Microalgae applications for wastewater treatment- CO_2 capture - protein production

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ΙΝΣΤΙΤΟΥΤΟ ΕΠΙΣΤΗΜΩΝ ΧΗΜΙΚΗΣ ΜΗΧΑΝΙΚΗΣ

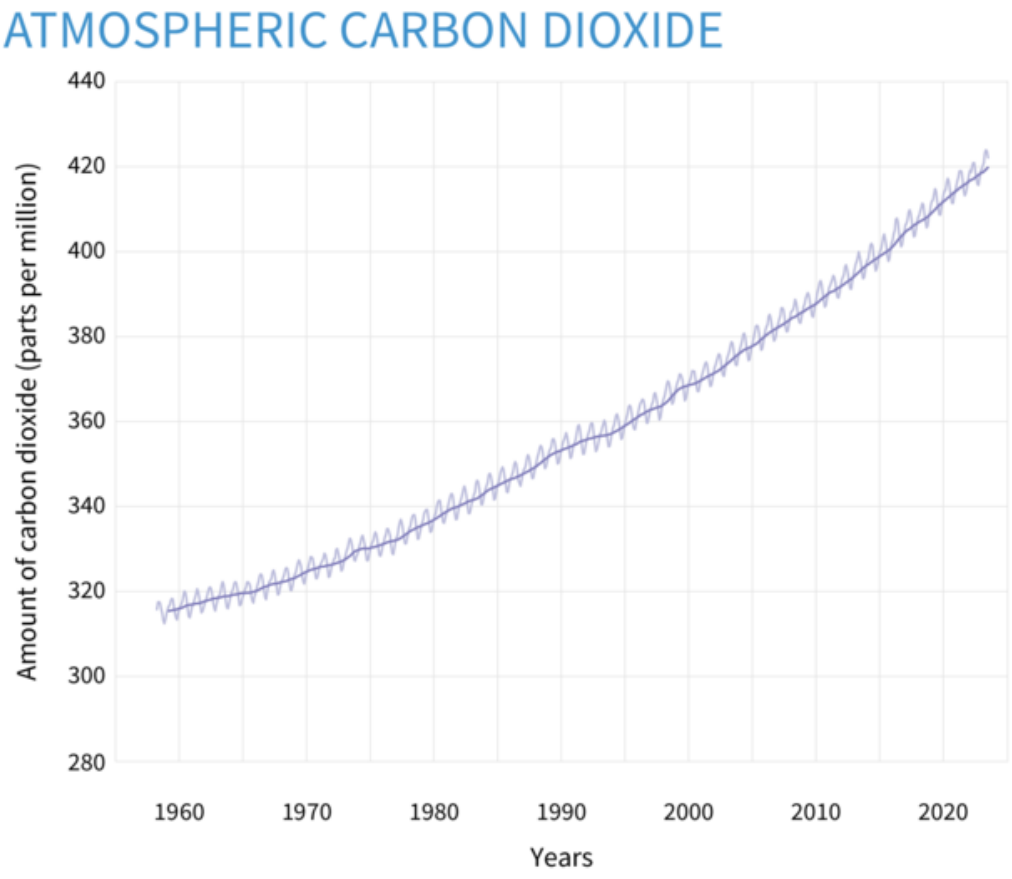
Climate Change: Atmospheric Carbon Dioxide

https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

Why carbon dioxide matters

Carbon dioxide is Earth's most important greenhouse gas: a gas that absorbs and radiates heat.

Carbon dioxide reacts with water molecules, producing carbonic acid and lowering the ocean's pH (raising its acidity). Since the start of the Industrial Revolution, the pH of the ocean's surface waters has dropped from 8.21 to 8.10. This drop in pH is called *ocean acidification*.



2013


Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data LDEO-Columbia, NSF, NOAA
Image Landsat / Copernicus
Google Earth

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Image Landsat / Copernicus
Google Earth

Western Achaia 2013

New Vouprasio 11-2012

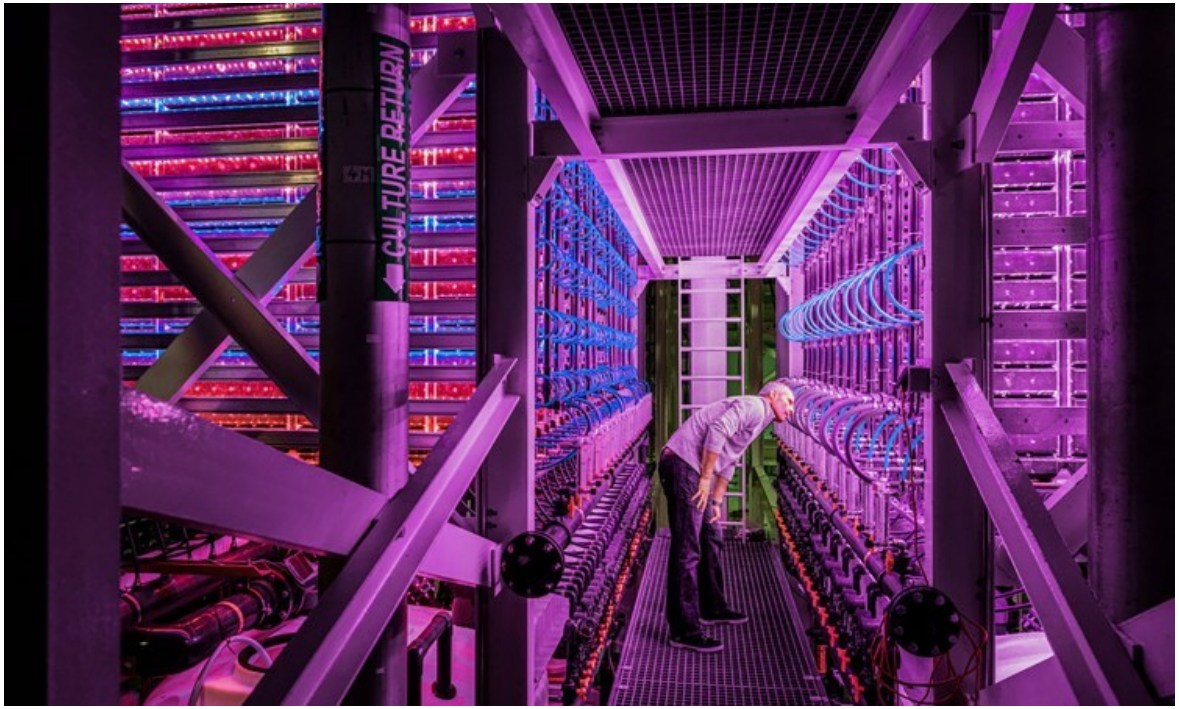
New Vouprasio 12-2023

Results of climate change

Insects and algae: The ‘Future foods’ which could combat malnutrition

https://www.varsity.co.uk/science/21461

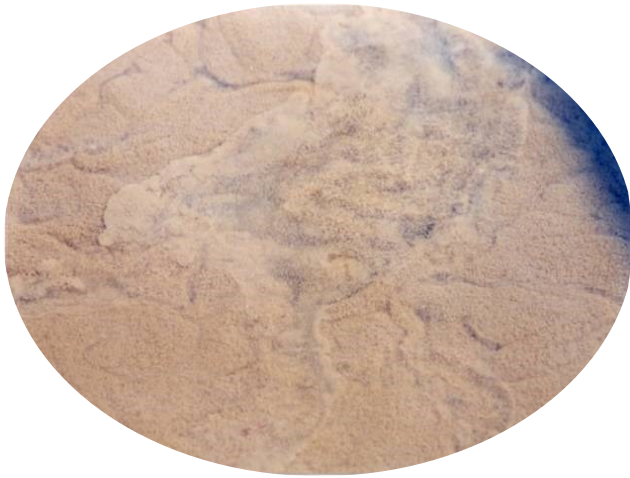
“Microalgae, macroalgae, and insect larvae can all be incorporated into foods such as energy bars, pasta, and burgers.”



“to future-proof our food supply we need to integrate completely new ways of farming into the current system.”

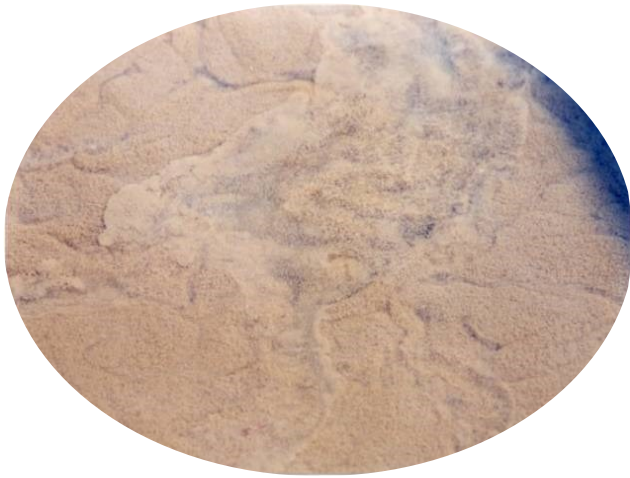
Insects vs microalgae

Patras Wastewater treatment plant



Activated Sludge system (suspended growth)

Patras Wastewater treatment plant



Activated Sludge system (suspended growth)

Quantifying the greenhouse gas emissions of wastewater treatment plants

https://edepot.wur.nl/138115

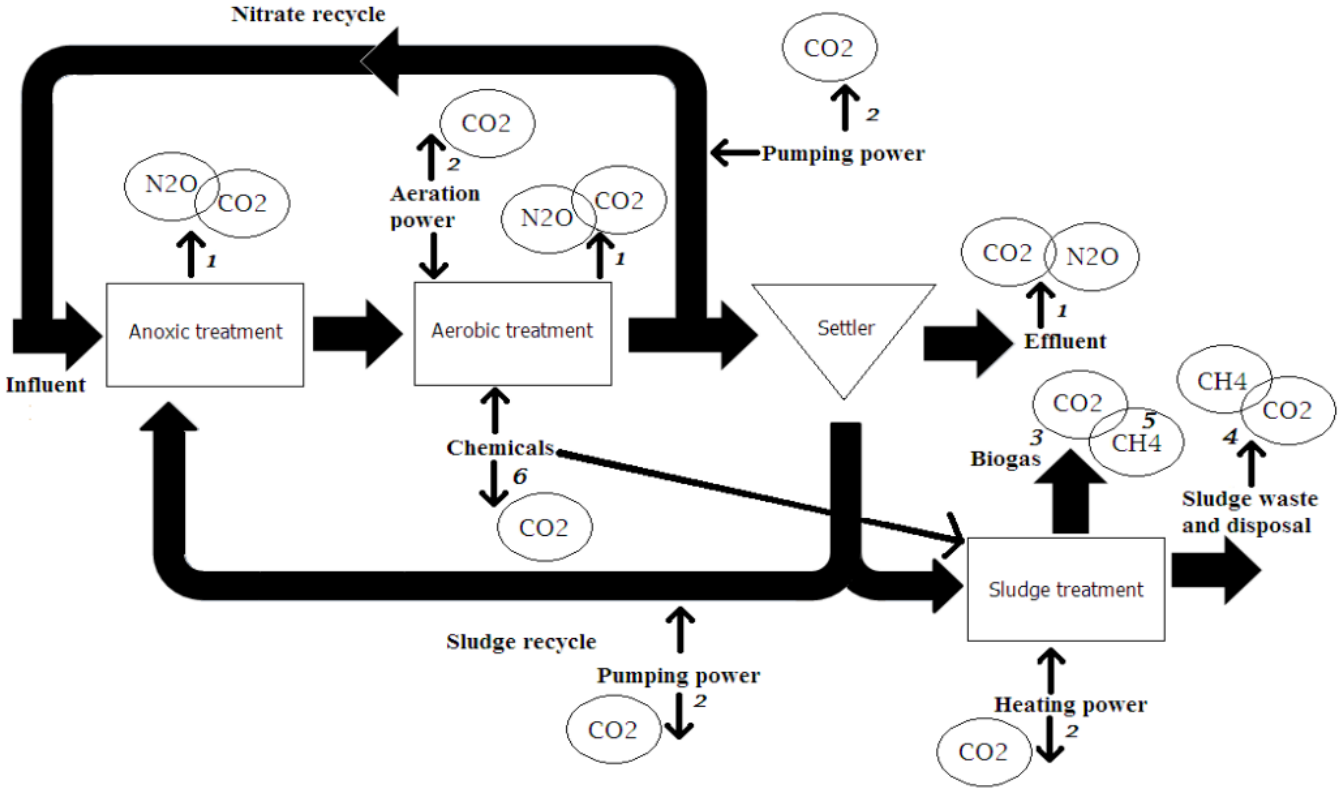
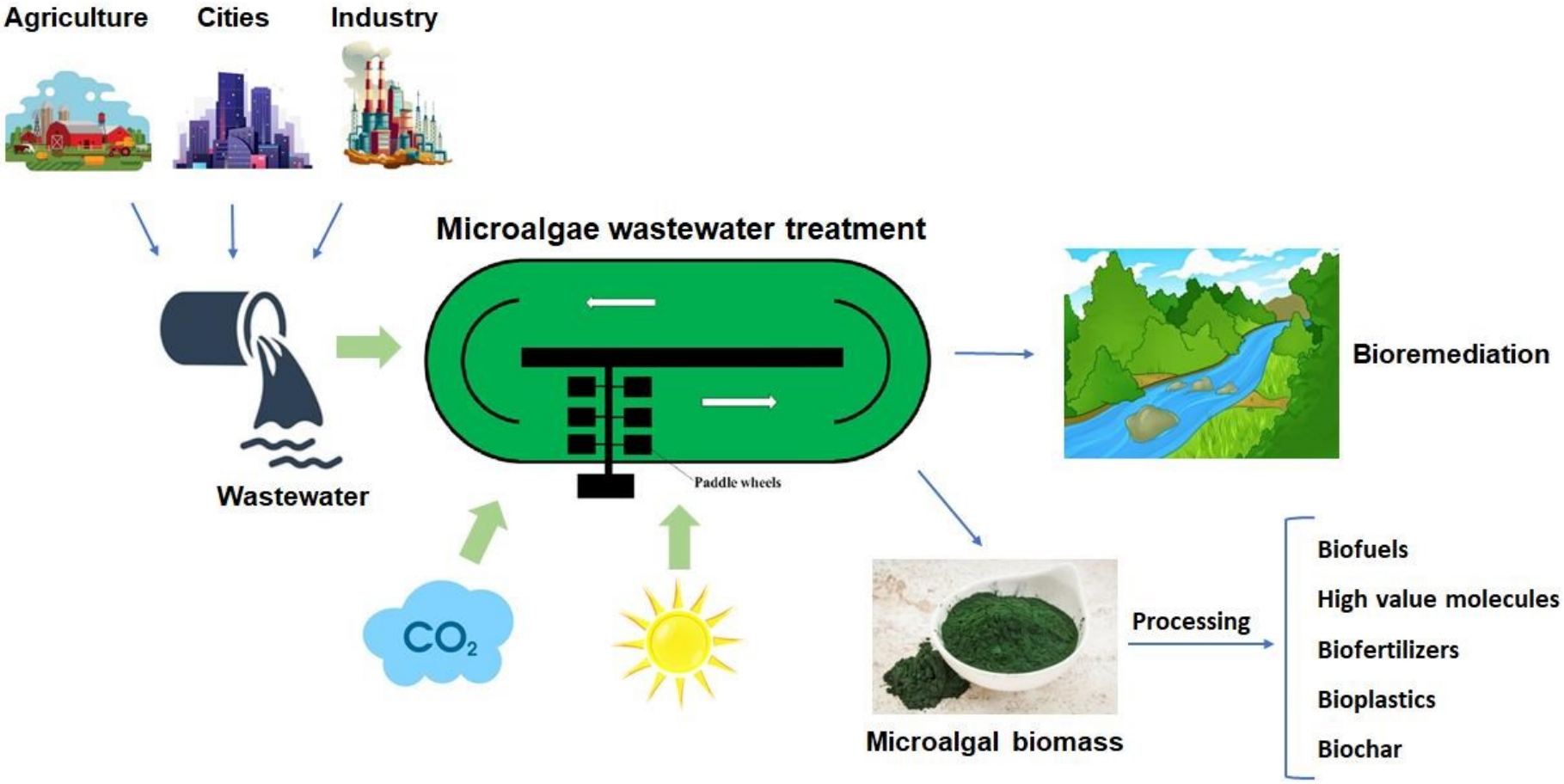


Figure 1.1. Greenhouse gas emissions of a wastewater treatment plant that are taken into account

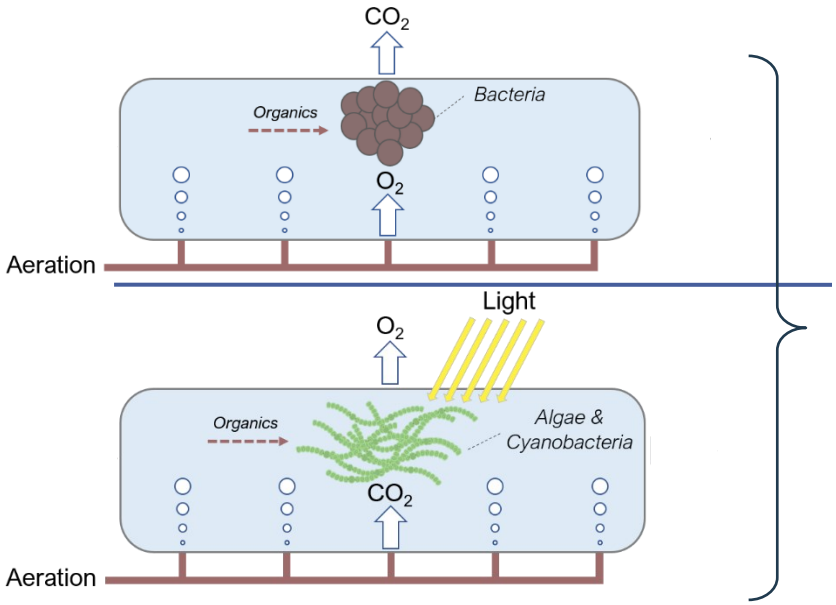
2009

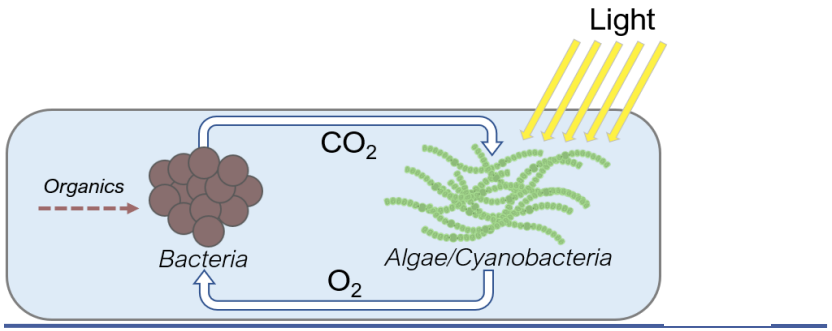
Human survival and environmental impacts



https://www.mdpi.com/2076-3298/8/12/136

Wastewater treatment: Algae-bacteria symbiotic cultures

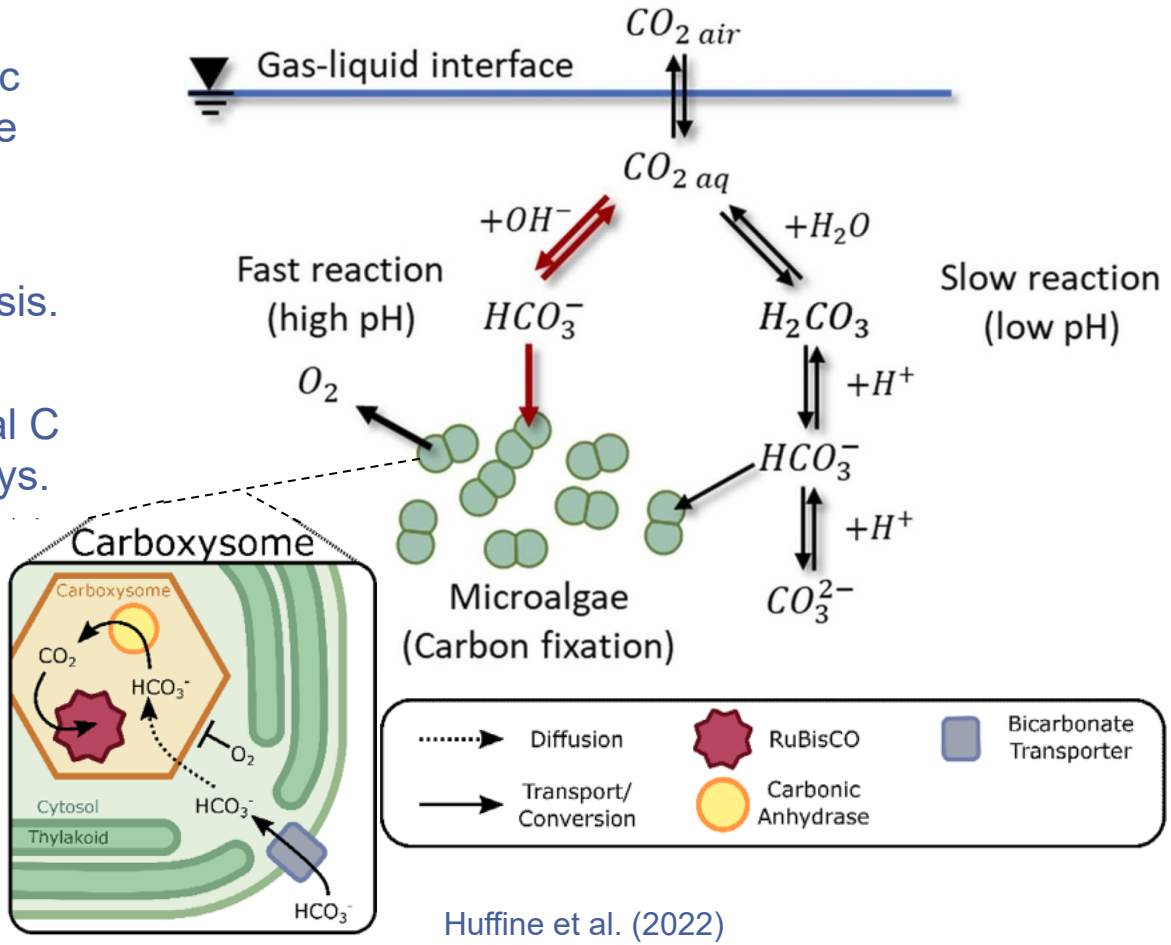




+ Efficient, low-cost COD removal
+ Biomass of biotechnological interest
+ Decreased CO_2 emissions (≅C neutral)
– Potential antagonism ($\mu_{bacteria} >> \mu_{algae}$)
– Complexity

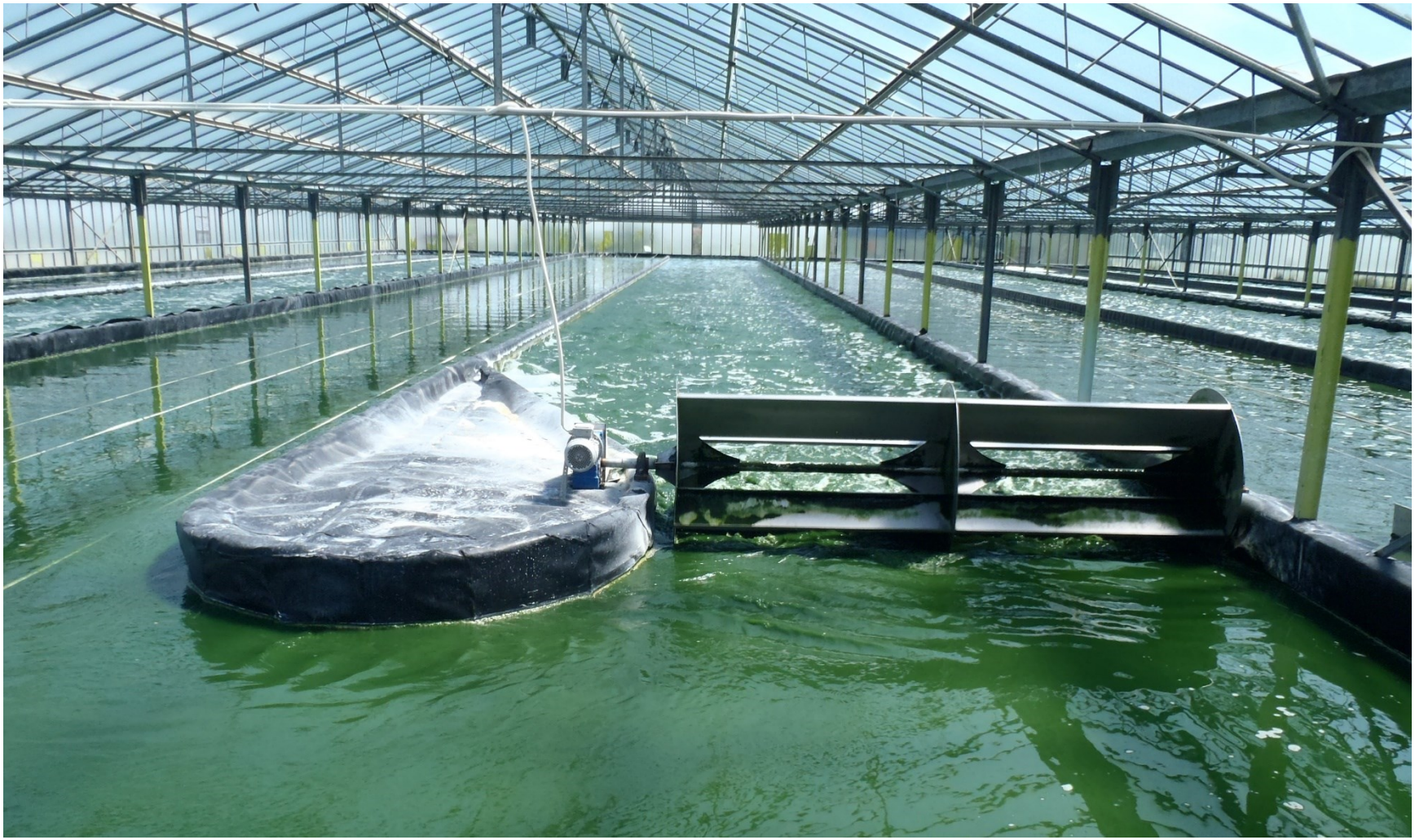
Cyanobacteria/microalgae

- Cyanobacteria are prokaryotic organisms that live in extreme conditions.
- CO_2 capture via photosynthesis.
- Responsible for 25% of global C fixation via metabolic pathways.



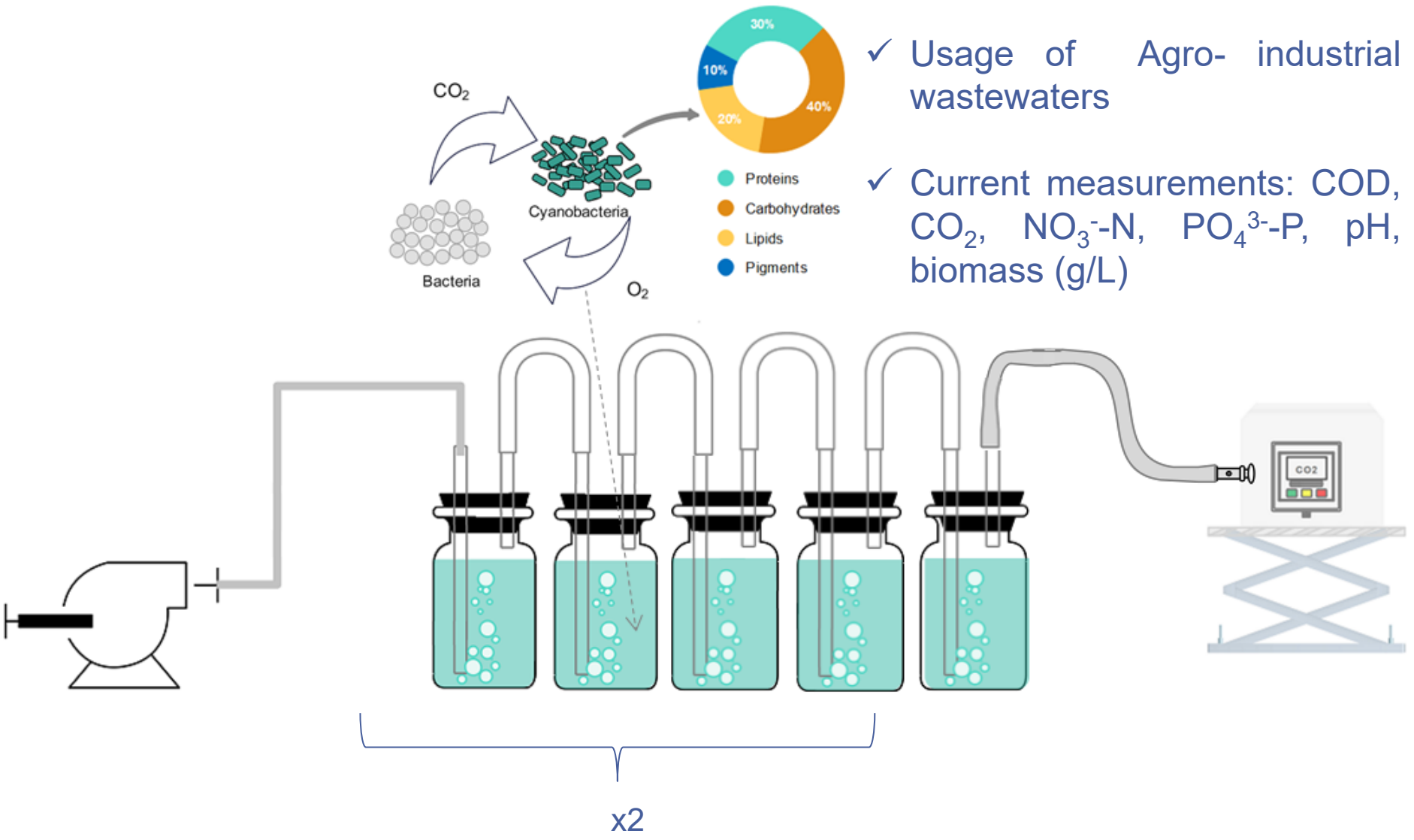
Huffine et al. (2022)

Spirulina production



Methodology

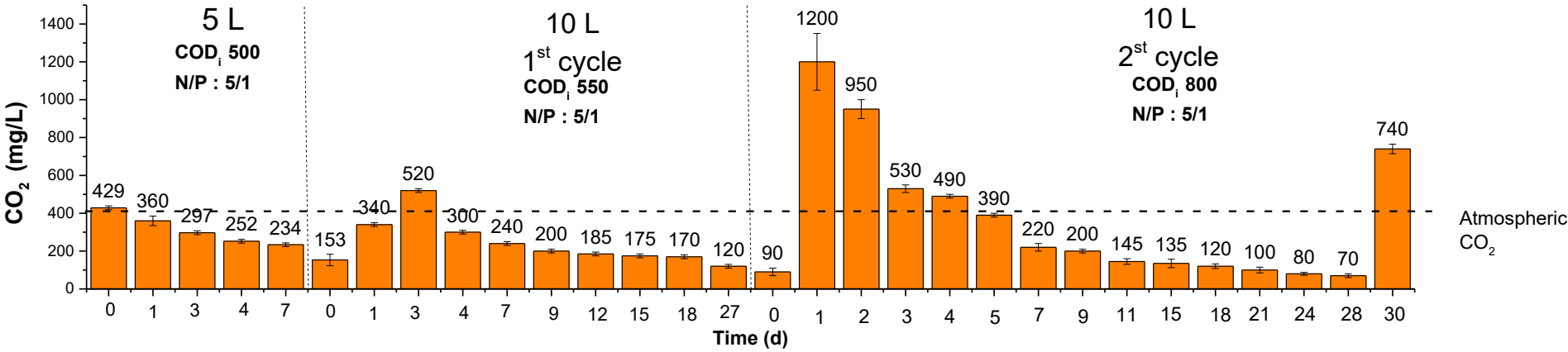
- ✓ CO_2 capture via cyanobacteria - bacterial consortia
- ✓ Usage of Agro- industrial wastewaters
- ✓ Current measurements: COD, CO_2, NO_3^--N, PO_4^{3-}-P, pH, biomass (g/L)

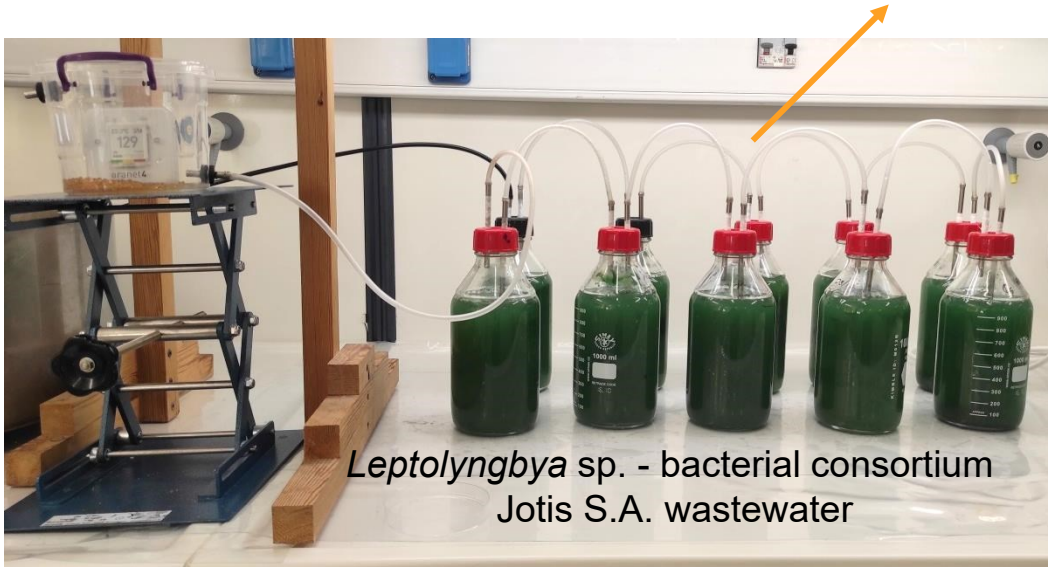


Leptolyngbya sp.: food processing wastewater treatment ~ 40-50% protein production

Spirulina: sea water + fertilizers ~70% protein production

Results: CO_2 capture





Results: Observations from Cycle 2

t_0 t_1 t_3 t_4 t_7

Biofilm formation

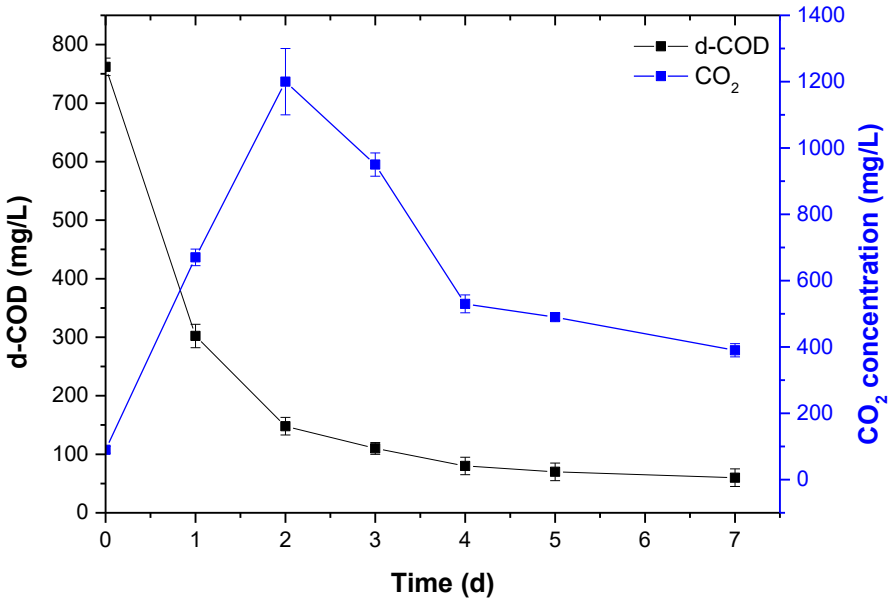
Bacteria Dominance

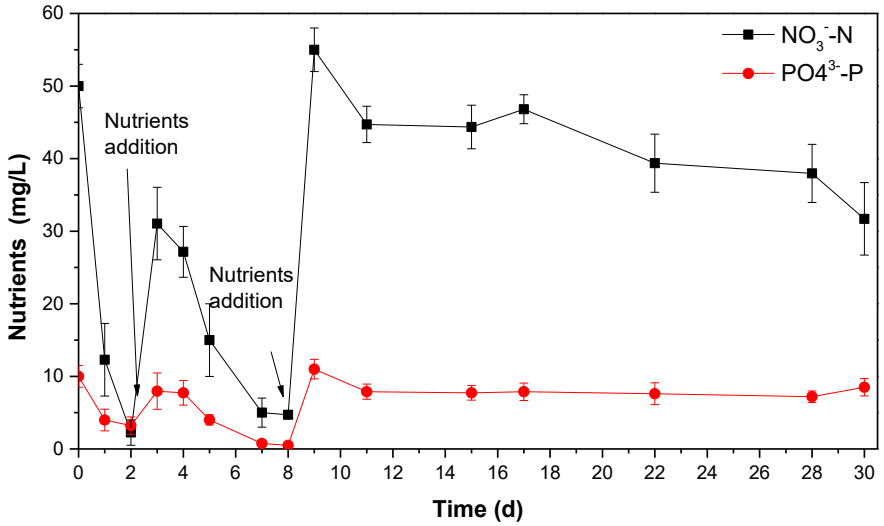
Results: Observations from Cycle 2

t_{11} t_{16} t_{20} t_{28}

Biomass increase in biofilm

Results: Nutrients & pollutants consumption





- CO_2 concentration is increasing with bacteria dominance and decreased with cyanobacteria biomass increase.

- The nutrients are highly consumed till the cyanobacteria biomass is dominated and then the consumption rate is decreasing.

Conclusions & Future work

- A biological CO_2 sink was developed promoting Direct Air Capture (DAC).
- CO_2 (mg/L) decrease is correlated to COD consumption and cyanobacteria growth.
- Research of Spirulina growth in seawater is going on.
- There is a need for the establishment of the "CO_2 capture and utilization center".


Thank
You