WalBioPower:
Valorising organic waste into energy

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Aim of the project

Walbiopower aims at valorising organic waste, such as food waste, urine and the liquid fraction of effluents.

- The solid fraction of **food waste** is transformed into gaseous **biomethane** and a solid/liquid waste called **digestate.** The aim is to reduce the carbon/environmental footprint of the process by improving its yield, allowing its decentralisation and increase the valorisation of its by-product, digestate.
- The **urea** contained in urine can be valorised to produce **hydrogen**, either by using it in a reaction of electrocatalysis or by producing ammonium in a controlled fashion which will be valorised energetically at later stages of the project.

1. Psychrophilic anaerobic digestion

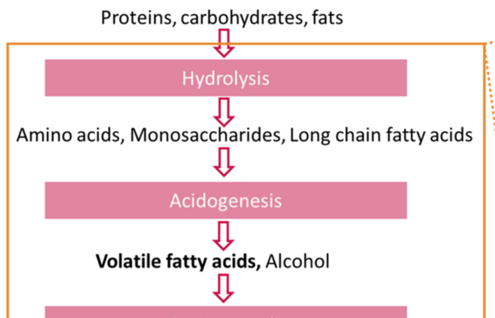


Figure 1.1. Anaerobic digestion process

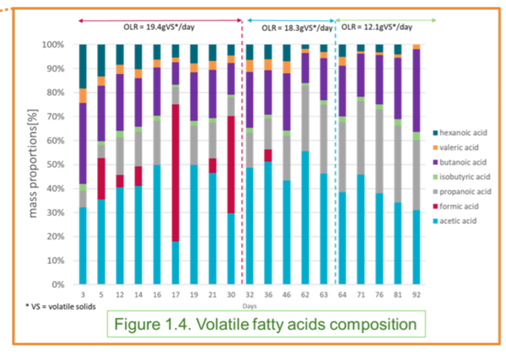


Figure 1.4. Volatile fatty acids composition

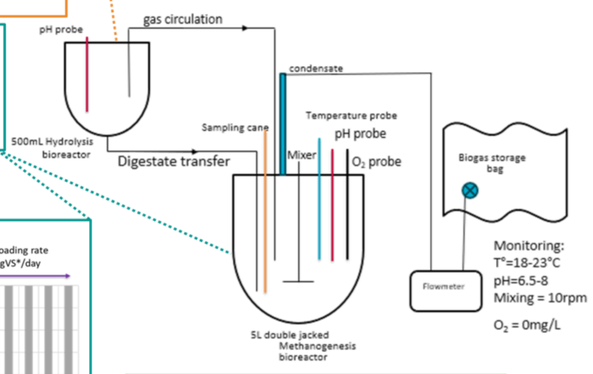


Figure 1.2. Two-stages bioreactor configuration

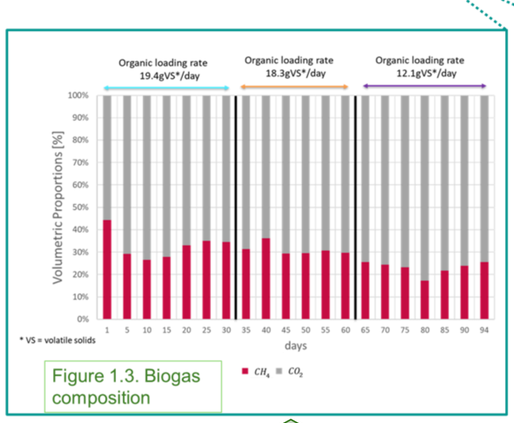


Figure 1.3. Biogas composition

Anaerobic digestion is a process where microorganisms break down organic matter, in the absence of oxygen, into valuable biogas composed of methane (50-75%) and CO_2 (25-50%).

2. Valorisation of digestate by *Rhodospirillum rubrum*

Digestate contains volatile fatty acids which can be assimilated by purple non-sulphur bacteria (PNSB), such as *Rs. rubrum.*

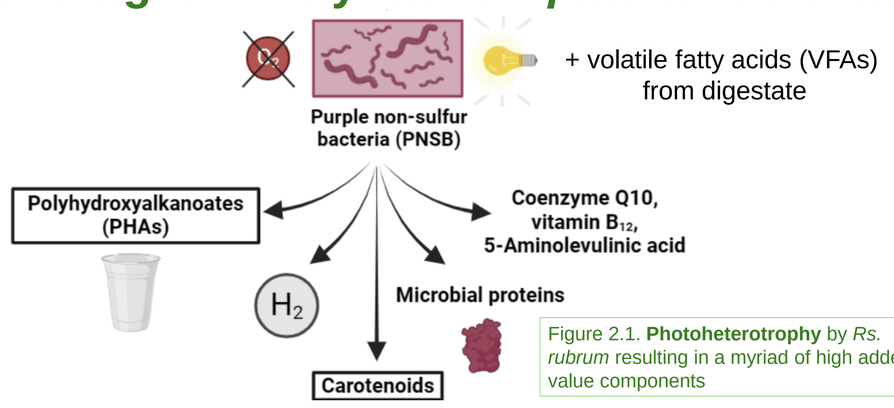


Figure 2.1. **Photoheterotrophy** by *Rs. rubrum* resulting in a myriad of high added value components

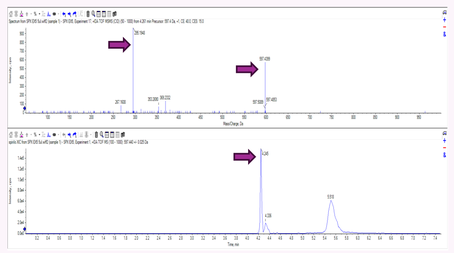


Figure 2.3. **Characterisation of spx by mass spectrometry.** MS/MS spectra show fragments at m/z = 295.19 and 597.44, and XIC (extracted ion chromatogram) corresponding to a peak at 4.245 min.

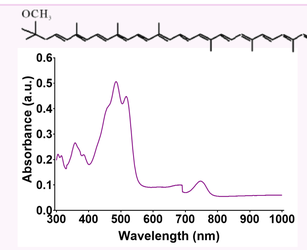


Figure 2.2. **Molecular structure and absorbance spectrum** of spirilloxanthin (spx), the main carotenoid in *Rs. rubrum*

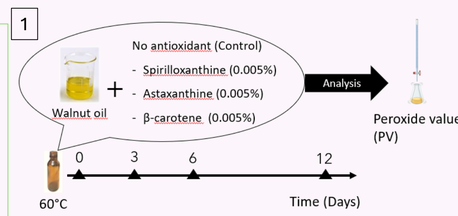
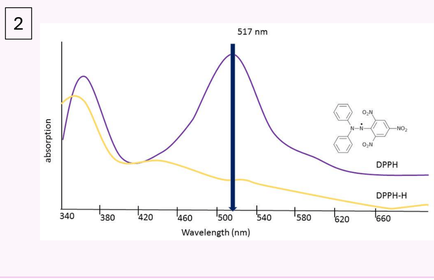
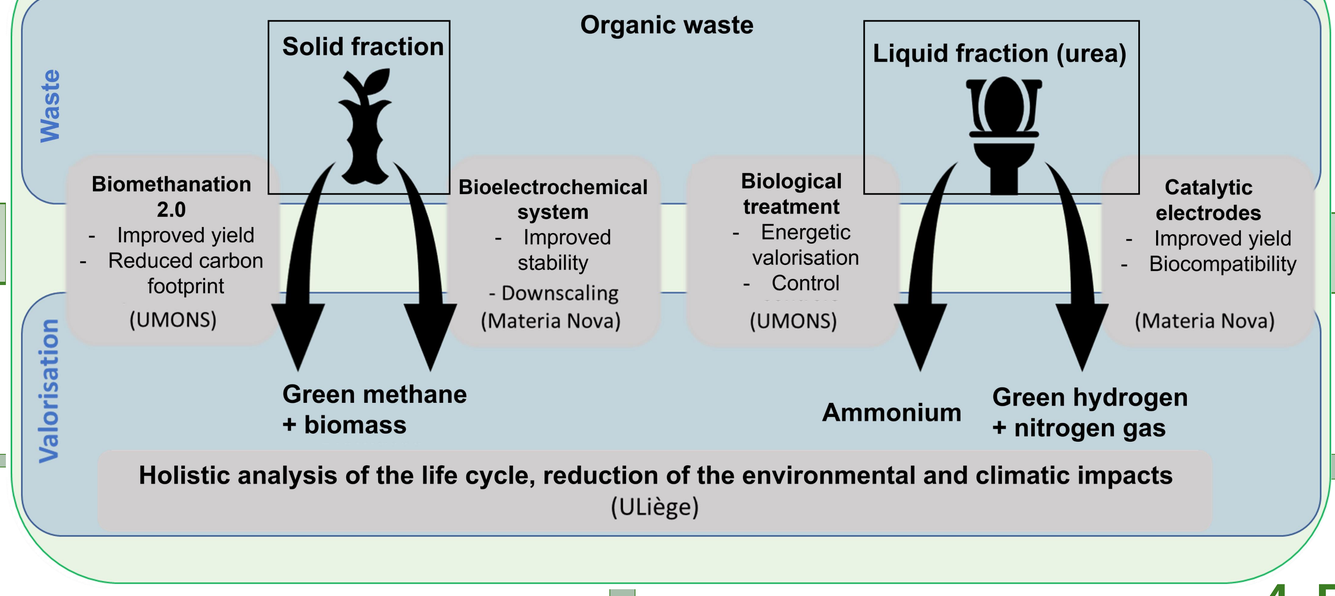


Figure 2.4. **Antioxidant properties of spx** are evaluated using assays measuring the reduction of peroxide production (1) and a free radical quenching assay (DPPH, 2,2-Diphenyl-1-picrylhydrazyl) (2).



Circular and durable valorisation system



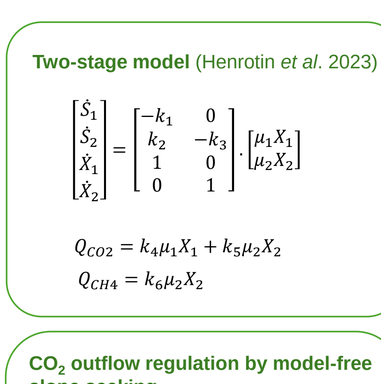
3. Modelling and optimising control of anaerobic digestion

Two-stage model (Henrotin *et al*. 2023)

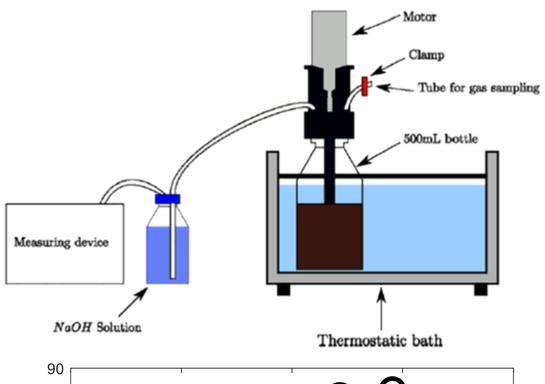
$$\begin{bmatrix}\dot{S}_1\\ \dot{S}_2\\ \dot{X}_1\\ \dot{X}_2\end{bmatrix} = \begin{bmatrix}-k_1 & 0\\ k_2 & -k_3\\ 1 & 0\\ 0 & 1\end{bmatrix} \cdot \begin{bmatrix}\mu_1 X_1\\ \mu_2 X_2\end{bmatrix}$$

$$Q_{CO2} = k_4\mu_1 X_1 + k_5\mu_2 X_2$$
$$Q_{CH4} = k_6\mu_2 X_2$$

CO_2 outflow regulation by model-free slope seeking

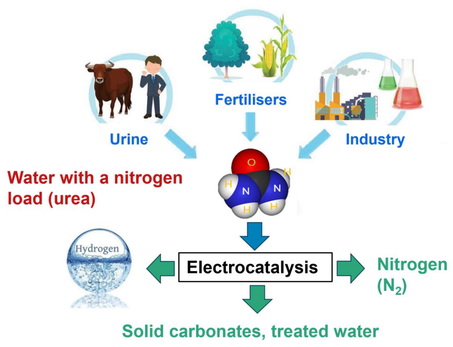


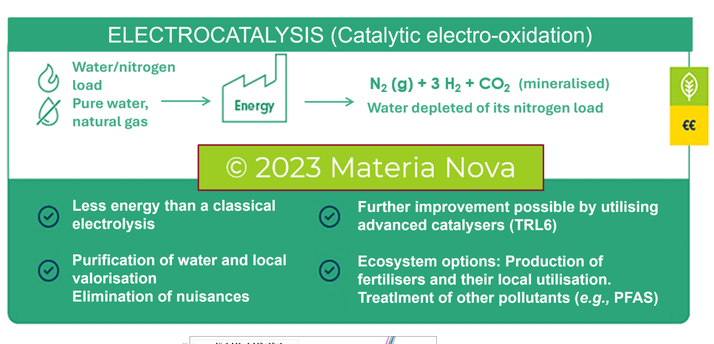
(1) Q_{CO2} = 83,5 mL (Extremum seeking)
(2) Q_{CO2} = 63 mL
(3) Q_{CO2} = 79 mL



4. Electrocatalysis of urea

-30% of the electrical energy (vs. electrolysis)
No CO_2 emitted (10 t of CO_2 avoided per t H_2)





OBJECTIVE
Development of ternary/ quaternary alloys based on Ni

Quaternary Ni alloy
→Increased current density of the UOR (urea oxidation reaction) (x2/Ni)
→Low activation overpotential
→Stability of the catalytic activity over time (/Ni)
→Excellent corrosion resistance

Conclusions and future work

- Anaerobic digestion in the reactor, the growth of *Rs. rubrum* and the model have been set up and optimised. Further optimisations will be carried out by feeding the model experimental data and with regards to the bacterial cultures.
- Life cycle assessments (LCA) will be used to evaluate the feasibility of the decentralisation process.
- The quaternary Ni alloy increased the current density of the urea oxidation reaction and had a higher catalytic stability compared to Ni alone.
- The production of ammonium and its subsequent energetic valorisation will be carried out in the coming months.

Acknowledgements

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