Climate-KIC is supported by the EIT, a body of the European Union

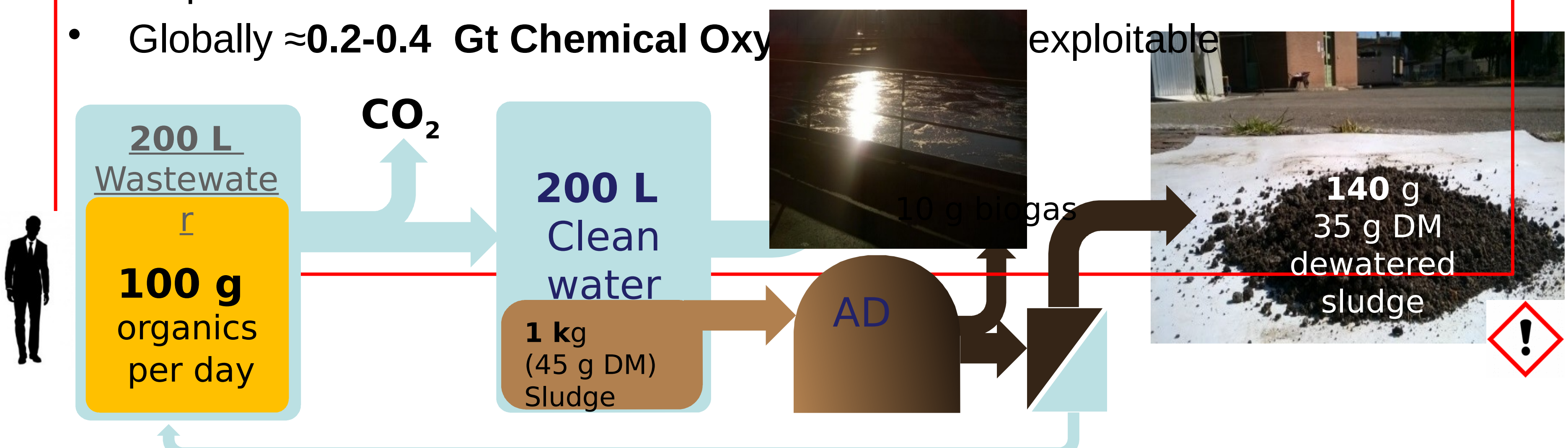
Production of polyhydroxyalkanoates from anaerobically digested sewage sludge: **the B-PLAS proof of concept.**

Cristian Torri, Chiara Samorì, Alisar Kiwan, Eleonora Torricelli
Dipartimento di Chimica "Giacomo Ciamician", University of Bologna, Via Selmi 2, Bologna, Italy

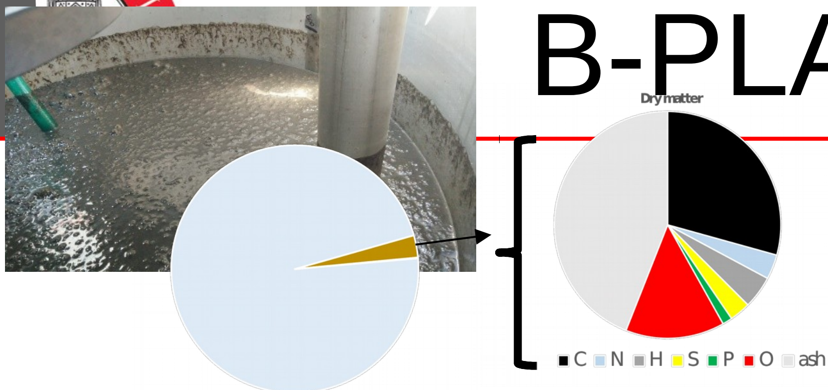
Wastewater treatment

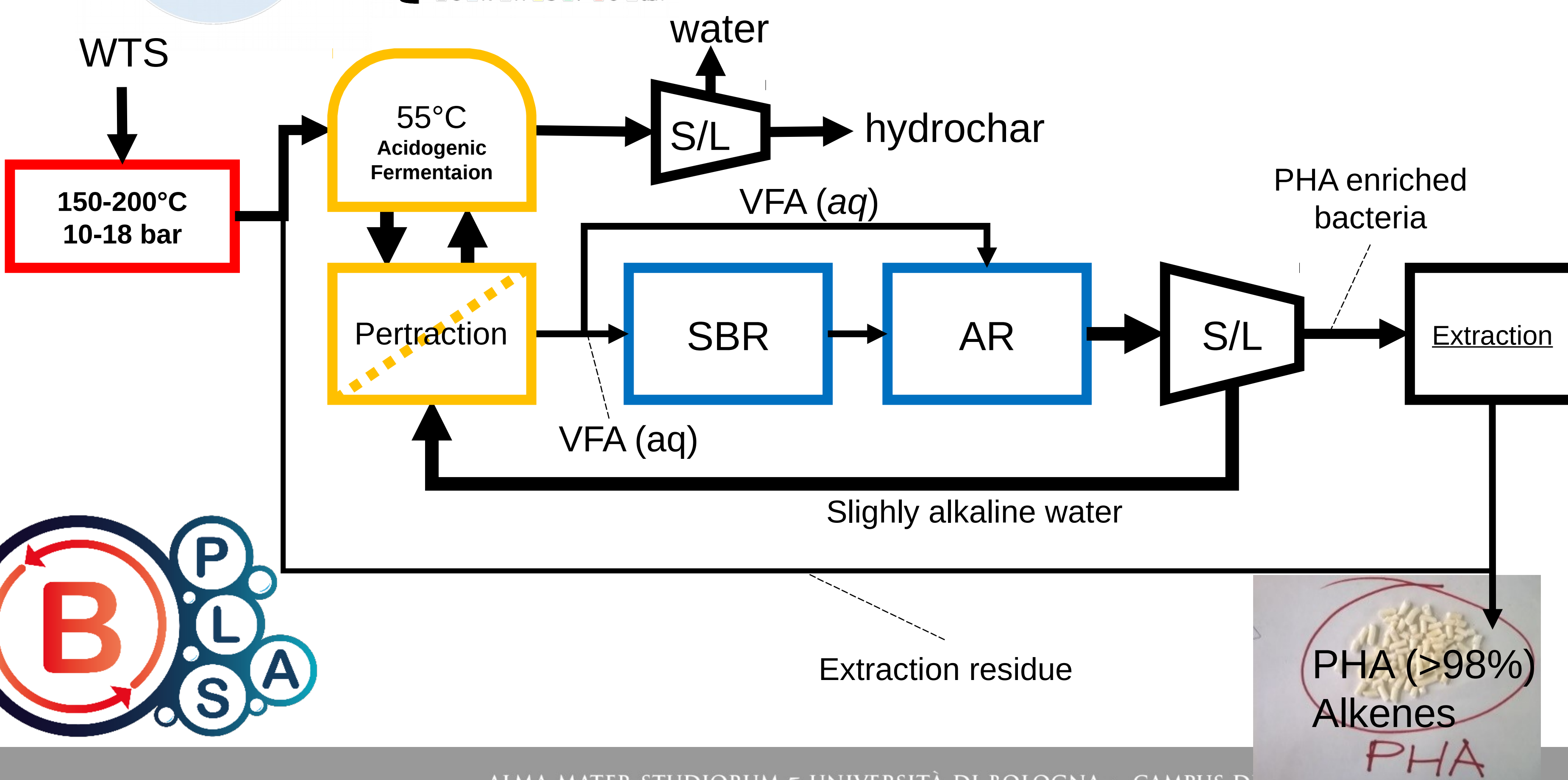
How Wastewater treatment sludge (WTS) is generated

- Wastewater treatment converts soluble substances mainly into excess activated sludge (mostly bacterial biomass).
- In best practices, excess sludge is subjected to Anaerobic digestion
- >300 Mt_{dry}/y worldwide (1.2 Gt/y), mostly dumped, applied to soil, landfilled and dried and incinerated.
- Disposal cost **50-120** €/ton
- Globally ≈**0.2-0.4 Gt Chemical Oxy** exploitable



B-PLAS process



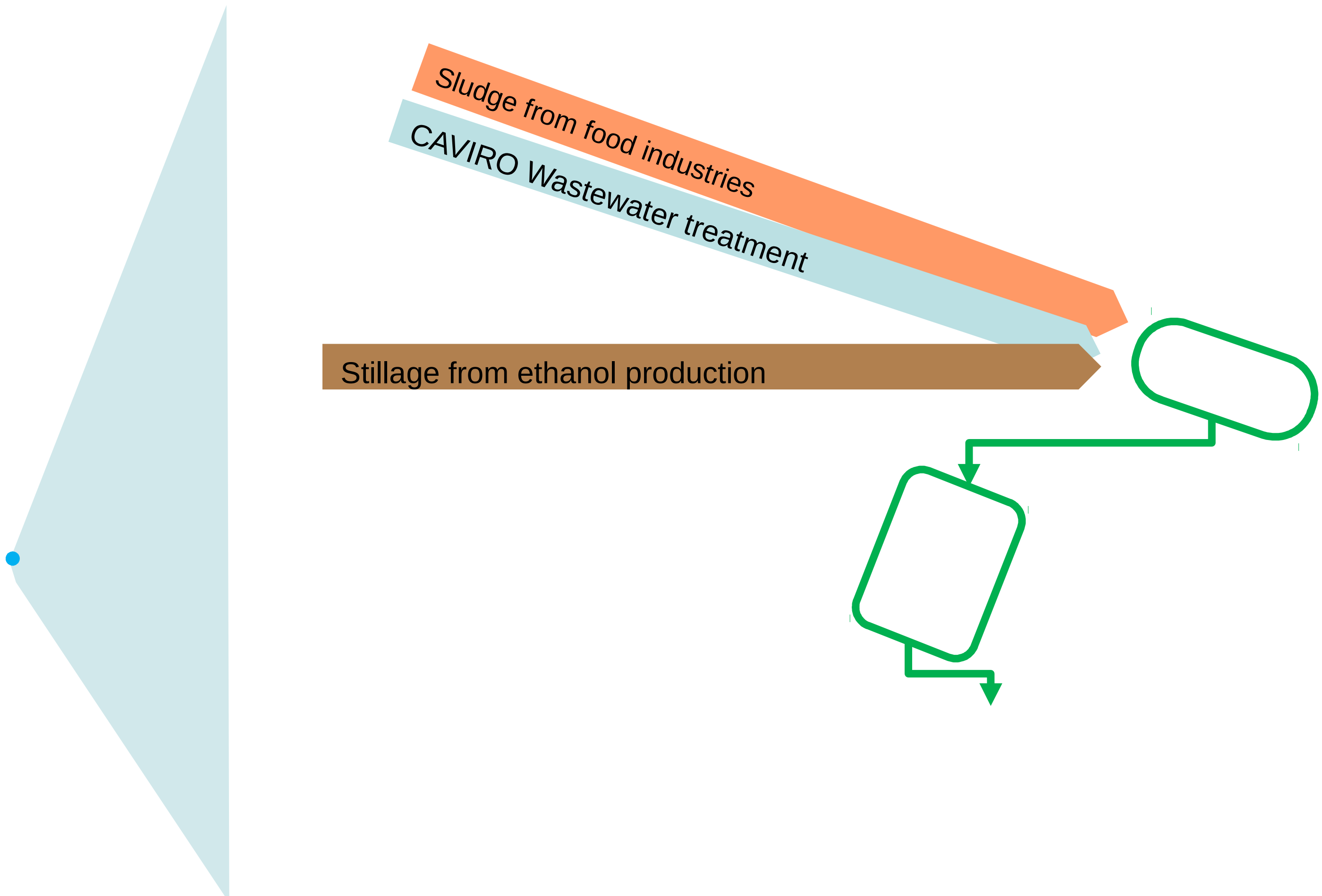


B-PLAS DEMO

Industrial demonstration of sludge to bioplastic pathway

CAVIRO EXTRA BAU

0,5 Mton sludges→**<u>70 kton</u>** <u>WTS</u>



HTC

- Test on sludge as received (**2.9% VSS**, **27 g/L COD**)
- From 150 to 200°C gradual increase of conversion to water soluble substances (peaks at 200°C, 60 min RT)
- Mostly formed by oligomers and non GC-MS detectable compounds.
- >250°C oil formation, increased production of aromatic compounds.
- 150-200°C best trade of between reliability and efficiency.

Water soluble organics

1 ml reactor

1 h treatment

200HTC-AD

Soluble COD

- 4 days HRT
- 55°C
- 60d test

Bioavailable

VFA yield

- **35%** soluble COD
- **20%** of total COD

P to solid

N to liquid (NH_3)

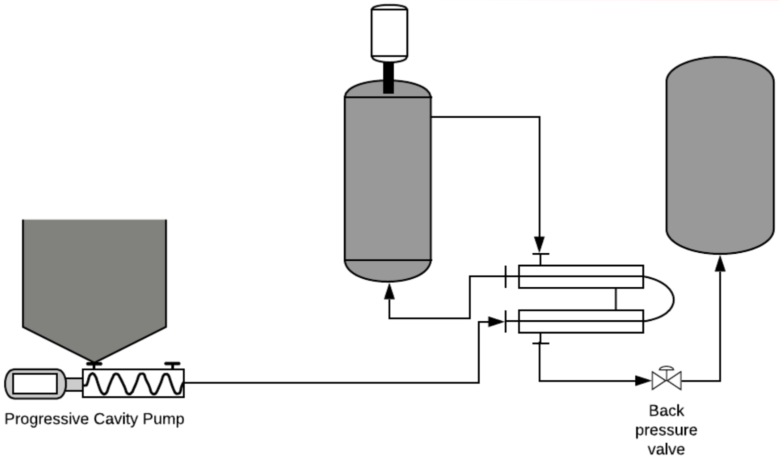
- Initial pH=7.8
- Final pH=6.5

Easier
S/L separation

22% DW

9.5% DW

HTC energy req.



500 L/h module

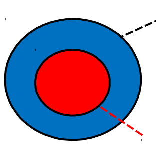
- Pressurized Reactor 500 L
- ½ in. Airpin heat exchanger
- 100 m (3 m^2 HA)
- T=200°C , ΔT=12 K

Sludge at 45 g/L (as received)

- En. required=**3 MJ/kg$_{\text{COD sludge}}$**
- En. Required=15 MJ/kg$_{\text{COD}}$ VFA

Pumpable Sludge at 90 g/L

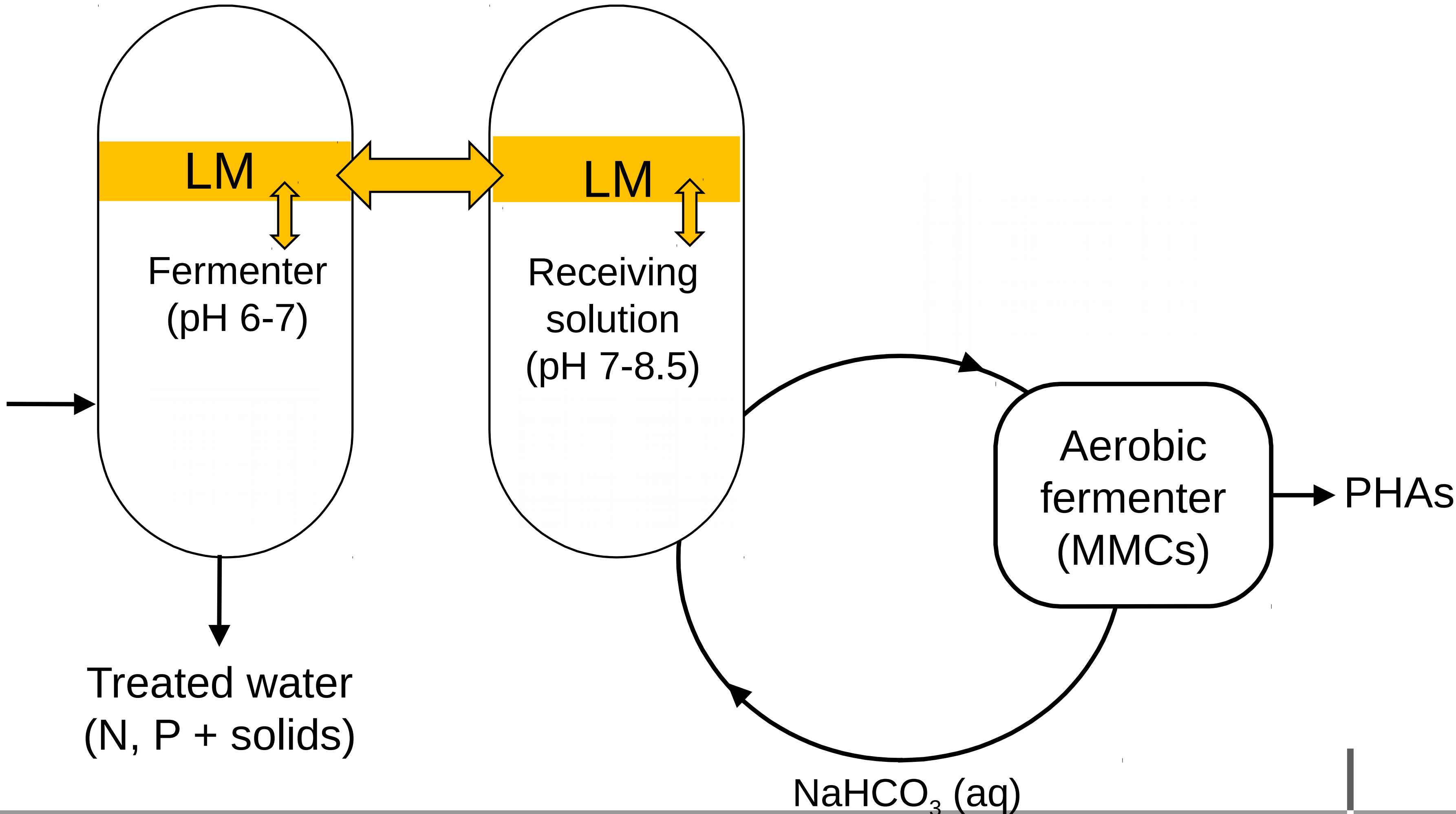
- En. required=**1.5 MJ/kg$_{\text{COD sludge}}$**
- En. Required=**7.5 MJ/kg$_{\text{COD}}$ VFA**



3 keuro/m^2

Pertraction of VFA

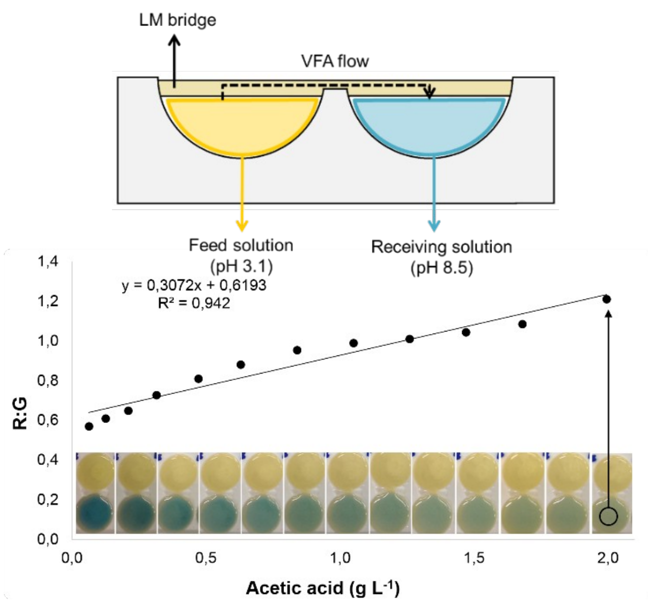
Liquid membrane (LM) diluent + VFA carrier



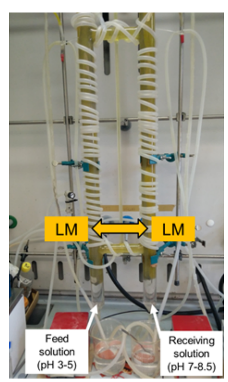
Pertraction of VFA

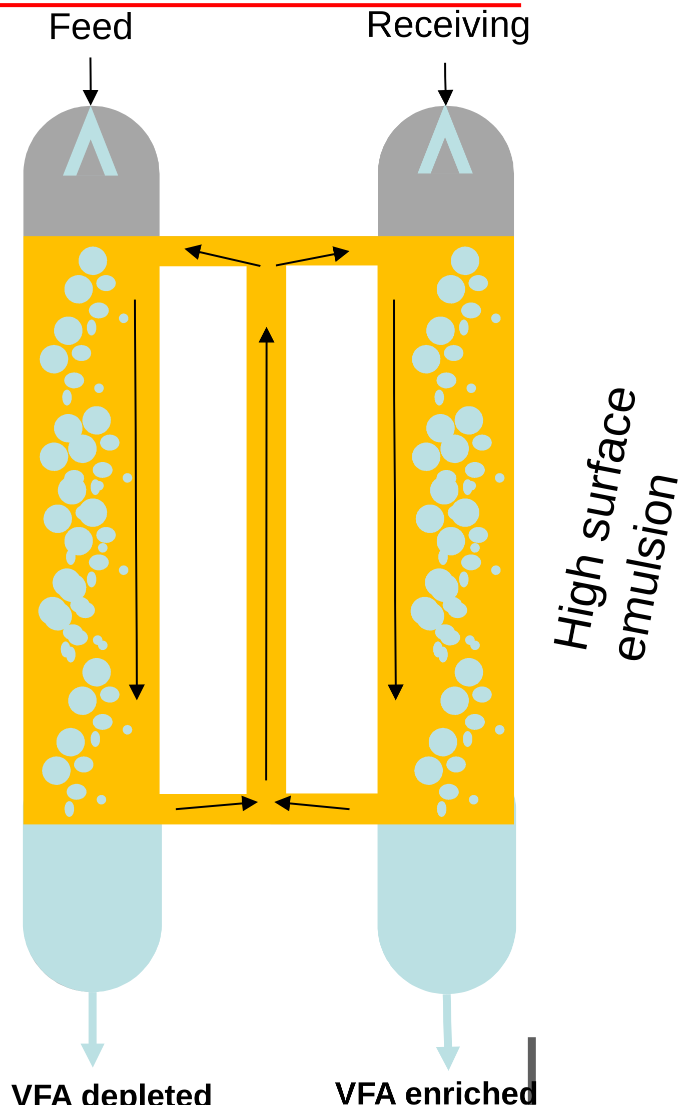
Screening of LM
- water solubility
- kinetic of phase trasfer
- toxycity toward bacteria
- cost, stability

Best Mix
89% Biodiesel
+
10% TOA
+
1% Palmitic acid



40 mix tested





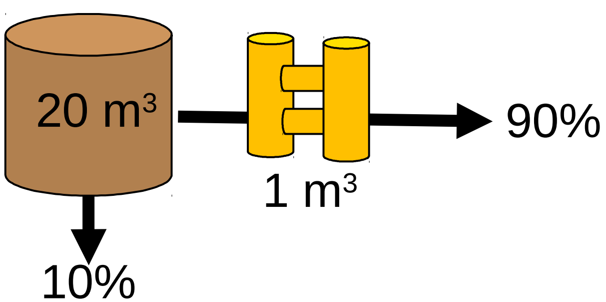
Torri et al. Chemical Engineering Journal 366 (**2019**) 254-263,

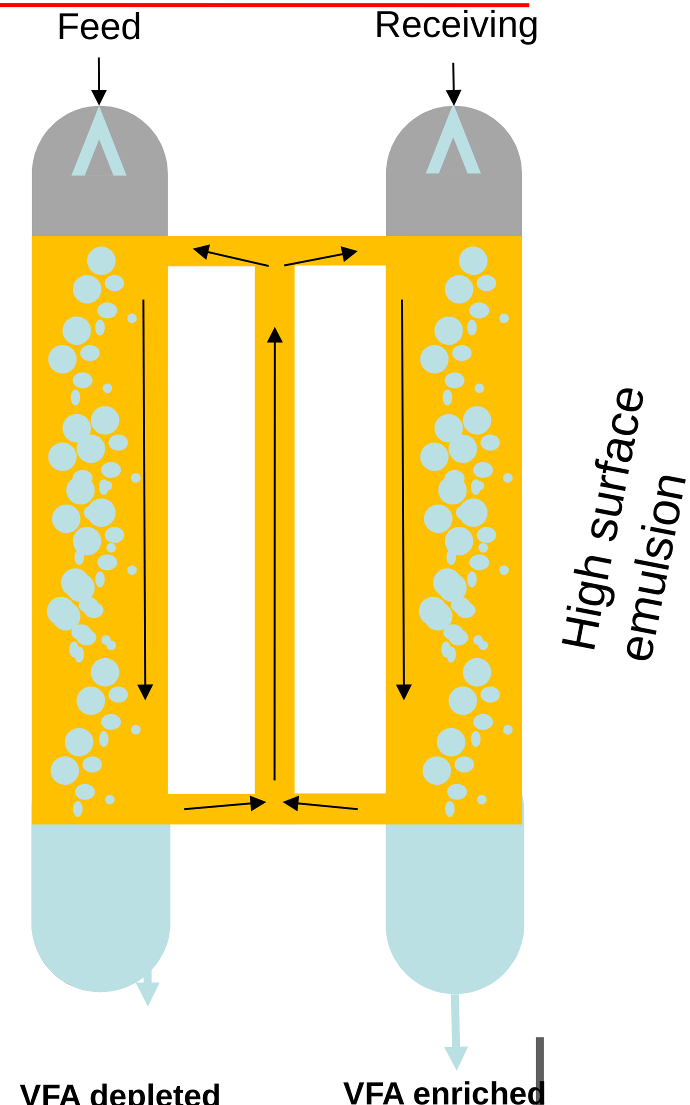
Pertraction of VFA

Main effects:

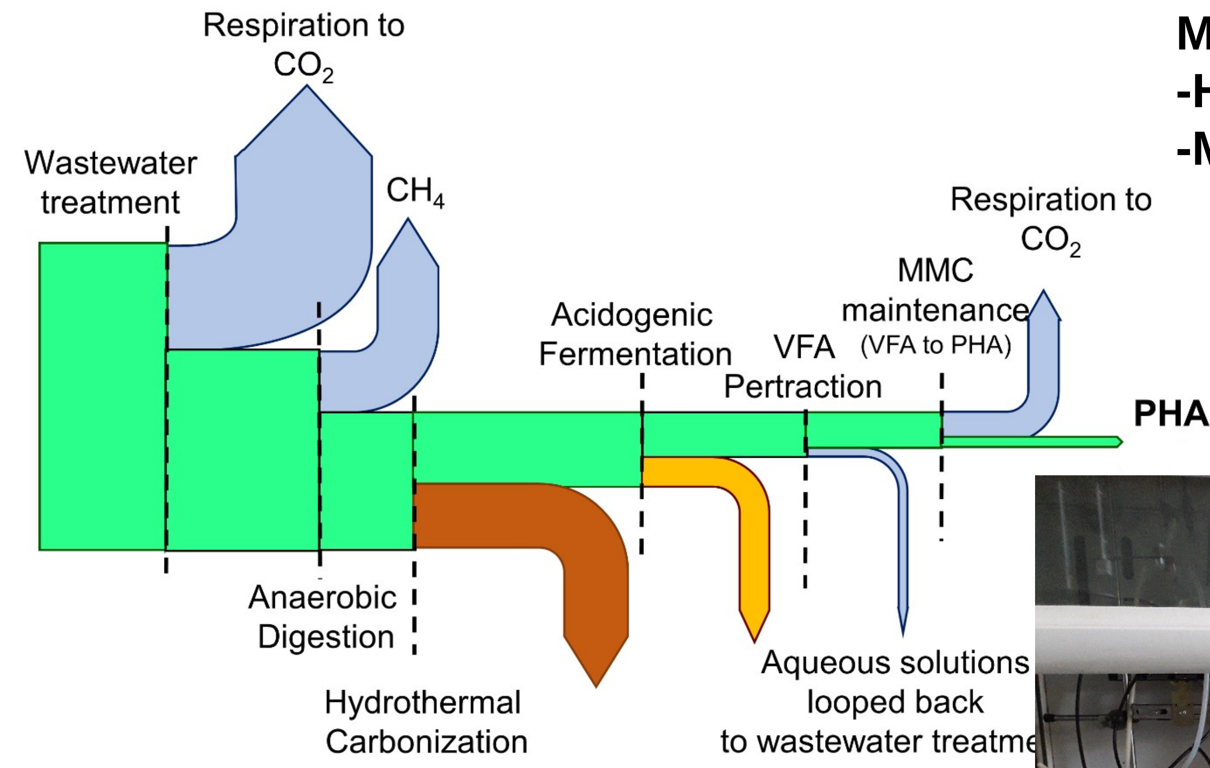
- LM composition
- **Temperature**
- Trickling mode
- pH (especially at low T)

- Opt. productivity





Overall yields



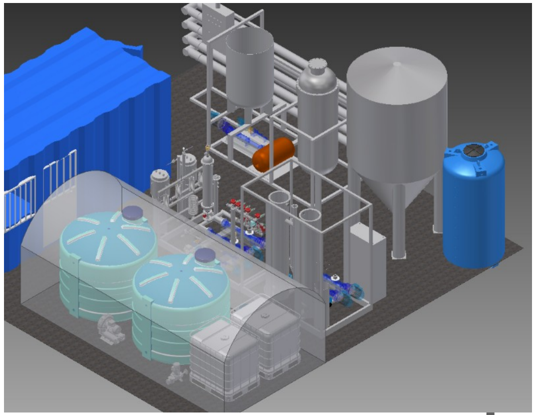
Most relevant losses
-HTC (difficult to improve)
-MMC (potentially halved)

Samorì et al. ACS Sustainable Chem. Eng.201971210266-10273

Conclusions

- HTC can release **50 % of organic matter** in WTS with acceptable energy requrement.
- HTC coupled to fermentation allows to decrease the amount of sludge (mainly due to improved dewatering) by a **factor 6**.
- Overall conversion of WTS to VFA =20%, no inhibition.
- Pertraction of VFA using recirculated alkaline solution allows to obtain a **clean VFA solution**, suitable for MMC feeding.
- Preliminar economics is promising:

1. Saving disposal cost: 60% revenues
2. Production of PHA: 40% revenues
3. Expected ROI>35%.



- 26/07/2029DEMO open doors

Cristian Torri
Dept of Chemistry – Unibo
cristian.torri@unibo.it

Thank You for your attention

For more information on B-PLAS please visit the B-PLAS DEMO website:
https://site.unibo.it/b-plas/en