Start-up Of The First Pilot Plant For Short-Cut Enhanced Phosphorus And PHA Recovery From Real Sieved Wastewater

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OUTLINE

- The world needs new resources…from wastewater;
- The water industry consumes about **1%** of the overall electricity (Caldwell, 2009; 2° Eur Water and Wastewater Conf);
- Activated sludge is the major energy consumer (ca 55% of the energy use);
- The water factory concept of the future: «**Not Dissipate**» but «**Upgrade**» low cost carbon source into high added value bioproducts (IWA Resource Recovery Cluster, 2016).

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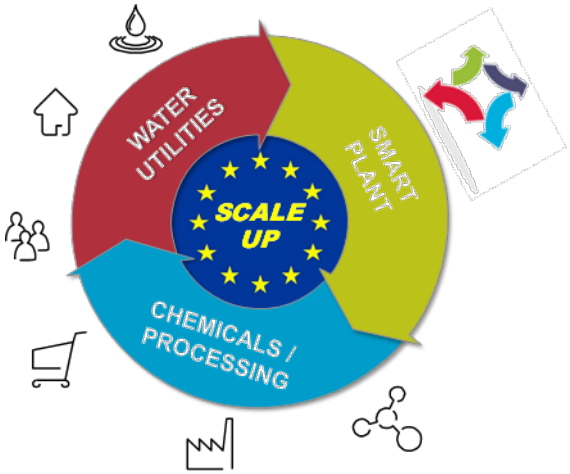
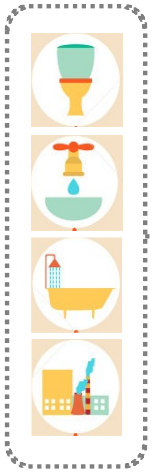
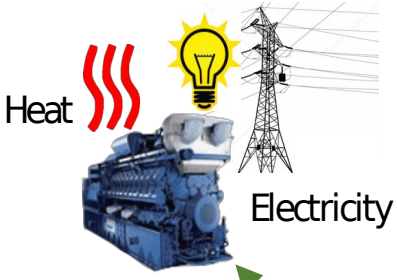
HORIZON 2020 – SMART-PLANT PROJECT







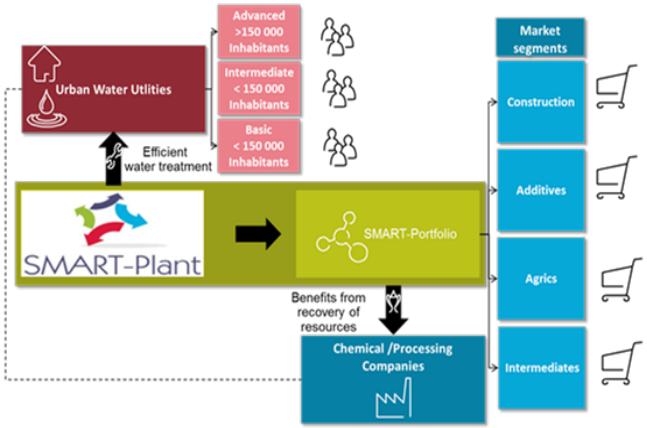
Wastewater

Treated wastewater

Ammonum sulphate

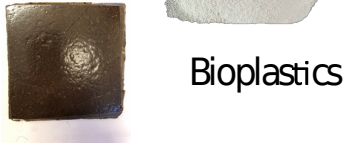
Struvite

Schematic view of SMART-Plant Model



Organic compounds

Cellulose



Phosphorus rich biosolids

Biocomposite

Bioplastics

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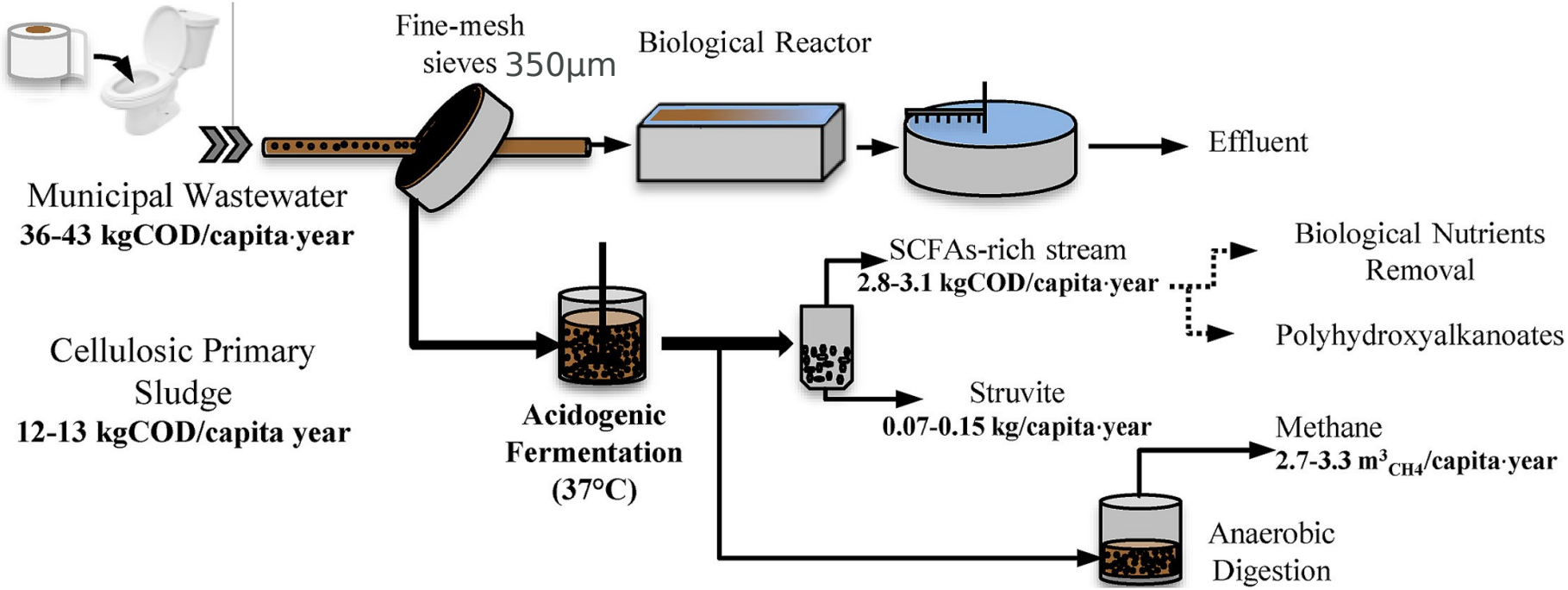
BIOREFINERY OF CELLULOSIC PRIMARY SLUDGE (CPS)

Up to 10 Kg/PE y
(Ruiken et al., 2013)



Crutchik et al., 2018

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OBJECTIVE

- Recovery of cellulosic primary sludge (CPS) through dynamic rotating belt filter;
- Start-up and operation of the Short-cut Enhanced Phosphorus and PHA recovery pilot plant at the Carbonera WWTP (owned by Alto Trevigiano Servizi Srl)
- Selection of PHA storing bacteria during the via-nitrite nitrogen removal from anaerobic supernatant (aerobic feast and anoxic famine);
- Mass balance around the system and recovered (organics) resources

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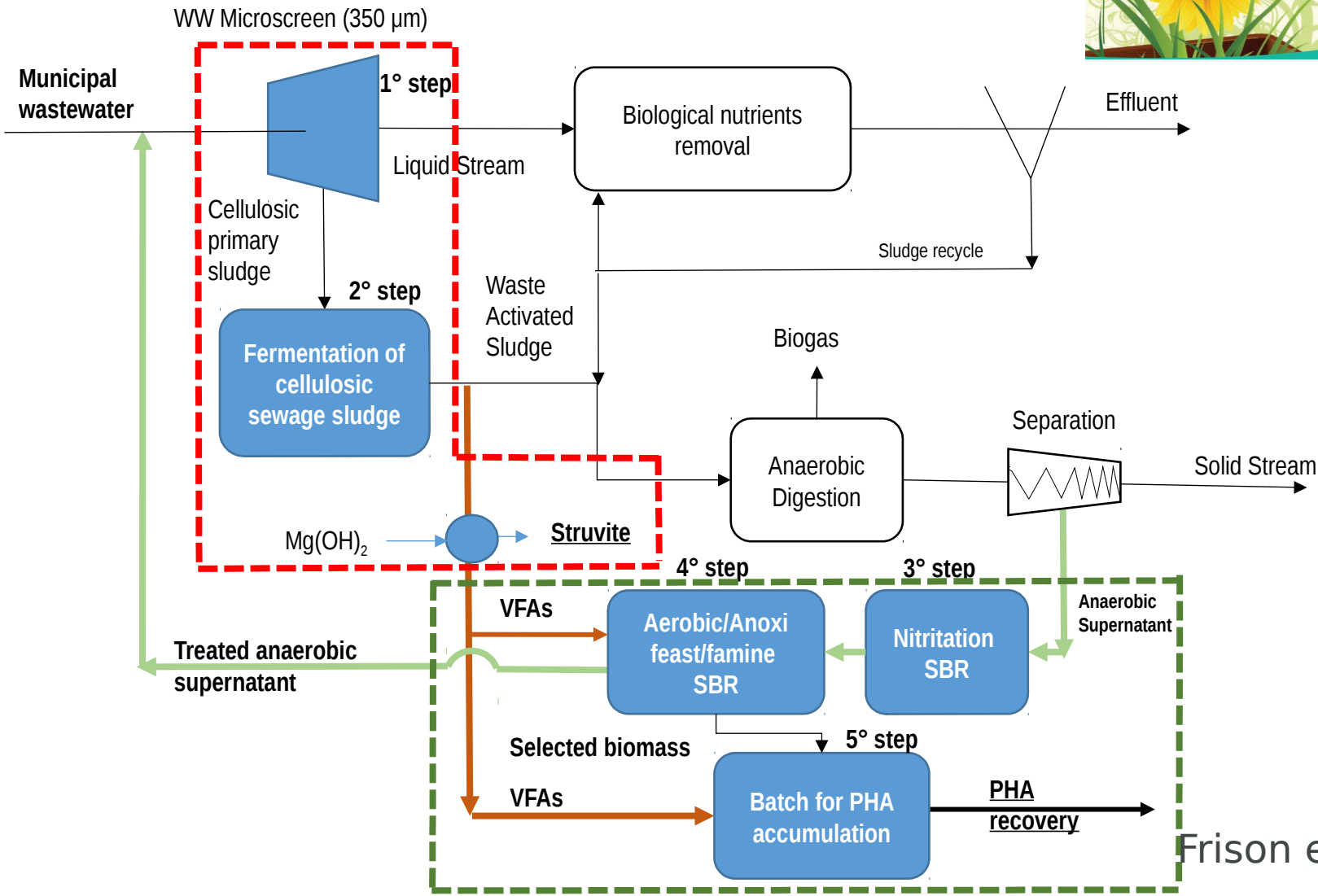
SCEPPHAR: PROCESS CONFIGURATION



Frison et al., 201

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ROTATING BELT FILTER FOR CELLULOSIC PRIMARY SLUDGE (CPS) RECOVERY

Fine mesh size: 350 µm

Wastewater Flowrate: 29-40 m^3/h

Fixed surface contact area: 0,24 m^2

Variable belt rotation speed

Average TSS removal = 45-50%

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FERMENTATION UNIT FOR SCFAS PRODUCTION FROM CPS

- Volume: 3.0 m^3
- Operating Temperature: 37°C
- HRT: 4-5 days
- Probe for the monitoring of th influent TSS concentration

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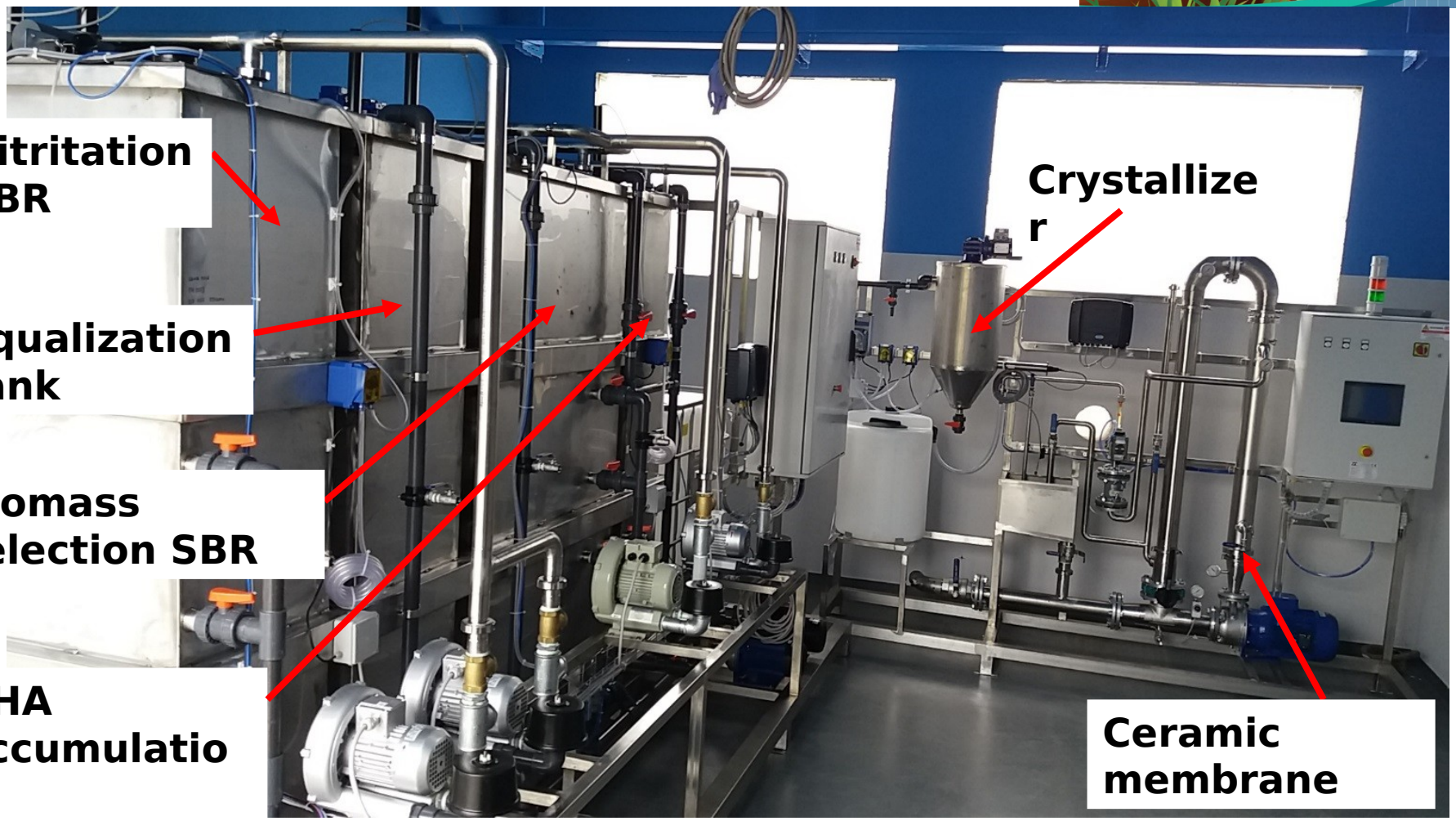
SHORT-CUT ENHANCED PHOSPHORUS AND PHA RECOVERY (SCEPPHAR)



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CHARACTERISTICS OF THE FERMENTATION LIQUID

Parameter	Unit	Average	Min	Max
pH	-	4,9	4,8	5,0
VFAs	mgCOD/L	17467	13993	23564
NH_4-N	mgN/L	283	252	307
PO_4-P	mgP/L	68	44	82

- Observed VFAs yield around 0.40 $mgCOD/gVSS_{fed}$
- COD:N:P ratio in the liquid fraction ~ 257:4:1
- HPr to HAc ratio >2 (PHBV)
- Phosphorus (and fraction of ammonia) recovered as P salts forms.

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NITRITATION SBR

- Run 1: not heated; Period 2: heated
- In Run 2 the vNLR was increased up to 1,55-1,60 kgN/m^3 day (T = 28°C);
- In Period 3 the observed nitritation rate was 55-60 mgN/L h, 80-90% of the nitrogen was nitrified;

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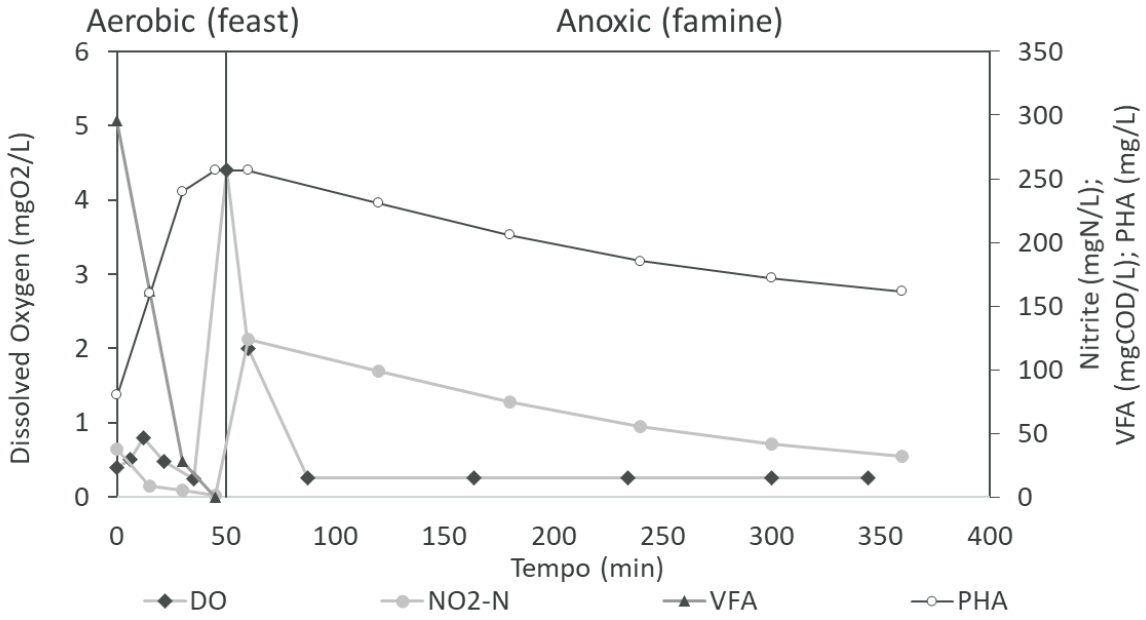
SELECTION SBR



- Nitrite removal efficiency around 85%;
- The kd (@20°C) was 8-10 mgN/gVSS h (driven by PHA degradation);
- Feast/Famine ratio was 0,15 – 0,20 min/min

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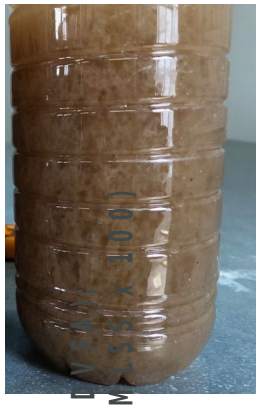
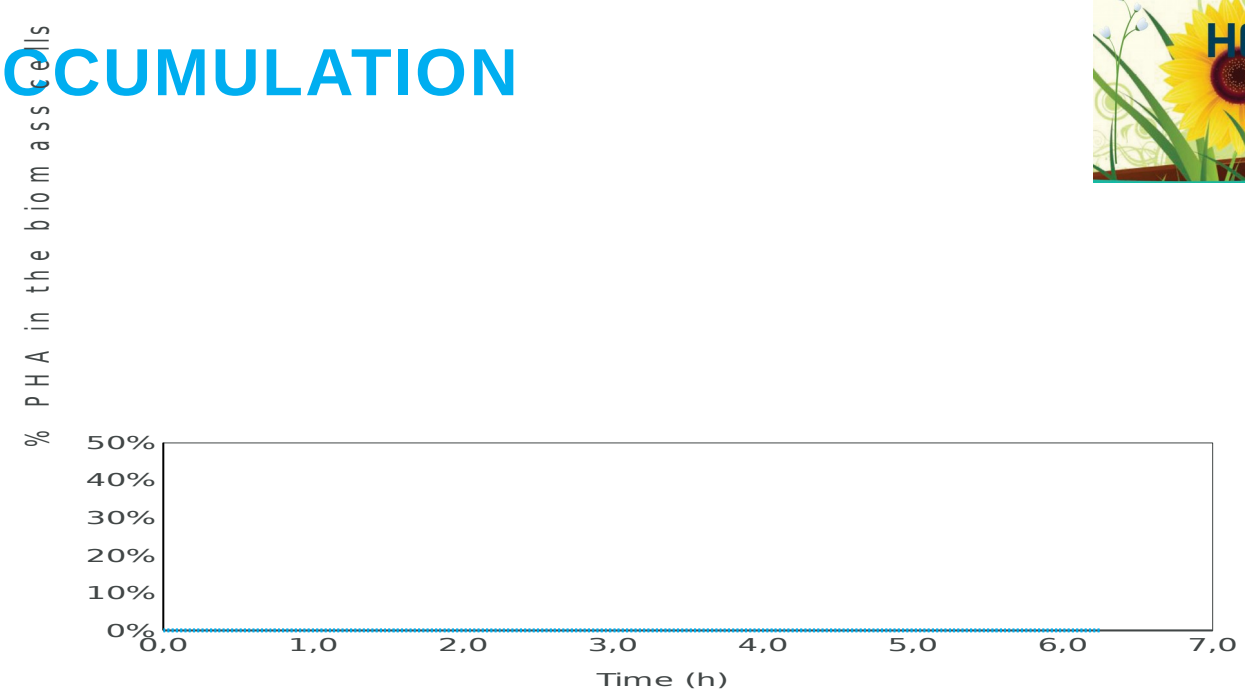
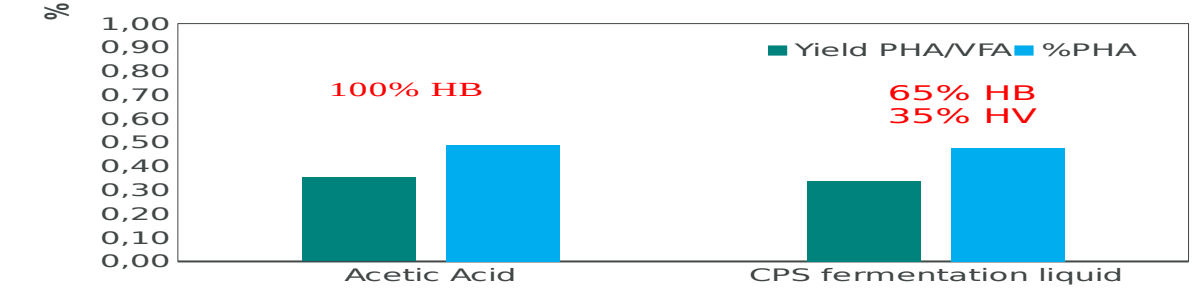
PHA ACCUMULATION







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MASS BALANCE AROUND THE SYSTEM

Municipal Wastewater
(adapted from Metcalf&Eddy, 2013)
25-30 kgSS/PE y
4 kgN/PE year

Wastewater Sieving

Sieved Wastewater
13-15 kgSS/PE y
~ 4 kgN/PE year

To mainstream wastewater treatment

CPS
13-14 kgSS/PE y

VFAs
5-5,5 kgCOD/PE y

Fermentation Efficiency
0,38-0,40 $gCOD_{VFA}/gVSS$

Selection SBRs:
$Y_{X/VFA}$ = 0.32 $gVSS/gCOD_{VFA}$

Accumulation PHA
$Y_{PHA/VFA}$ = 0.36-0.42

PHA
~ 1 kgPHA/PE y

Treated reject water
0,06 kgN/PE y

To biogas production

Nitrogen from reject water
0,4 kgN/PE y

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ESTIMATED COST OF CHEMICALS FOR PHA EXTRACTION: CHEAP AND/OR GREEN?

- Extraction recovery efficiency: 75%
- Purity of the extracted PHA: 90-95% without extensive polishing
- Extraction with «Green-Chemicals » : 1,2 Euro/kgPHA extracted (currently very affected by the scale of the process)
- SDS-Sodium hypochlorite: 0,29 Euro/kgPHA extracted (adapted from CalRecycle, 2013)

Courtesy of Biotrend SA (Portugal)

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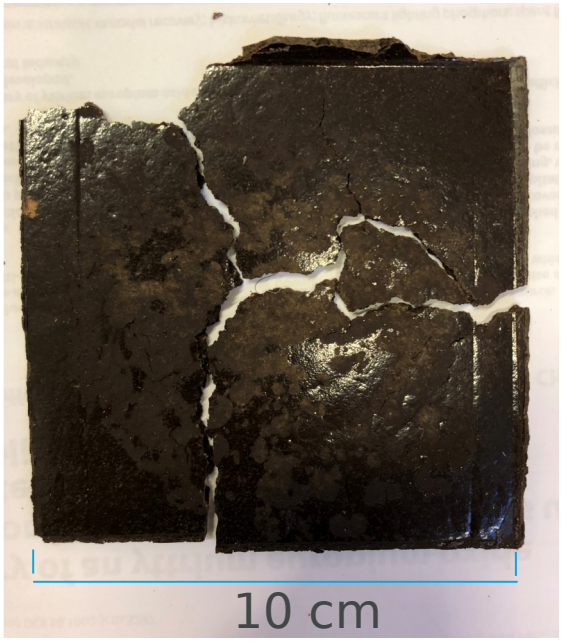
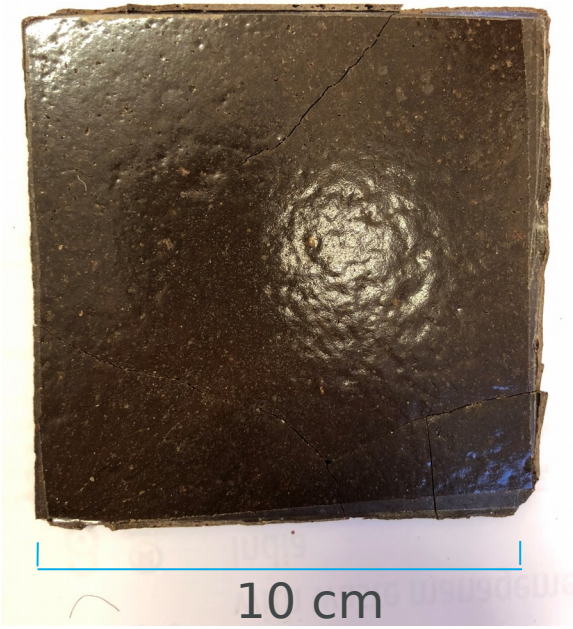
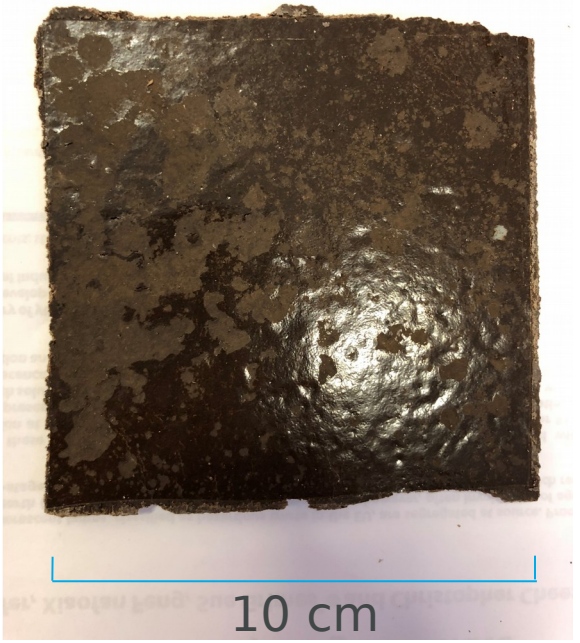
FIRST BIOCOMPOSITES FROM RAW PHA-ACCUMULATED BIOMASS



Dried accumulated PHA Biomass (105°C for 24 h)



Dried accumulated PHA Biomass + 20% of PHBV



Dried accumulated PHA Biomass + 20% of PE

Courtesy of Yonghui Zhou, University of Brunel (UK)

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CONCLUSIONS

- Cellulosic primary sludge is suitable for the production of VFAs (0,40 $gCOD_{VFA}/gVSS$);
- The SCEPPHAR system allows the integration of the PHA production from sewage sludge with the nitrogen removal via-nitrite from the reject water through the aerobic-feast and anoxic-famine regime;
- The nitrogen removal efficiency was around 85%;
- Observed PHA production was around 1 kgPHA/PE y. The productivity will be validated during the two years of Smart-Plant Project.

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Thank you for your attention!

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