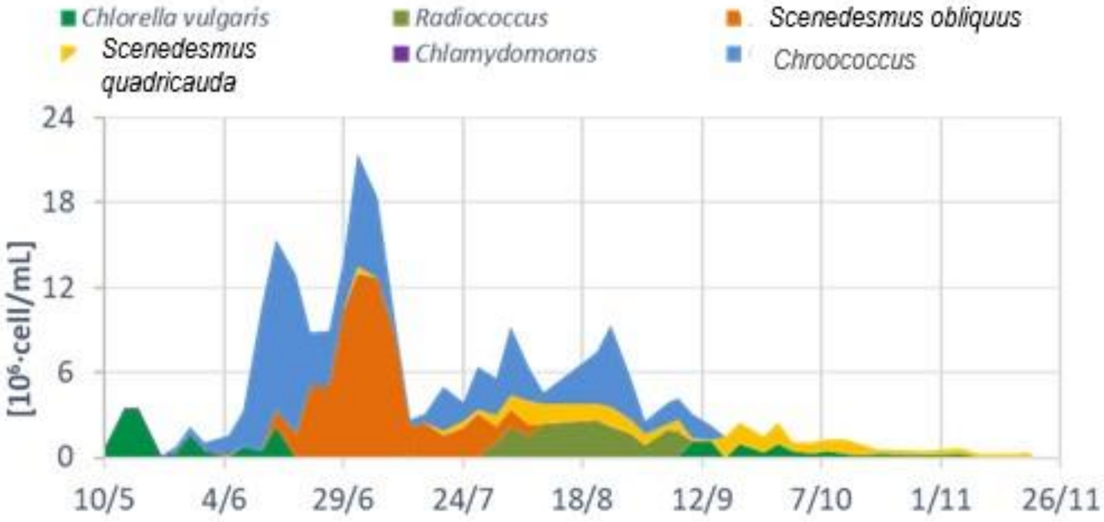
A = 3.8 m^2 (V =0.9 m^3),

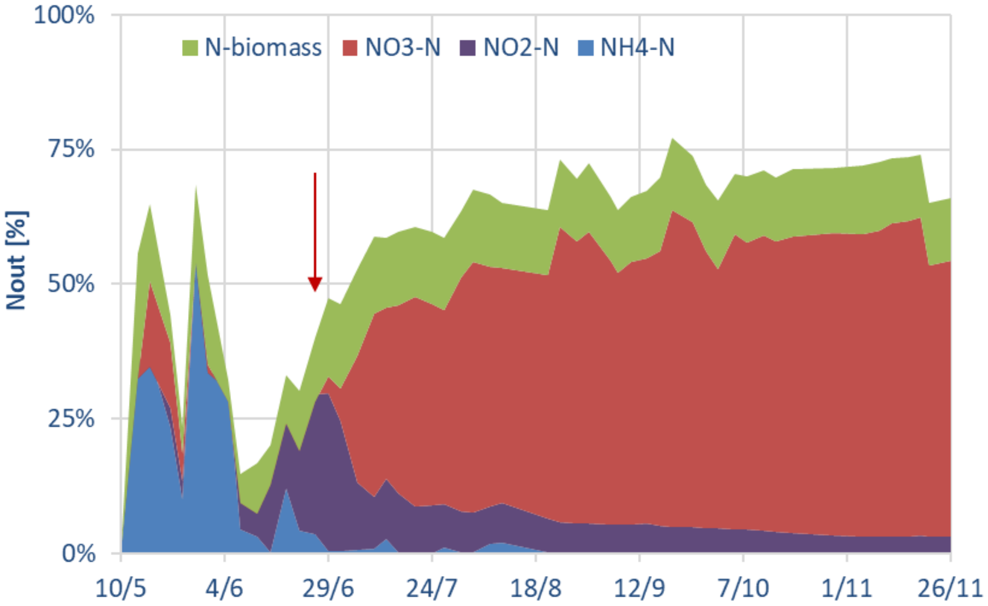
- paddlewheel
- pH control by bubbling CO_2
- CO_2 sump
- feeding pump

TSS (g/L)	1.4±1.6
VSS (g/L)	1.2±0.5
pH	7.7±0.8
NH_4-N (g/L)	30±10
PO_4-P (mg/L)	1.3±0.5
OD (680 nm)	4.0±6
COD_{sol} (g/L)	6.3±4
Tot COD (g/L)	0.6±0.1
Sol BOD_5 (g/ L)	1.0±0.2
Sol BOD_{20} (g/L)	18
N:P (molar ratio)	2.4



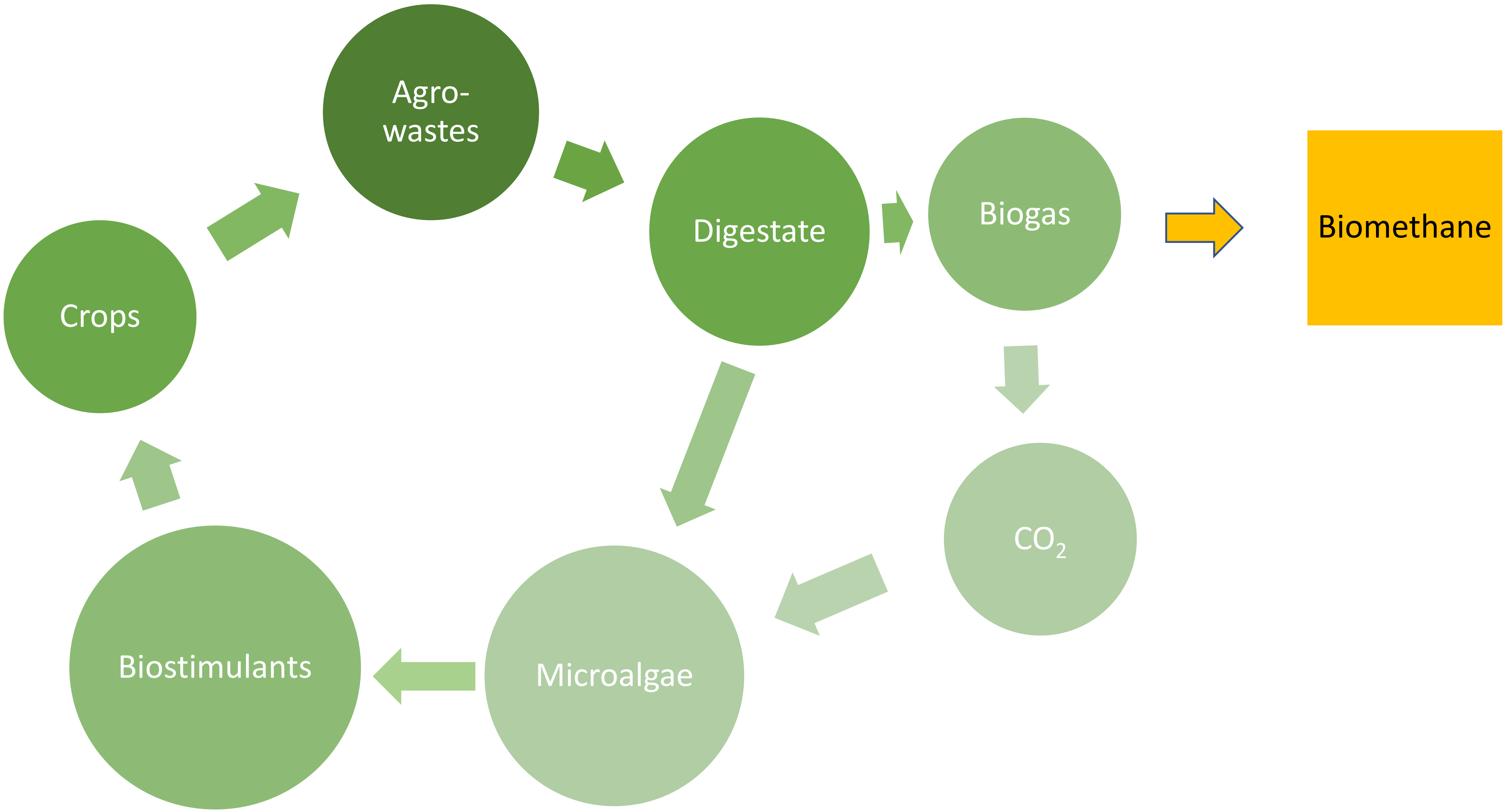
- A mixed population of microalgae and bacteria could grow
- Stable nitrification was established and supported by oxygen from photosynthesis
- Approximately 7±3% of N was assimilated by microalgae while 61 ± 24% was nitrified
- Productivity was 6.2 g TSS m^{-2} d^{-1}
- N in the biomass = 13 %
- N-NH_4 fully removed



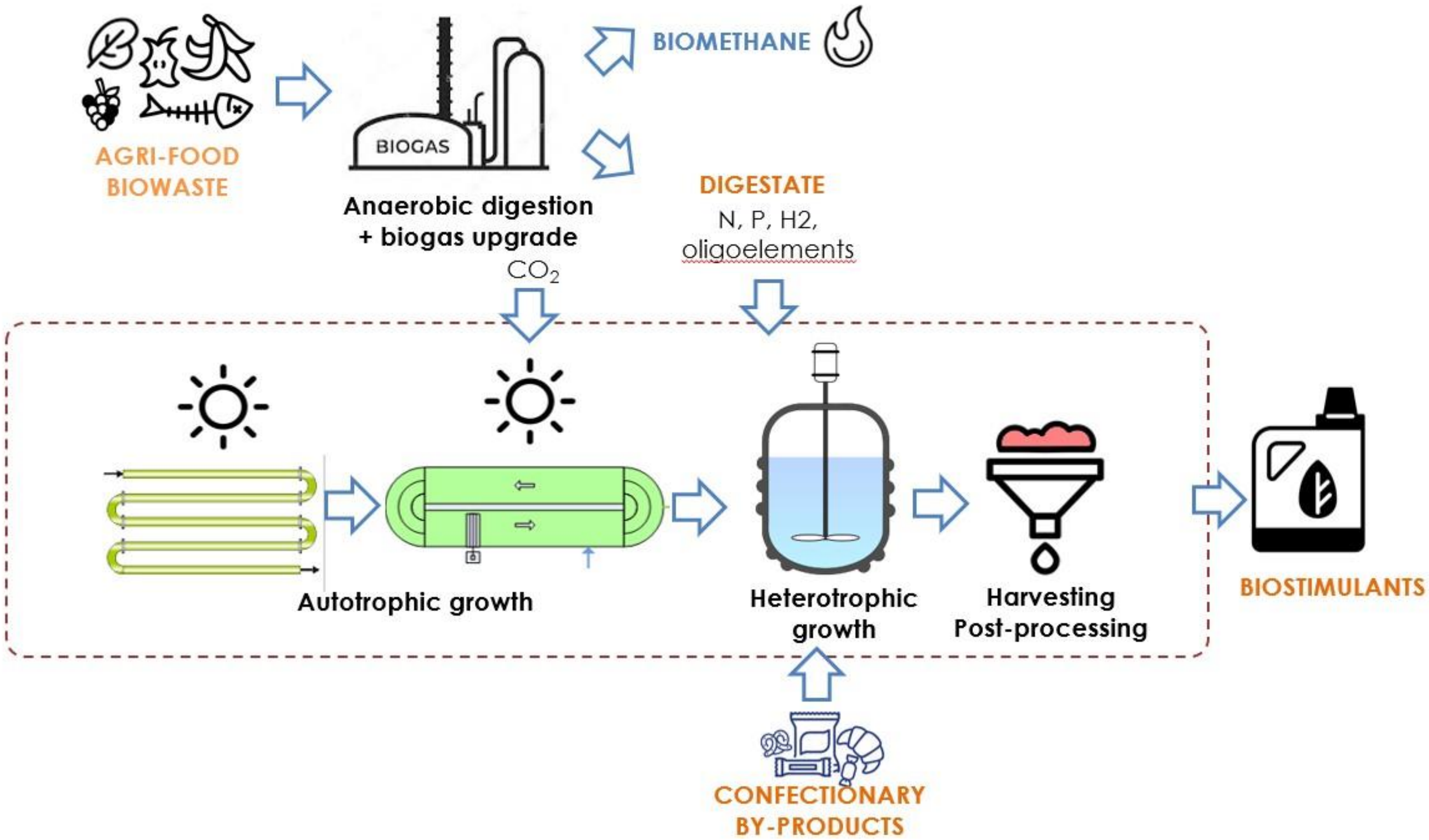


THE BEST VALORIZATION PATH FOR BIOMASS GROWN ON A «DIRTY SUBSTRATE» IS THE PRODUCTION OF BIOSTIMULANTS FOR AGRICULTURAL CROPS

….AND THIS WOULD CLOSE THE LOOP → CIRCULAR ECONOMY



INTEGRATION OF ALGAE IN AGRICULTURAL BIOMETHANE PLANTS TO PRODUCE BIOSTIMULANTS



a2a LIFE COMPANY

POLO DELLE MICROALGHE
WWW.POLOMICROALGHE.IT

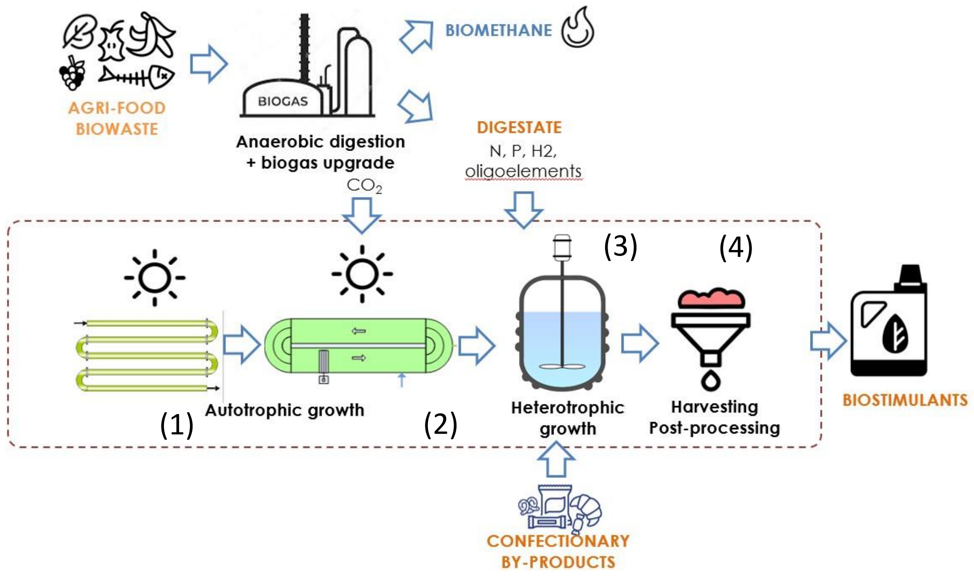
The project is designed to be located next to an industrial AD plant producing around 76’869 $Sm^3 \cdot y^{-1}$ (1 MW_{el} equivalent) of biomethane in Northern Italy.

The main plant feedstocks include cow slurry (60% vv, 42’705 $t \cdot y^{-1}$), cow manure (10% vv, 4’205 $t \cdot y^{-1}$) and other agro-industrial by-products largely available from nearby factories.

The plant produces 158 t $CO_2 \cdot y^{-1}$ through biogas membrane filtration.

The amount of digestate produced by the digester is approximately 56 $kt \cdot y^{-1}$, generating 50 $kt \cdot y^{-1}$ of liquid digestate after S/L separation via screw press.

Plant design and assumptions

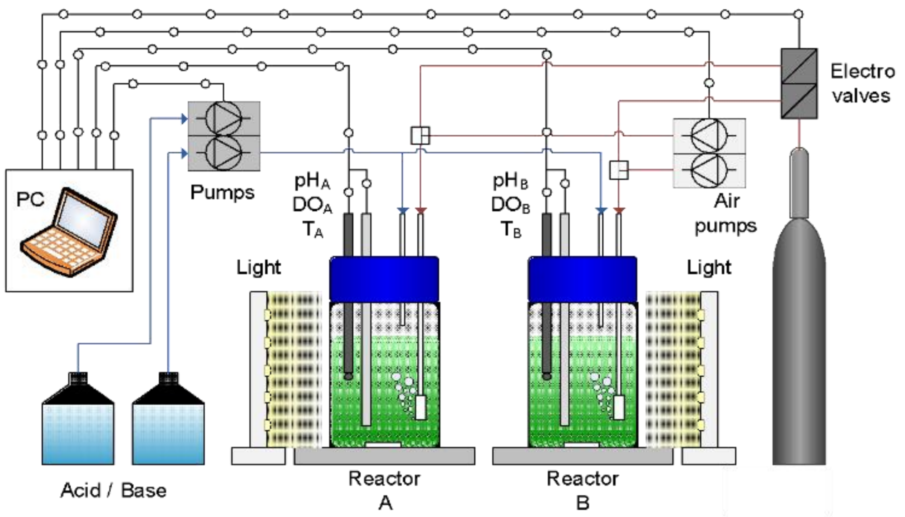


(1) Inoculum preparation under controlled conditions (closed photobioreactor, synthetic medium) to produce approximately 10% of the expected productivity of the following HRAP section, designed according to conventional procedures

(2) HRAP section, with operational parameters and productivities estimated via a model-based approach with a model validated on similar case-studies (ALBA model), covered by a greenhouse

(3) Heterotrophic section designed to triple the algal biomass density, using confectionary wastes from a local factory. Heterotrophic growth parameters (as rates and yields) will be validated experimentally

(4) Biomass harvesting (BH) by centrifugation of the heterotrophic algal biomass, without further pre-concentration treatment. The electric consumption of the centrifuge is assumed as 1.5 kWh·m^{-3} of algal suspension harvested



Preliminary design based on:

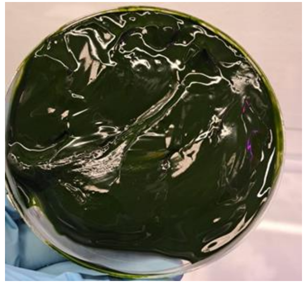
- Results from pilot-scale experimentation → Raceway
- Literature criteria for reactor design → PBR and Heterotrophic growth

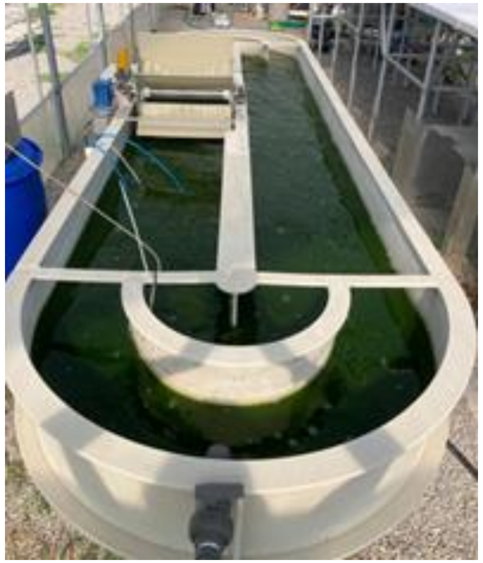
Pilot and lab-scale experimental trials in progress focusing on:

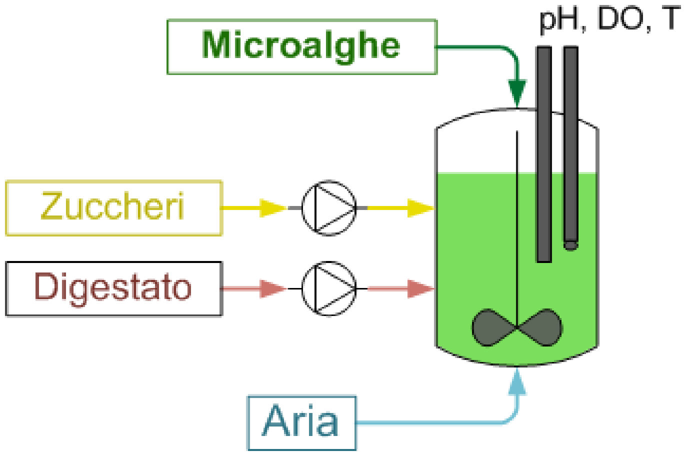
- Digestate pre-treatment
- Validation of phototrophic productivities for selected algal strains
- Daily re-inoculation to keep the culture pure
- Heterotrophic productivities on sugar-rich by products, final biostimulant effect
- Optimization of algae culturing (lab-scale results and model-based)
- Monitoring of potentially pathogenic bacteria
- Energy costs for heating/cooling as a function of expected increase in productivity
- CAPEX and OPEX confirmation after a detailed design

www.disat.unimib.it

Experimental-based optimization and validation of the design assumptions







GRADUAL ACCLIMATION:
25 % DILUTION
40 % DILUTION
....

Experimental-based optimization and validation of the design assumptions

Digestate characterization and pretreatment

Relevant parameters:

- TSS, VSS, COD, BOD, TKN, NH_4-N, K, total P, PO_4-P, trace elements, electric conductivity, pH, TIC, turbidity,
- bacterial counts, *E. coli, Salmonella*

Digestate treatment alternatives:

- Dosage of activated carbon,
- Solid / liquid separation (flocculation, centrifugation, sedimentation, filtration) for the reduction of turbidity,
- Sterilization (filtration, heat treatment, UV) to reduce the bacterial load
- Dilution, micro and macro-nutrients

Selection of suitable algal strains for the production of biostimulants

- Literature screening → algae that are growing on digestate & have interesting biostimulant effect, validation of their growth rate on pre-treated digestate
- Growth tests in bench-scale photobioreactors → growth rates on pre-treated digestate, biomass characterization

PRESENT ACHIEVEMENTS

- The most sustainable treatment process for digestate is centrifugation with the addition of polyelectrolite coagulants. The most suitable dose and procedure has been defined
- Till now two microalgal strains (*Chlorella* and *Scenedesmus*) have been tested for autotrophic growth on digestate and, then, heterotrophically on confectionary by-products and are being tested for their biostimulation potential also after heterotrophic growth
- The purity of algal biomass grown in the raceway has always been >95%
- The photosynthetic efficiency of the algal culture, measured by PAM, has always been >0.5
- NH_4-N was removed by assimilation and partial nitrification, with accumulation of NO_2

PRESENT ACHIEVEMENTS

- The obtained biomass complies with the bacterial limits set by the EU Regulation on fertilising products and amending (UE 2019/1009) for potential pathogens (*Salmonella*, *E.coli, Enterococcaceae)*

- Bacterial counts were lower in the algal suspension than in the fed digestate (disinfection in HRAP)

- C, N and P concentrations in the biomass were 50, 10 e 1%, respectively

- Pilot tests with increasing concentration of digestate will be performed next Spring

THANK YOU FOR YOUR ATTENTION

And thanks to Francesca Marazzi, Marco Mantovani, Andrea Pizzera, Simone Rossi, Davide Carecci