



HAL
open science

Life cycle analysis of water resource recovery facilities based on algae-bacteria processes

Diego Penaranda, Francesca Casagli, Fabrice Beline, Olivier Bernard

► **To cite this version:**

Diego Penaranda, Francesca Casagli, Fabrice Beline, Olivier Bernard. Life cycle analysis of water resource recovery facilities based on algae-bacteria processes. Watermatex 2023 - 11th IWA Symposium on Modelling and Integrated Assessment, Sep 2023, Quebec City, QC, Canada. hal-04284605

HAL Id: hal-04284605

<https://hal.science/hal-04284605v1>

Submitted on 22 Nov 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Life cycle analysis of water resource recovery facilities based on algae-bacteria processes

Diego Penaranda¹, Francesca Casagli², Fabrice Beline³, Olivier Bernard⁴

¹ Biocore, Univ Cote d'Azur, Inria, Sophia-Antipolis, France, diego.penaranda-sandoval@inria.fr

² Biocore, Inria, Sophia-Antipolis, France, francesca.casagli@inria.fr

³ OPAALE, Inrae, Rennes, France, fabrice.beline@inrae.fr

⁴ Biocore, Univ Cote d'Azur, Inria, Sophia-Antipolis, France, olivier.bernard@inria.fr



A waste-to-energy LCA was performed for an open raceway system fed by two effluents from the environmental biorefinery process: digestate (for N and P source) from methanization and CO₂ from biogas upgrade process.

Liquid digestate

Liquid digestate flow of 60.67 tones/d
(3.33 kg total N/m³ and 0.26 kg total P/m³).



(Source: www.atlanticgreenfuels.com)

Nutrients recovery in microalgae open raceways cultivation

Electricity

Main objective

This study determines the effects of operational parameters, SRT and HRT, on microalgae biomass pond area, seasonal removal efficiency of nutrients (nitrogen and phosphorous) and environmental impacts. In addition, this case study provides a circular economy perspective on microalgae cultivation for liquid digestate by recycling of nutrients (nitrogen, phosphorous and CO₂) and water, reducing the discharge to the natural environment, while producing compounds from microalgae to source green chemistry.

MATERIALS AND METHODS

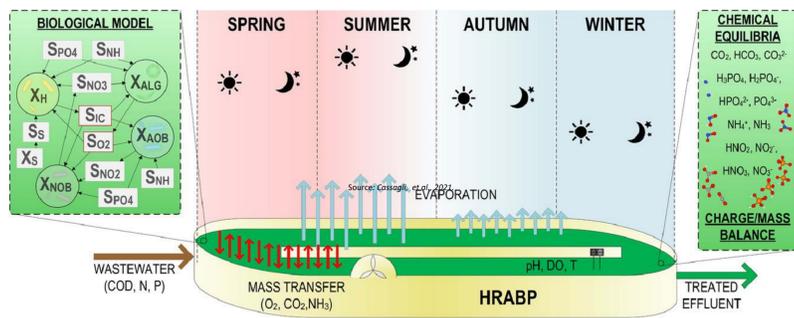


Fig.1. Microalgae growth model ALBA was used for determining productivities and mass balances of COD, C, O, H, N and P. This model describes algae-bacteria ecosystem evolution in an outdoor raceway for wastewater treatment, while local climate drives light and temperature (Casagli et al., 2021).

RESULTS

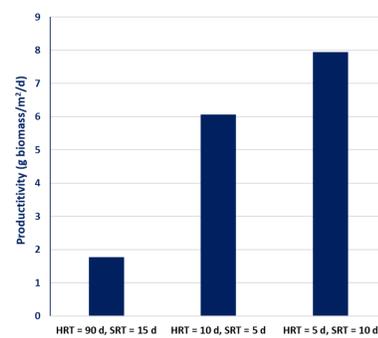


Fig.3. Comparison of average annual biomass productivity for the three scenarios.

	1st Scenario	2nd Scenario	3rd Scenario
HRT/SRT	(90 / 15) d	(10 / 5) d	(5 / 10) d
Liquid depth	0.2 m	0.2 m	0.2 m
Area production	140000 m ²	15000 m ²	7500 m ²
N° ORP units	15	2	1

Fig.4. Comparison of productivity area, number of units and size of raceway ponds for the three scenarios.

$$Eff_{N,RECYC} = (Flux_{Nout,ALG} / Flux_{Nin}) * 100$$

where: Flux_{Nout,ALG} is the mass flow of Nitrogen [gN d⁻¹] in the harvested algal biomass and Flux_{Nin} is the mass flow of Nitrogen [gN d⁻¹] fed to the HRABP.

$$Eff_{P,RECYC} = (Flux_{Pout,ALG} / Flux_{Pin}) * 100$$

where: Flux_{Pout,ALG} is the mass flow of Phosphorus [gP d⁻¹] in the harvested algal biomass and Flux_{Pin} is the mass flow of Phosphorus [gP d⁻¹] fed to the HRABP.

(Casagli et al., 2023)

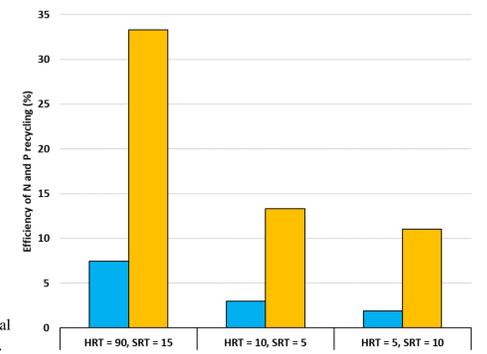


Fig.5. Efficiency of Nitrogen and Phosphorous recycling.

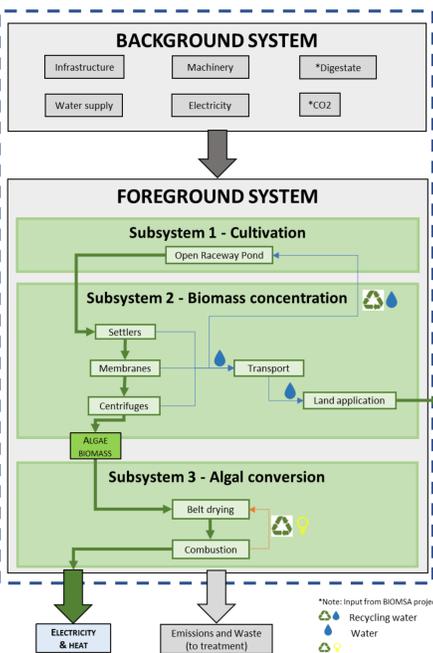


Fig.2. System boundaries.

- The boundaries include the biomass production, infrastructure, machinery production, emissions, and transport related to the chemical and materials used in the process units. The dismantling and final disposal of machinery and infrastructure material are also included.

- The functional unit (FU) is 1 m³ of liquid digestate entering the microalgae cultivation system.

- ReCiPe (H) v1.005 was used as life cycle impact method using midpoint and endpoint approach.

- Three case studies at different HRT (Hydraulic Residence Time) and SRT (Solid Residence Time):

- HRT: 90 d, SRT: 15 d
- HRT: 10 d, SRT: 5 d
- HRT: 5 d, SRT: 10 d

ACKNOWLEDGEMENT

The research work was financed by the ADEME BIOMSA project and of the Région Sud Grant funding the PhD of D. Penaranda.

REFERENCES

- Casagli et al, 2021. ALBA: A comprehensive growth model to optimize algae-bacteria wastewater treatment in raceway ponds. *Water Research*, 190, 116734.
- Casagli et al, 2023. Optimizing resource recovery from wastewater with algae-bacteria membrane reactors. *Chemical Engineering Journal*, 451, 138488.

CONCLUSIONS

The best scenario from a point of view of environmental impacts is scenario (HRT= 5 d, SRT= 10), with the lowest impacts in damage to human health, ecosystems and resources. In addition, this scenario leads to a high productivity with a reduced production area (lower than 10,000 m² ponds) for treating the digestate. More scenarios should be analyzed to find the best trade-off between productivity, N and P removals and reduced environmental impacts.