Innovative biogas siloxanes removal processes

URBIOFIN PROJECT

urban biorefinery

Horizon 2020
European Union funding
for Research & Innovation

Project details

Type of action:
Innovation Action - Demonstration
Value Chain:
VC4 – organic waste
Start date:
01 June 2017
End date:
31 December 2021
Project Budget:
15 M€
BBI JU contribution:
€ 10,946,366.03

Web site
http://www.urbiofin.eu

Consortium

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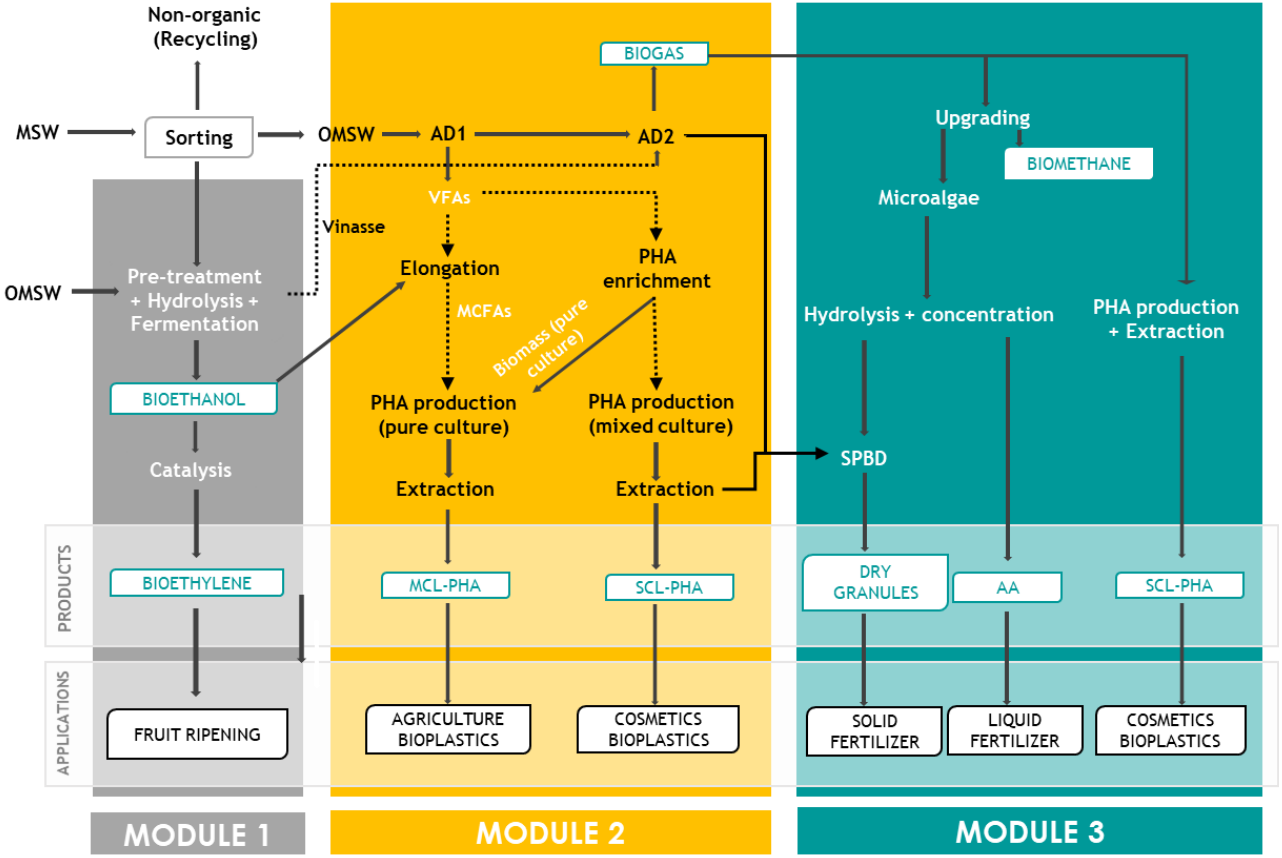

The aim of the **URBIOFIN** project is to demonstrate **techno-economic** and **environmental viability** of an integrated and innovative **biorefinery** for the transformation of the organic fraction of municipal solid waste (MSW) into :

- **Chemical building blocks:** bioethanol, medium or short VFAs, biogas.
- **Biopolymers:** PHAs.
- **Additives:** bioethylene, microalgae.

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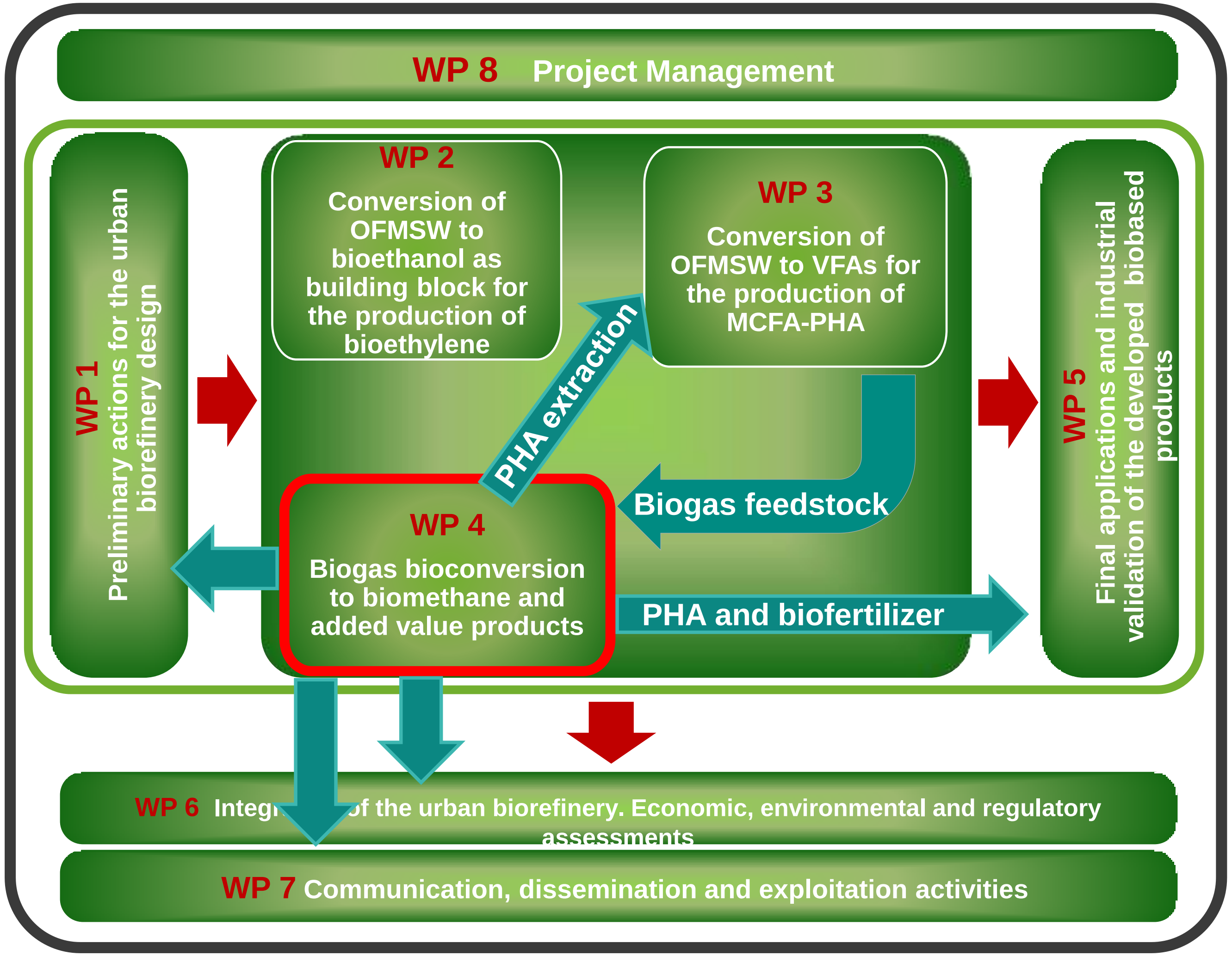

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Biogas bioconversion to biomethane and added value products

- Photosynthetic biogas upgrading
- Algal biomass recovery and revalorization
- Bioconversion of CH4 into added value products:
  biopolymers (PHAs)
- Development of a polishing step for siloxanes removal from biogas

Universidad de Valladolid

Scale-up

urbaser

Volatile Methyl Siloxanes

- Biogas contains trace level concentrations of volatile methyl siloxanes (VMS)

  SiO_2 ⟶ crystalline deposit

  - Decreased efficiency of the equipment
    - Corrosion
    - Erosion
    - Clogging of pipes
  - Increased maintenance costs

- Removal of VMS from biogas prior energy valorization is mandatory

  Siloxanes concentration in biogas = 20-400 mg m^{-3}

  ⇩

  Maximum concentration for biomethane injection in natural gas grid

  10 mg m^{-3}

Review of siloxanes removal technologies

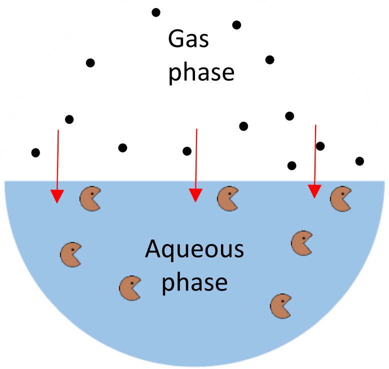
- Conventional physical-chemical processes for siloxanes removal:
  - High operating and investment cost

Physical-chemical processes	RE (%)	Disadvantages
Adsorption	90-99	Regeneration/replacement of the adsorbent
Absorption	> 90	Cooling to avoid organic solvent emissions Corrosive nature of acid solutions Alkaline deposits (alkaline absorbent solutions)
Cryogenic condensation	> 90	Extreme operating temperatures (-25, -70 ºC)
Membrane separation	> 80	Compressors or vacuum pumps energy consumption

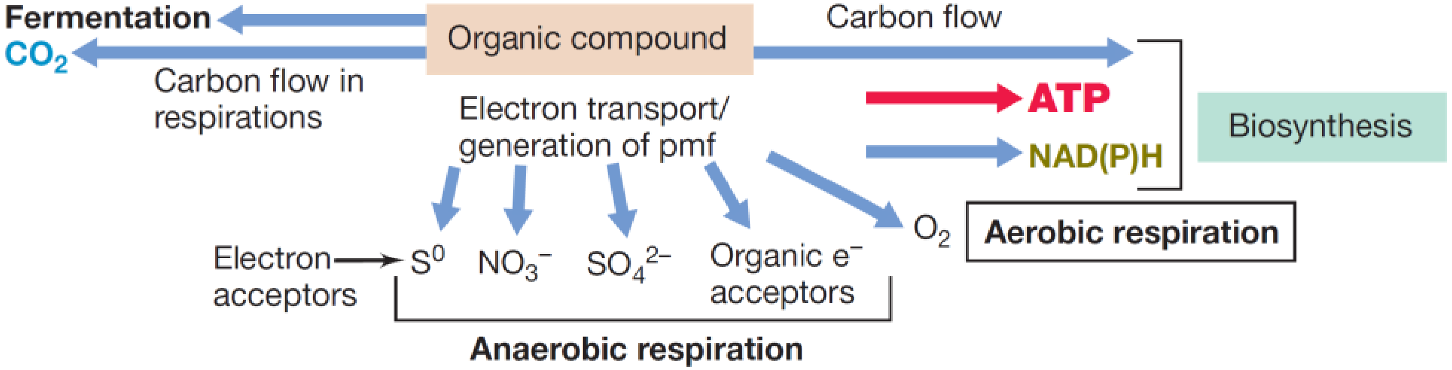
- Biological processes:
  - Low-cost
  - Environmentally friendly

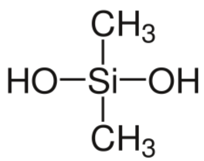
Biodegradation basis

Mass transfer

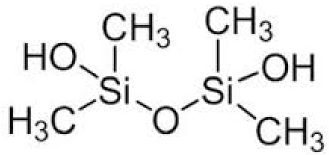


Biodegradation





Dimethylsilanediol



Tetramethyl-1,3-disiloxanediol

Review of siloxanes removal technologies: Biological processes

Previous research suggested that an effective VMS removal requires:

- High EBRTs.
- The presence of an organic phase (non-aqueous phase) capable of enhancing the mass transfer of VMS from biomethane to the microbial community.
- A microbial culture previously enriched with the ability to use VMS as the only carbon and energy source.

Work plan

Comparative assessment of two biotrickling filters for siloxanes removal: effect of the addition of an organic phase → UVa, iSP Institute of Sustainable Processes Valladolid University

Optimization of aerobic and anoxic BTF for siloxanes removal :

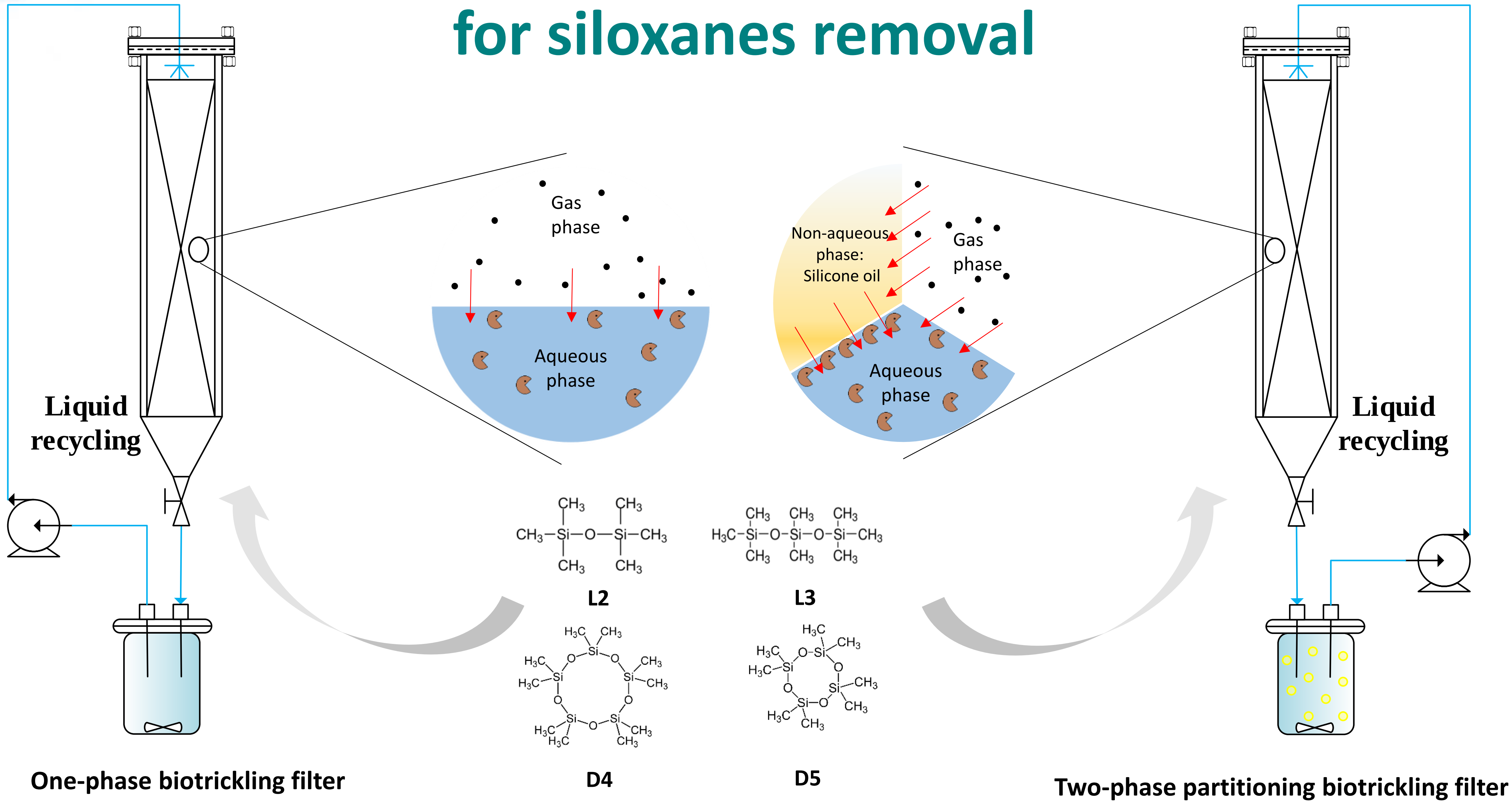
- Effect of the Silicone oil %
- Effect of the retention time

→ UVa, iSP Institute of Sustainable Processes Valladolid University

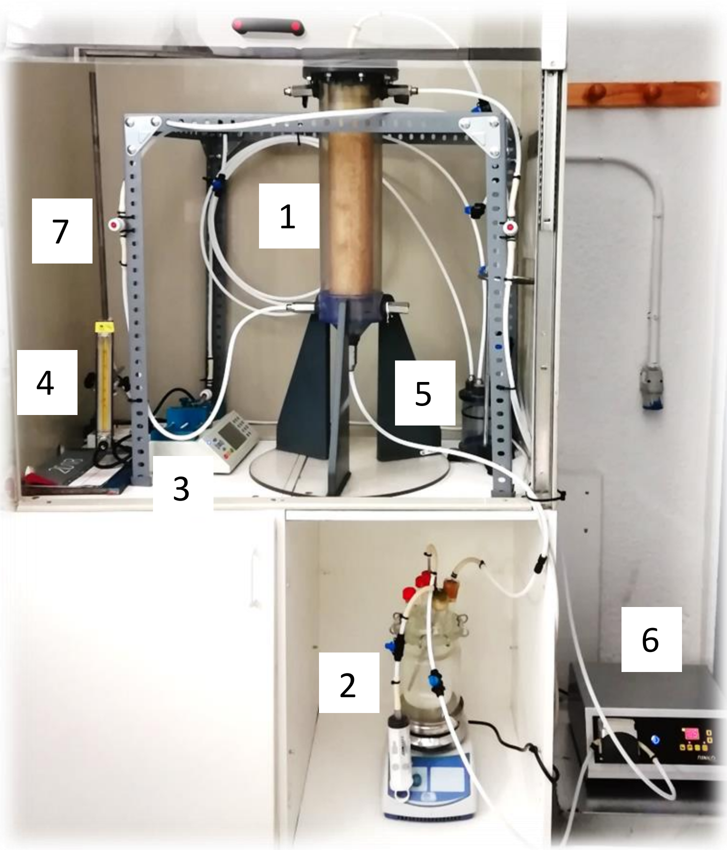
Study of the microbial community → Wageningen University & Research

Siloxanes removal pilot unit → urbaser

Comparative assessment of two BTFs for siloxanes removal



BTFs: Experimental setup



- Gas flow: 33 mL min^{-1}
- V = 2 L
- EBRT = 1 h
- [VMS] ~ 650 mg m^{-3}
- 30 % Silicone oil (2P-BTF)

1- BTF

2- Nutrient reservoir

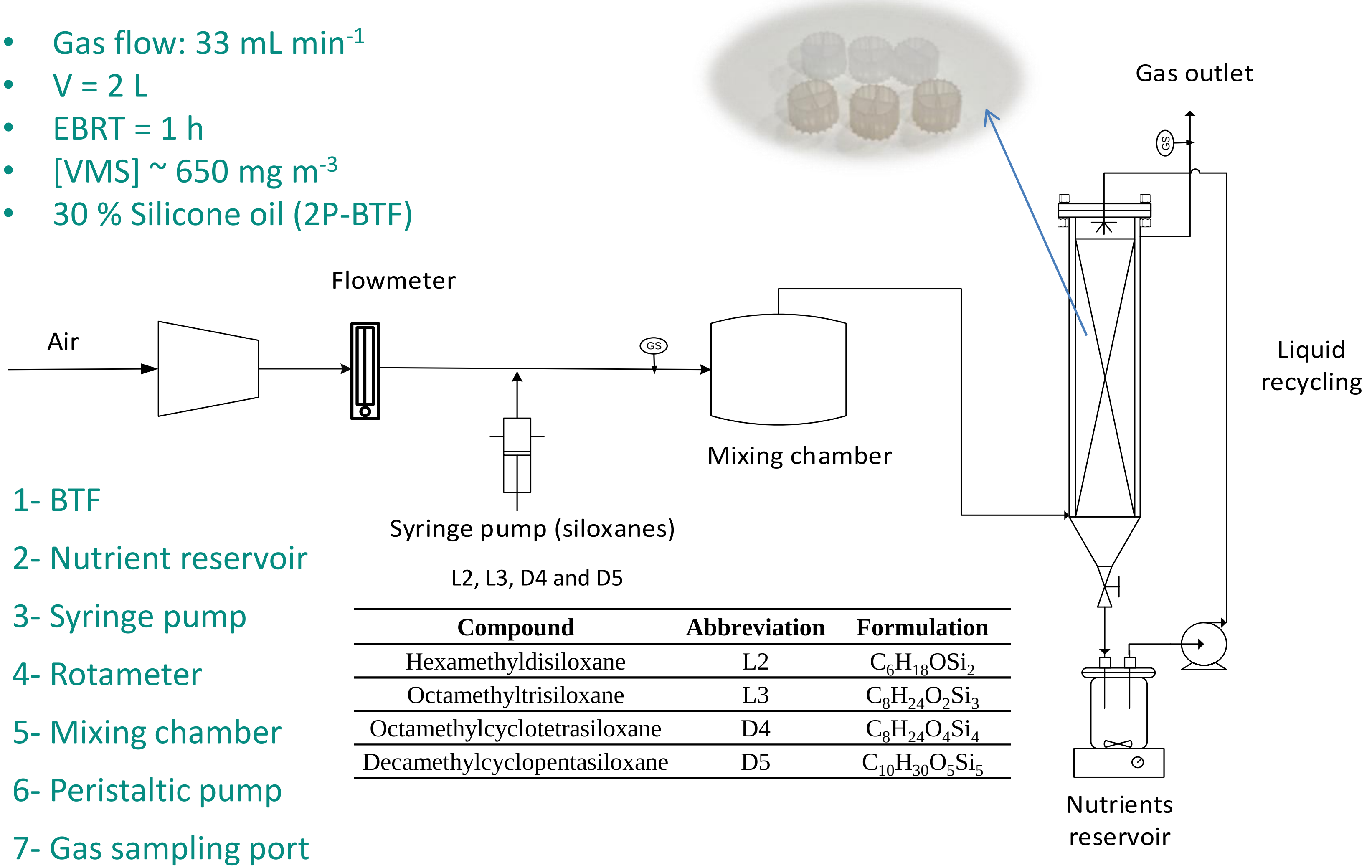
3- Syringe pump

4- Rotameter

5- Mixing chamber

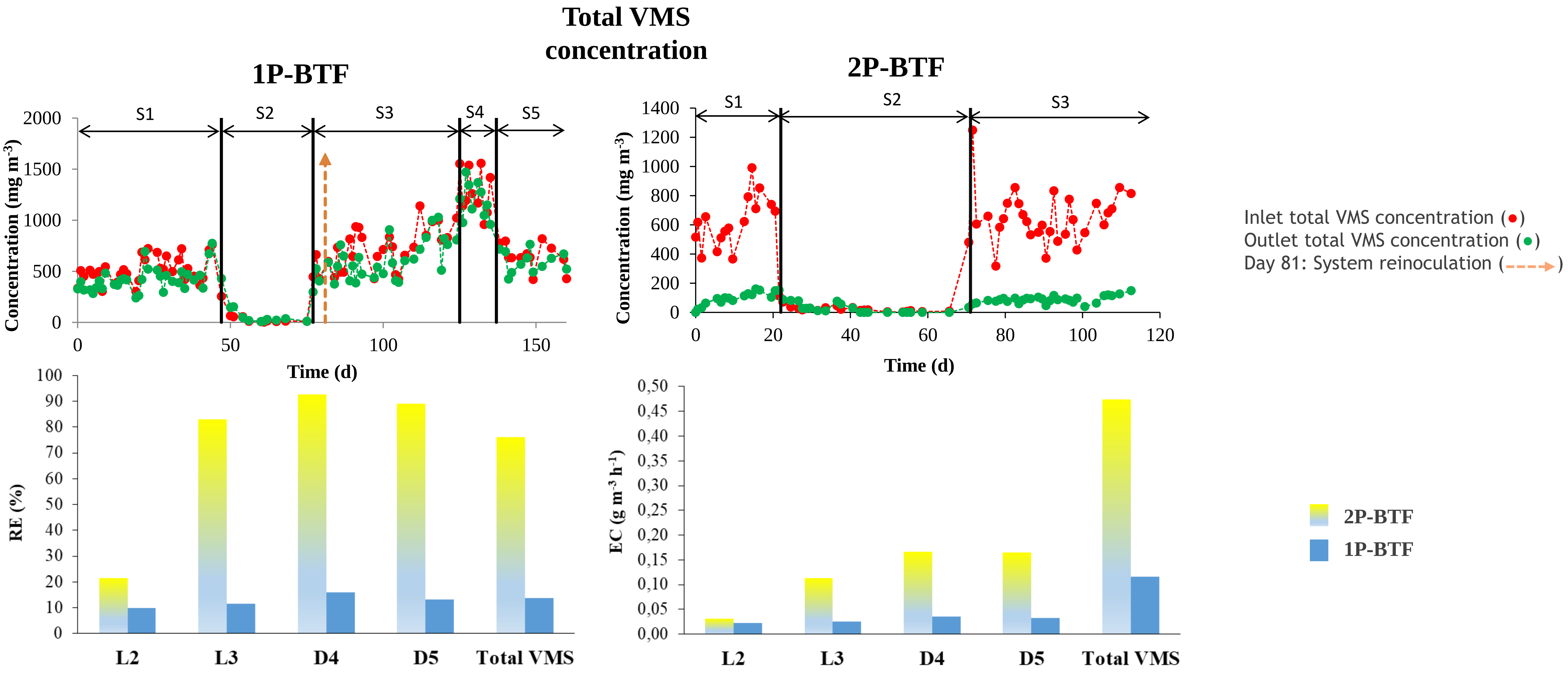
6- Peristaltic pump

7- Gas sampling port



Compound	Abbreviation	Formulation
Hexamethyldisiloxane	L2	$C_6H_{18}OSi_2$
Octamethyltrisiloxane	L3	$C_8H_{24}O_2Si_3$
Octamethylcyclotetrasiloxane	D4	$C_8H_{24}O_4Si_4$
Decamethylcyclopentasiloxane	D5	$C_{10}H_{30}O_5Si_5$

BTFs: Comparative results



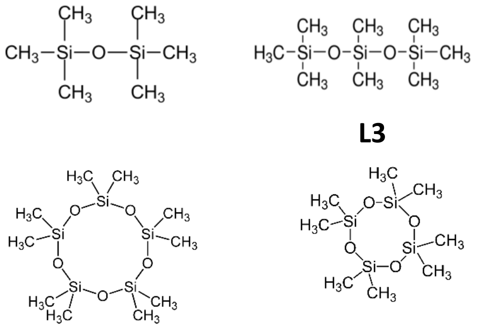
Optimization of aerobic and anoxic BTF for siloxanes removal

Effect of the retention time

	EBRT (min)
S1	60
S2	45
S3	30
S4	15

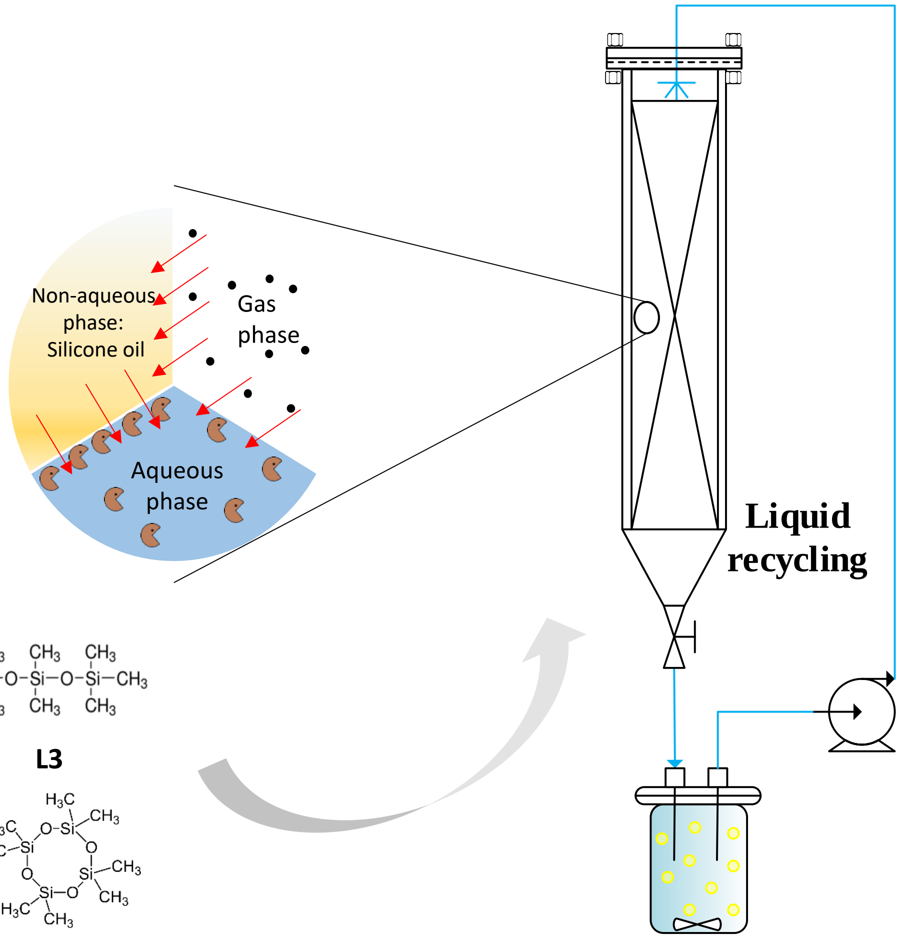
Effect of the Silicone oil %

	Silicone oil (%)
S1	5
S2	10
S3	15
S4	30
S5	45



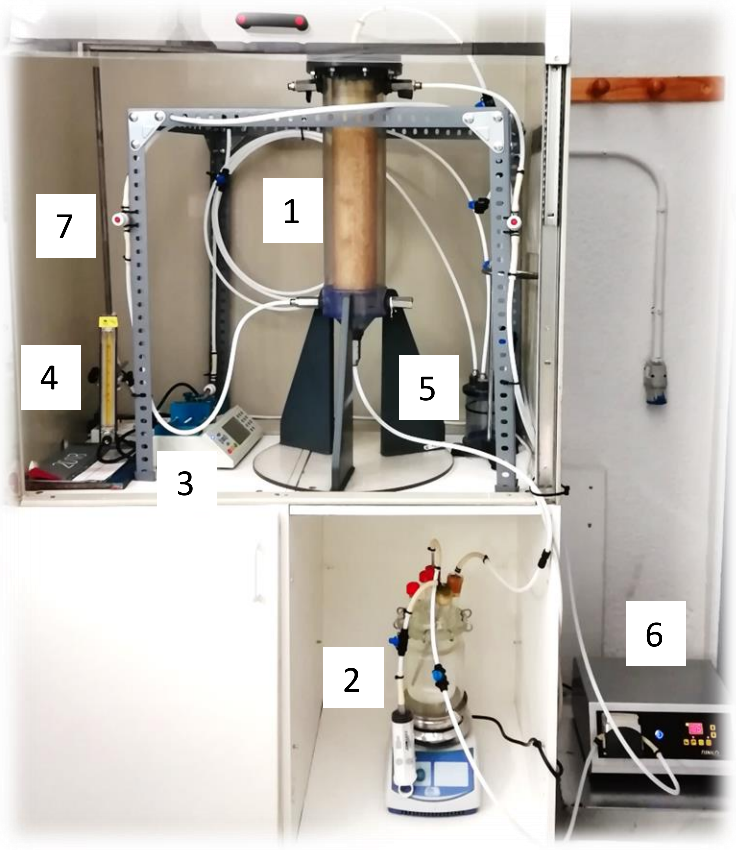
L3

D5

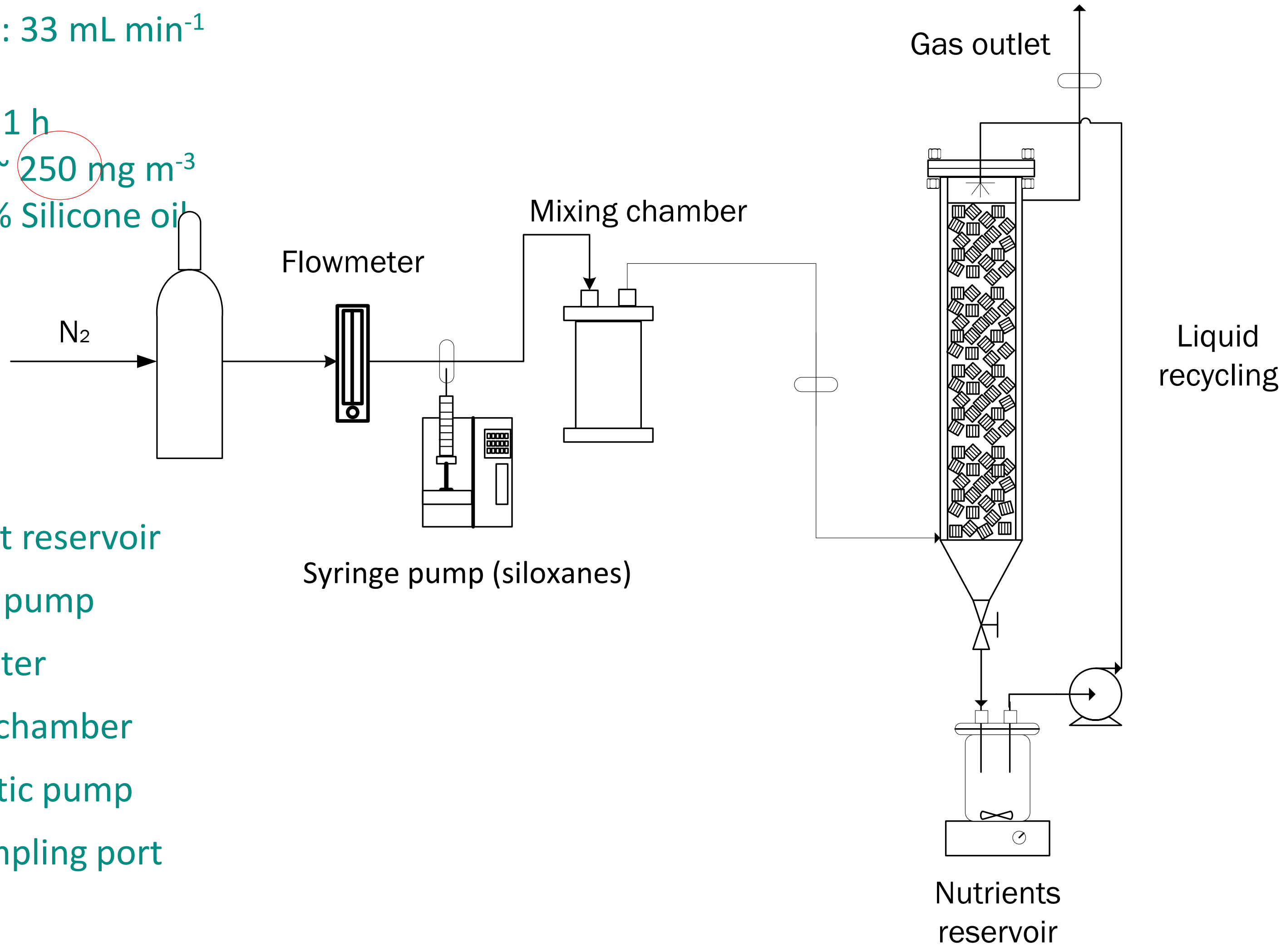


Two-phase partitioning biotrickling filter

Optimization of anoxic BTF for siloxanes removal



- N_2 flow: 33 mL min^{-1}
- V = 2 L
- EBRT = 1 h
- [VMS] ~ 250 mg m^{-3}
- 15-45 % Silicone oil



1- BTF

2- Nutrient reservoir

3- Syringe pump

4- Rotameter

5- Mixing chamber

6- Peristaltic pump

7- Gas sampling port

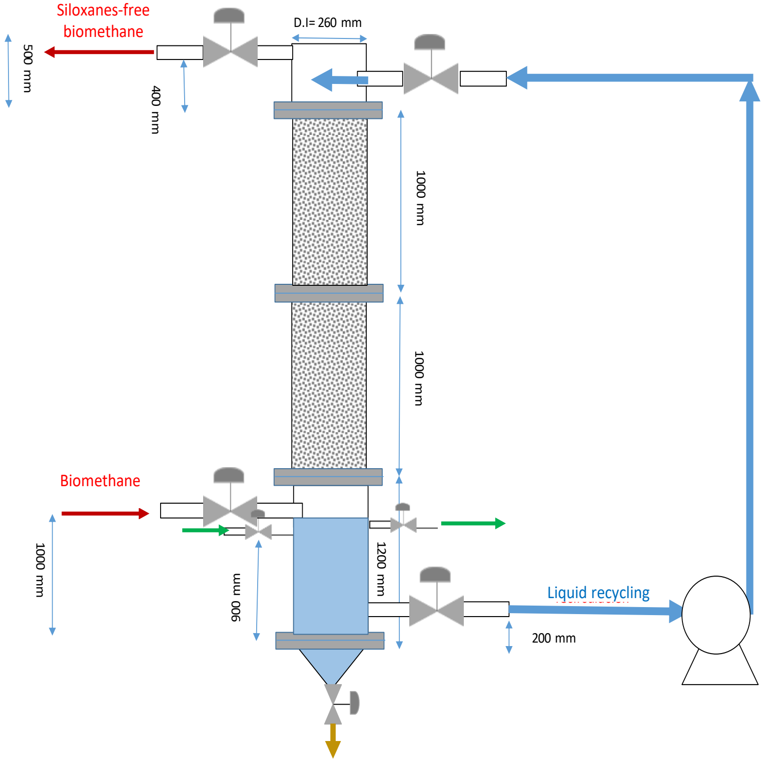
Study of the microbial community

- Study of the microbial community in the BTF under both aerobic and anoxic conditions
- Isolation of siloxane-degrading bacteria
- Identification of the metabolic pathway

WAGENINGEN
UNIVERSITY & RESEARCH

Laboratory of Microbiology

Siloxanes removal pilot unit



Biogas flow	2.7-7.2	m^3/d
Organic phase	30	L
Liquid phase exchange	2.25-3.25	L/d
EBRT	21-55	min
BTF volume	120	L

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Centro de Innovación Tecnológica de Residuos Alfonso Maíllo

CIAM

Collaboration

- Analysis of the siloxanes degradation compounds
  Química analítica, medioambiente y quimiometria

- Siloxanes Membrane Separation
  Materiales y superficies porosas

Thanks for your attention