SEMPRE-BIO

Cow manure digestate treatment with purple phototrophic bacteria and biomass valorization

Rosa Edith Atayupanqui Dueñas [1]*, Ramón Barat Baviera[2], Josué González Camejo [1]

[1] BETA Tech. Center (TECNIO Network). University of Vic - Central University of Catalonia (UVic-UCC), Carretera de Roda 70, 08500 Vic, Spain.
[2]CALAGUA, Unidad Mixta UV-UPV, Institut Universitari d'Investigaciò d'Enginyeria de l'Aigua i Medi Ambient, IIAMA, Universitat Politècnica de València, Camí de Vera s/n, 46022, Valencia, Spain

Agència de Gestió d'Ajuts Universitaris i de Recerca AGAUR
Generalitat de Catalunya Departament de Recerca i Universitats
Cofinançat per la Unió Europea
ACCIÓ Generalitat de Catalunya
tecnio catalonia

Problematic

Anaerobic digestion (AD) is a key technology for sustainable waste management

- ✓ Contributes to clean energy production and climate change mitigation
- ✓ AD as an alternative aligned with the Sustainable Development Goals (SDG)

However, the management and disposal of **digestate** are becoming a growing challenge.

Projected population will reach to 9 billion by 2050 poses significant **challenges to global food security** -> land demand, livestock expansion and need for waste management

- ✓ Efficient treatment of digestate
- ✓ The need for sustainable fertilizers

Opportunity

- ✓ Cow manure digestate is a valuable source of nutrients.

- ✓ Direct use → variability + leaching risks.

Direct use in agriculture

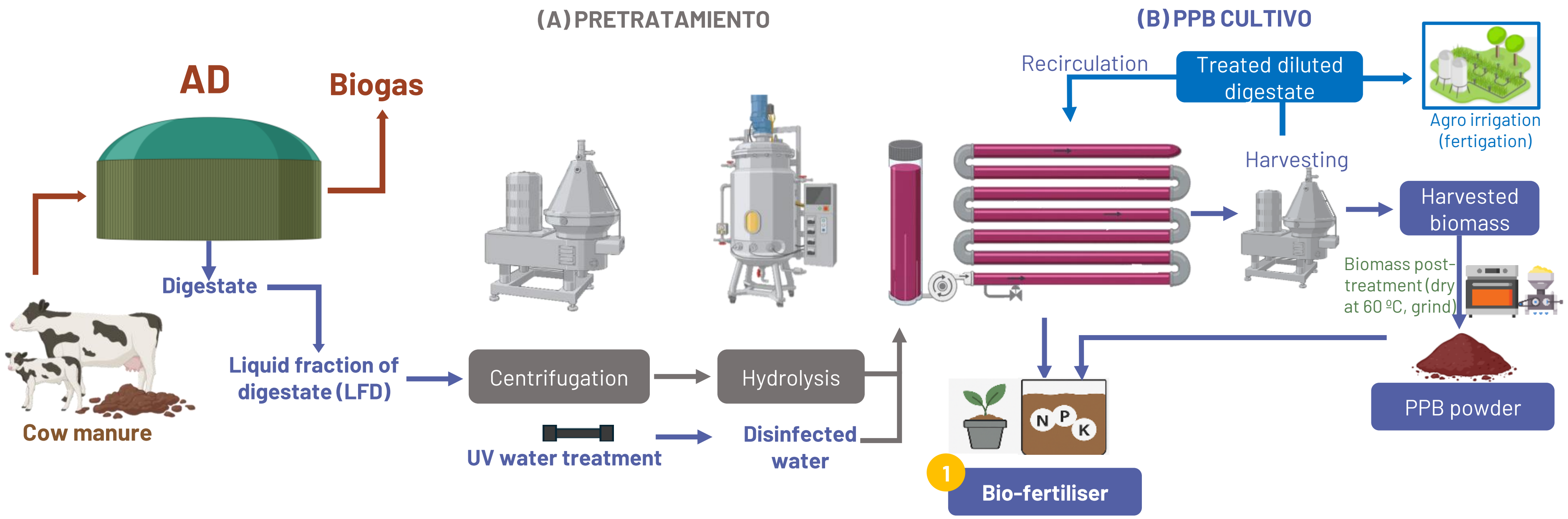
- ✓ Valorization → opportunity for circular economy & high-value by-product

- ✓ **Purple phototrophic bacteria (PPB) cultivation** using digestate could a powerful technology to produce valuable biomass.

- ✓ PBP have shown greater tolerance to high levels of turbidity and high concentrations of N, up to 4.5 g·L-1 of N-NH4+.

PPB cultivation

Our Solution



Experimental design

A) PRETREATMENT: HYDROLYSIS

L
bic
°C
m

experimental series

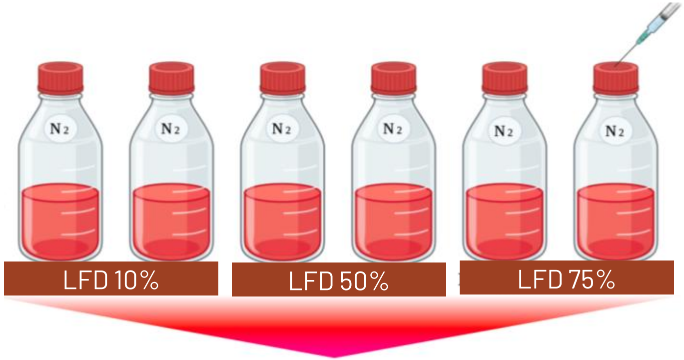
1. Chemical
   - alkaline NaOH
   - acidic HCl

2. NaOH dose (g/g ST)
   - 0.02
   - 0.05
   - 0.1
   - 0.2

3. Initial Total Solid (TS) concentration (g/L)
   - 48
   - 30
   - 28
   - 20

Experimental design

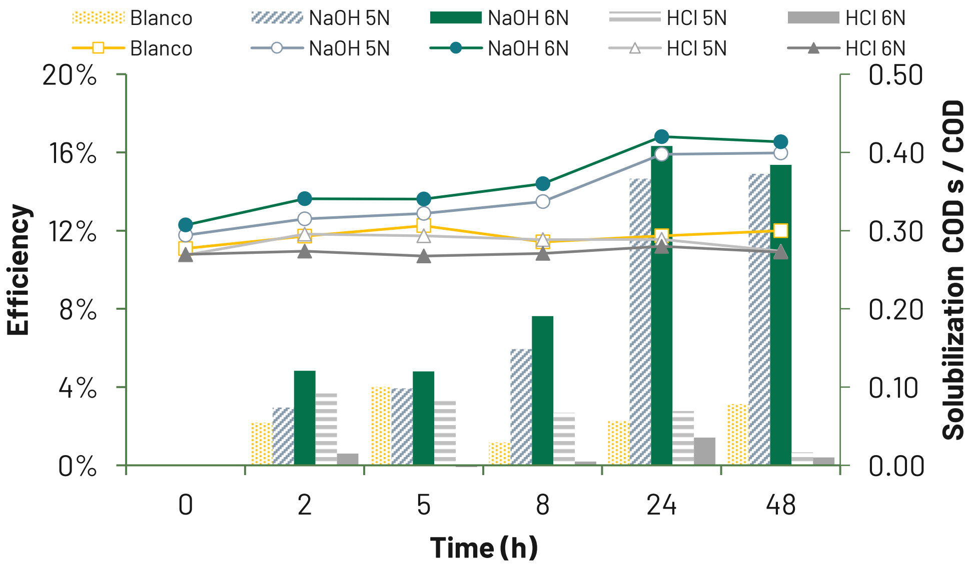
B) PPB CULTIVATION



Operational conditions	**Anaerobic** **Volume** = 0.9 L **pH**: 8.0 ± 0.1	**Led NIR λ**= 660/850 nm **Inoculum** = 10% **Ta =** 28 °C ± 2	*Rhodobacter sphaeroides* **3 dilution** 10, 50, 75% **5 days** cultivation time	▪ 10% : 10% LFD + 90% water ▪ 50% : 50% LFD + 50% water ▪ 75% : 75% LFD + 25% water

Results

A) HYDROLYSIS: Chemical effect

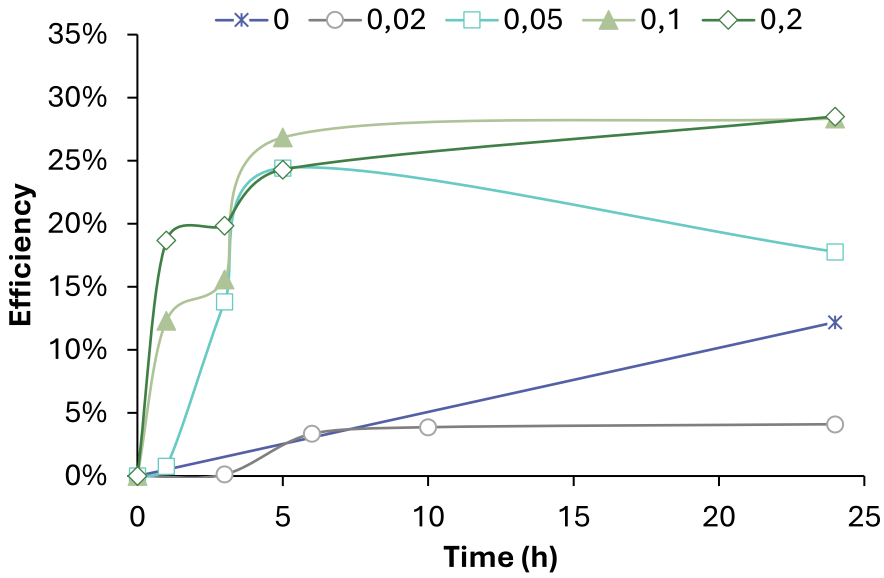


Key results

- ✓ Alkaline hydrolysis is 39 times higher than acid hydrolysis
- ✓ Efficiency 15.4% vs. 0.4%
- ✓ Solubilization grade 0.414 vs. 0.272.

Results

A) HYDROLYSIS: Effect of NaOH Dose



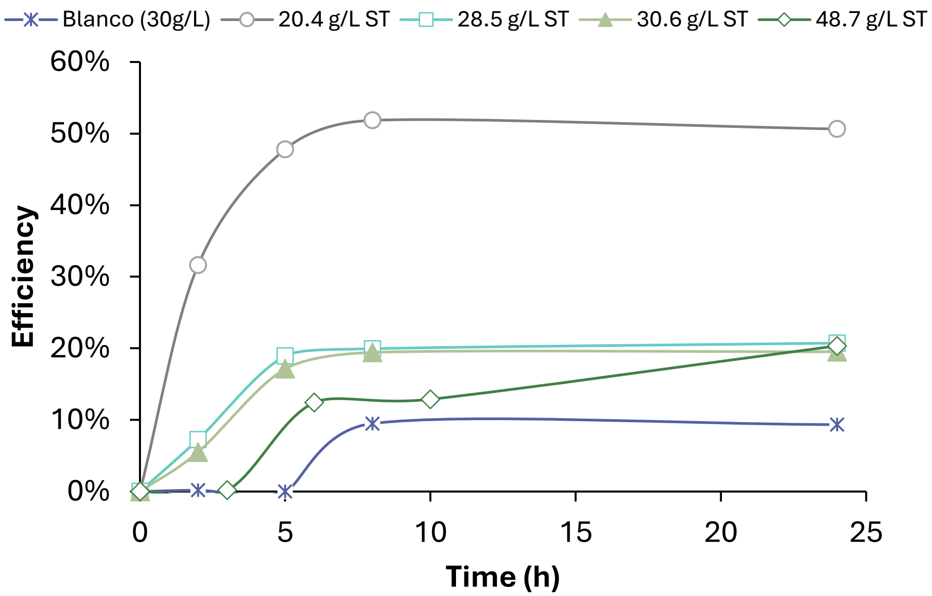
Key results

✓ A statistically significant difference was observed between low (0 - 0.05 g NaOH·g ST-1) and high (0.1- 0.2 g NaOH·g ST-1) doses.

NaOH Dose ($g \cdot g^{-1}$ ST)	$\frac{COD_S}{COD}$	Efficiency %
0.02	0.17	4
0.05	0.36	16
0.10	0.45	30
0.20	0.45	34

Results

A) HYDROLYSIS: Effect of initial ST concentration



Key results

✓ A Higher solubilization (0.817; 50.6% efficiency) was achieved at ~20 g L^{-1} ST .

Total Solid (g·L-1 ST)	$\frac{COD_S}{COD}$	Efficiency %
48.4	0.284	17
30.6	0.536	22
28.5	0.501	25
20.4	0.817	51

Results

A) HYDROLYSIS: OPTIMAL

Parameter	Unit	LFD	LFDH
pH	-	7.58	10.2
Conductivity	µS·cm-1	17360	18320
Alkalinity	mg CaCO3 ·L-1	7750	8187
Alkalinity	VFA	2563	3875
VFA Ind.	-	**0.3**	**0.5**
COD	mg·L-1	20580	19460
COD s	mg·L-1	**12830**	**16350**
NKT	g·L-1	1.77	1.58
N-NH4	g·L-1	1.72	1.47
TP	mg·L-1	673	659
P-PO4	mg·L-1	205	320
COD/N/P	m/m/m	100:8.35:1	100:7.6:1.6
CODS/COD		**0.62**	**0.84**

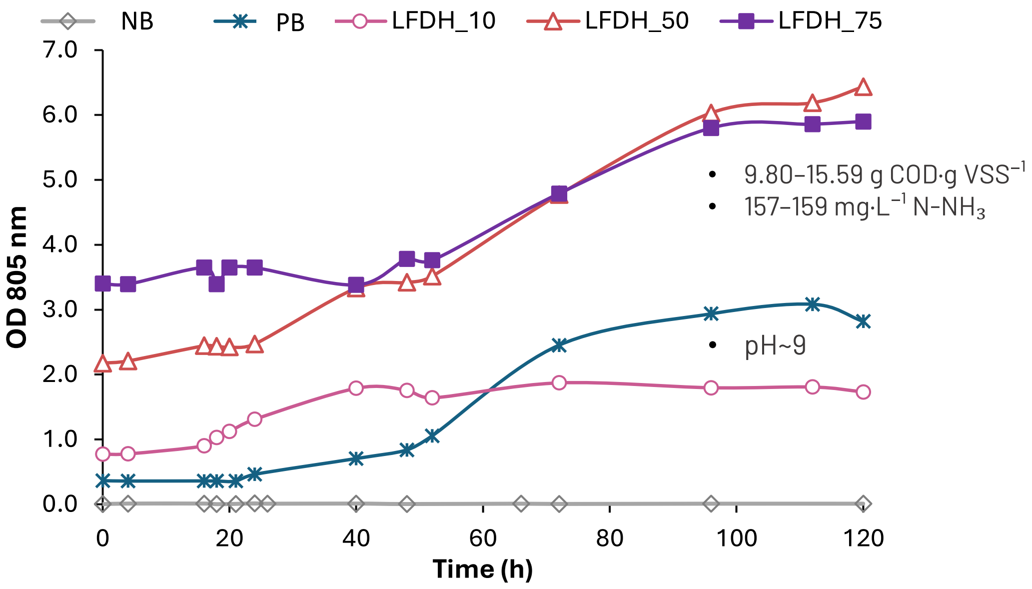
LFD: Liquid fraction of digestate
LFDH: Liquid fraction digestate with hydrolysis

Key results

The optimal experimental setup for LFD is anaerobic **alkaline** hydrolysis using **0.1 g NaOH·g^{-1} ST** in media with approximately **~20 g·L^{-1} ST.**

Results

B) PPB CULTIVATION: PPB growth curve



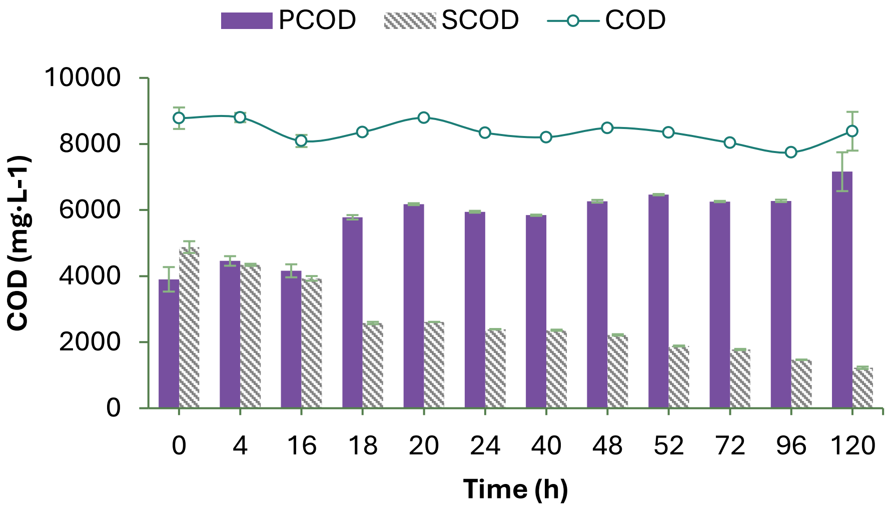
Key results

TEST	Y	μ (d-1)	HRT (máx. prod.)
PB	0.80	1.4	1.4
LFDH_10	0.73	1.8	1.1
LFDH_50	0.89	0.7	2.9
LFDH_75	0.23	0.4	4.9

- LFDH_10: 10% LFD + 90% water
- LFDH_50: 50% LFD + 50% water
- LFDH_75: 75% LFD + 25% water

Results

B) PPB CULTIVATION: Removal



Time evolution of COD during PPB growth in LFDH_50

Key results

TEST	Initial COD (mg·L-1)	Initial SCOD (mg·L-1)	SCOD %	N-NH4 %	P-PO4 %
BP	3360	3240	52	53	51
LFDH_10	1932	1178	68	48	90
LFDH_50	8780	4878	75	17	50
LFDH_75	13250	7300	35	11	31

Results

PPB BIOMASS COMPOSITION

Protein content (% dw)

PPB biomass (this study)

PB	40±2 %
10%_LFDH	36±3 %
50% LFDH	30±2 %

Soybean 40-50 % dw

Sunflower Seed 20-30 % dw

Microalgae biomass 40-50 % dw

Biofertilizer potential

Regulation (EU) 2019/1009 : Solid organic fertilizer (PFC 1A) must meet the following criteria

	% N	% P2O5	% K2O	$N + P_2O_5 + K_2O$	% C org	CFU/ml E.Coli
PB	6.4	1.0	2.8	10.2	33	~0
10%	5.7	1.0	2.7	9.4	39	~0
50%	4.8	0.9	5.7	10.4	27	~0
Regulation (EU) 2019/1009	>1	>1	>1	>4%	>15%	0-200

1,00E-03 dilution

Take home messages

Necessity to treat **digestate**, subproduct from biogas plants. **PPB** as a candidate technology for this treatment, surpassing other biotechnologies.

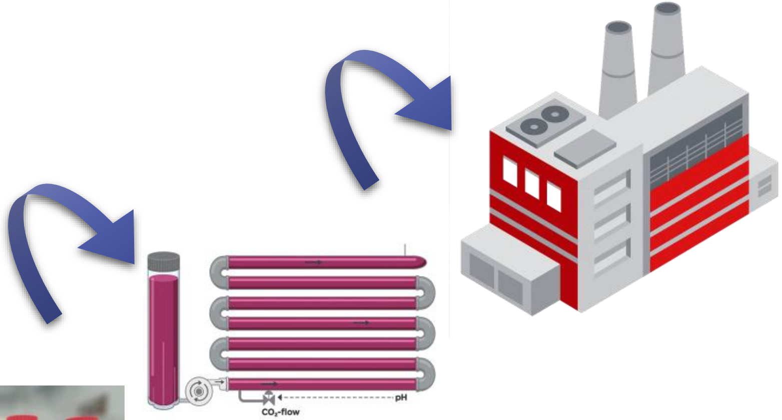
PPB can **tolerate up to 75%** digestate concentration, with maximum growth rate at 10% dilution, achieving 1.8 d^{-1}

The generated **PPB biomass** produced through this process has potential to be used as a **biofertilizer** and as an **alternative protein source** for livestock feeding.

75% Composition: (932 ± 11.3 mg ·L-1 N-NH4, 15 ± 1g DQO·SSV-1 , 13250 ± 400 mg ·L-1)

Future work

- ✓ Process upscaling (outdoor)
- ✓ Testing fertilizing capacity of PPB
- ✓ Legislative barriers of digestate
- ✓ Patent analysis
- ✓ Market analysis



Cow manure digestate treatment with purple phototrophic bacteria and biomass valorization

Rosa Edith Atayupanqui Dueñas [1]*, Ramón Barat Baviera[2], Josué González Camejo [1]

[1] BETA Tech. Center (TECNIO Network). University of Vic - Central University of Catalonia (UVic-UCC), Carretera de Roda 70, 08500 Vic, Spain.
[2]CALAGUA, Unidad Mixta UV-UPV, Institut Universitari d'Investigaciò d'Enginyeria de l'Aigua i Medi Ambient, IIAMA, Universitat Politècnica de València, Camí de Vera s/n, 46022, Valencia, Spain

Agència de Gestió d'Ajuts Universitaris i de Recerca
Generalitat de Catalunya Departament de Recerca i Universitats
Cofinançat per la Unió Europea
ACCIÓ Generalitat de Catalunya
tecnio catalonia