Scale-up of the P and PHA recovery from cellulosic sludge via SCEPPHAR system: first performances from Carbonera WWTP

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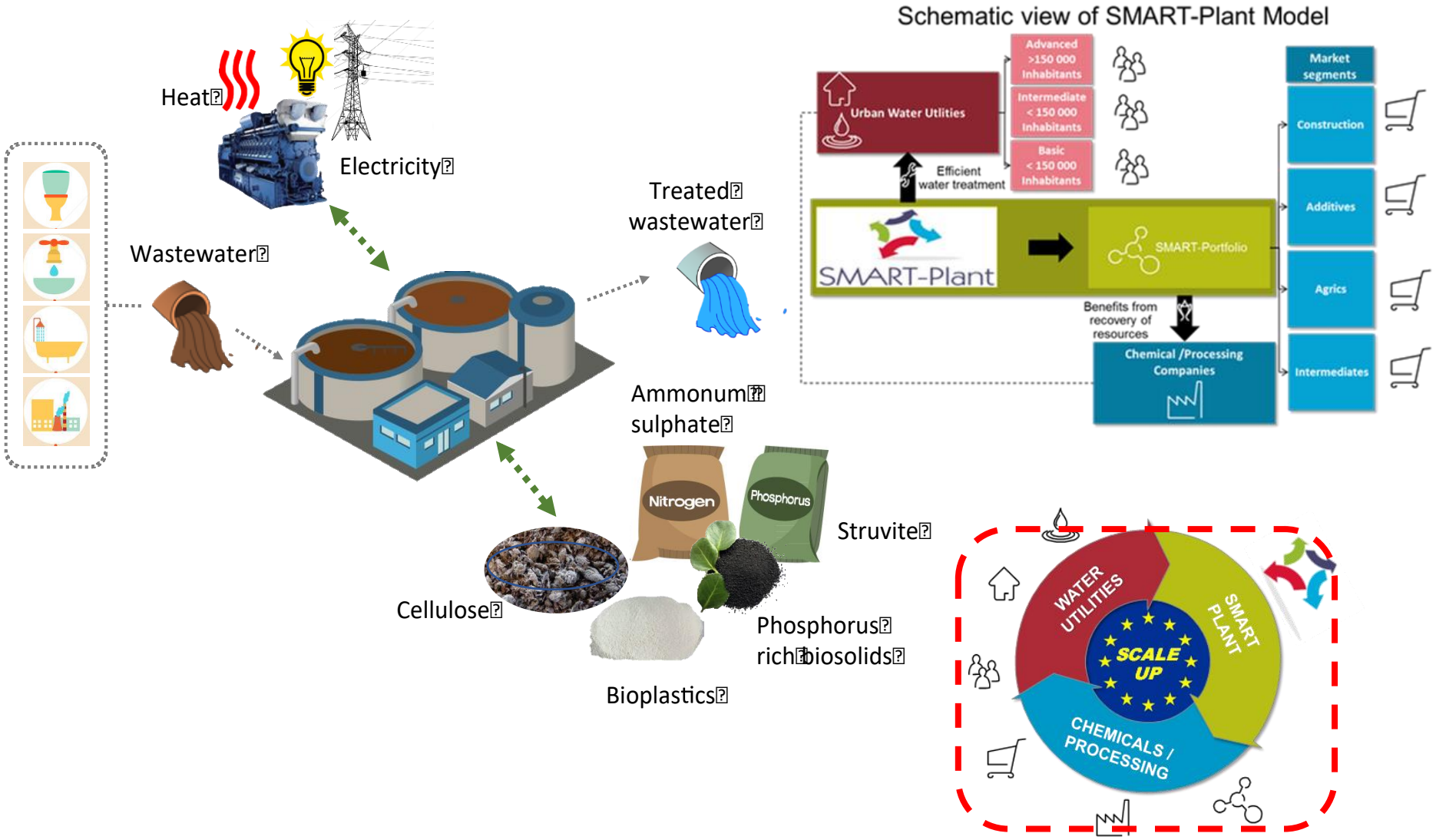
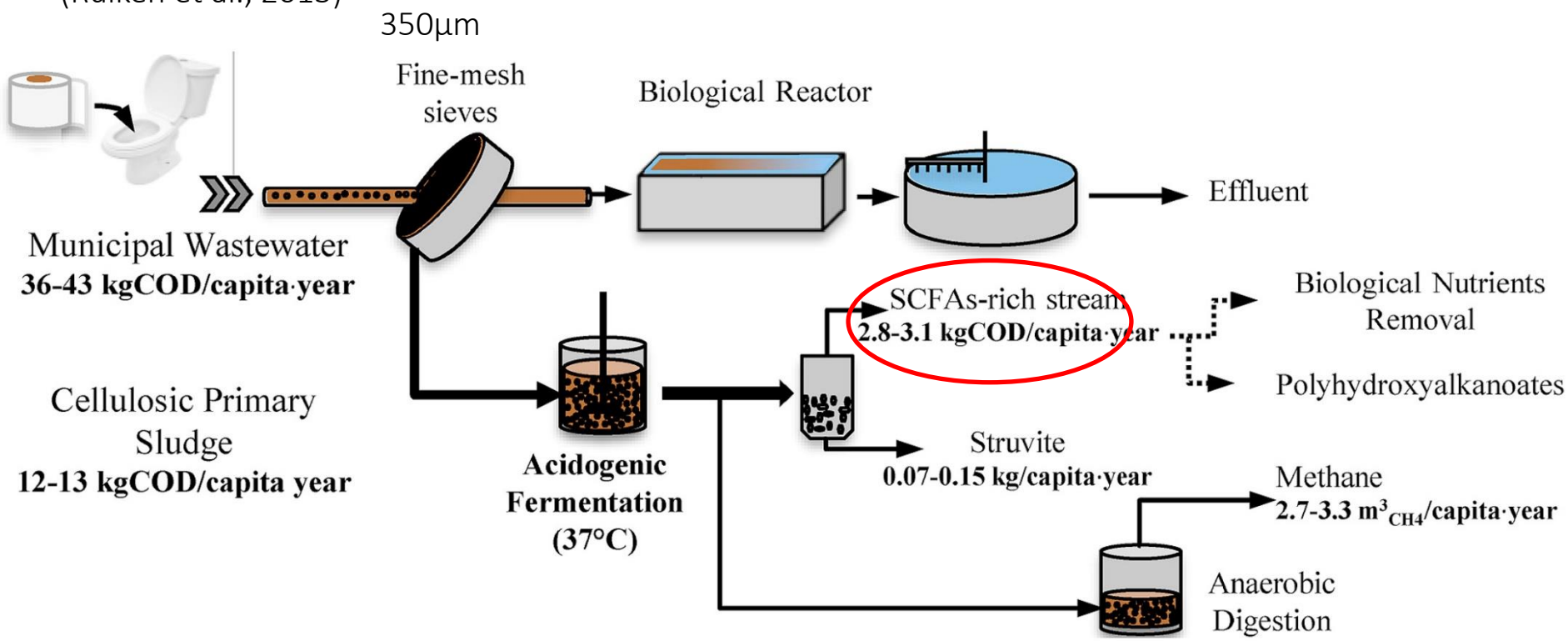
Horizon 2020 SMART-Plant Project



Biorefinery of cellulosic primary sludge (CPS)

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



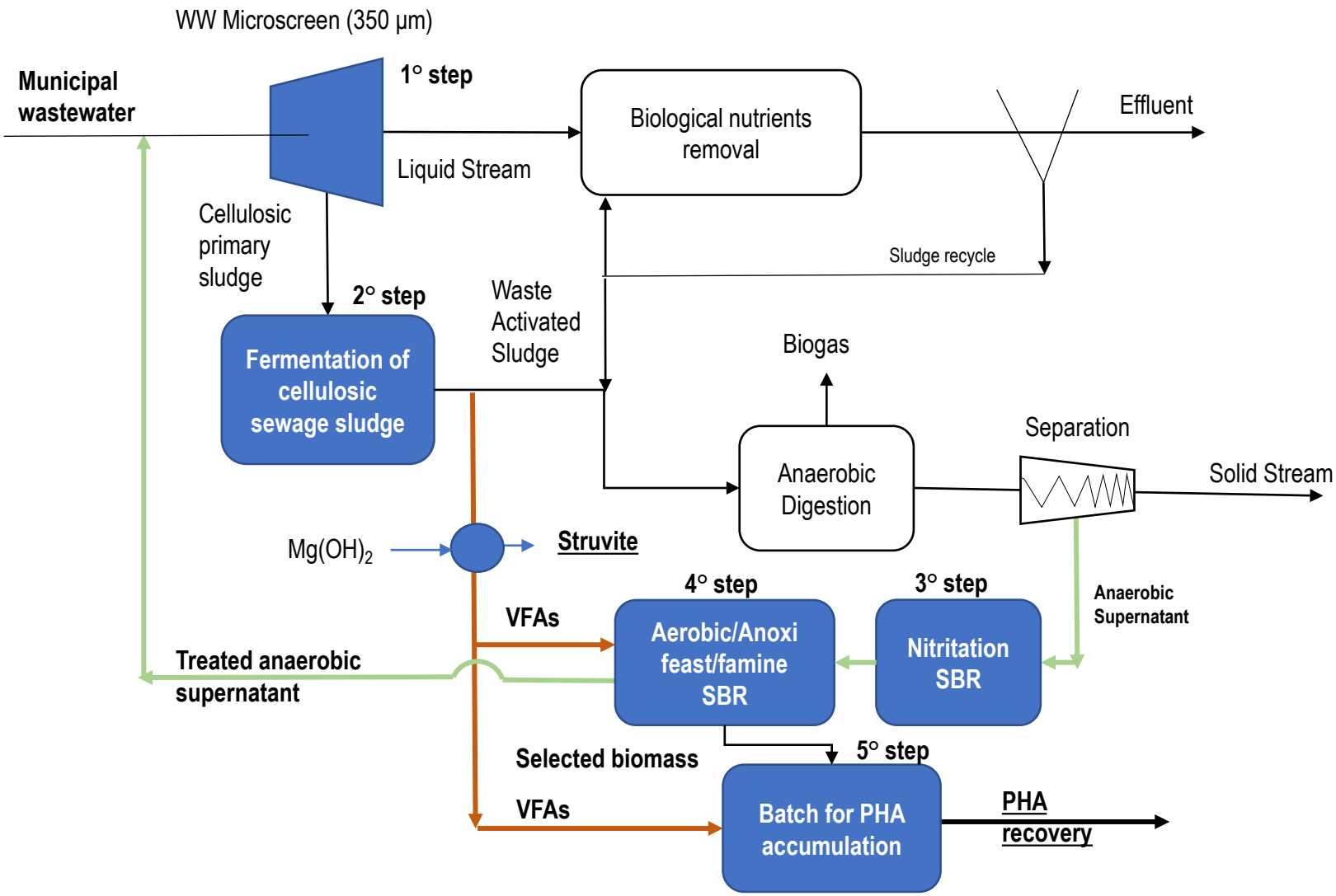
Crutchik et al., 2018

Role of VFAs in Wastewater Treatment

- VFAs are rbCOD and help the denitrification processes;
- Enhanced Bio-P removal (4-5 mgVFA are required for each mg P removed);
- Hydrogen production;
- Biological Nutrients Removal;
- Lipids for biodiesel;
- **Polyhydroxyalkanoates** (PHAs).

Lee et al., 2014. Chemical Engineering Journal.

SCEPPHAR: process configuration



Objectives

- The short-cut Enhanced Phosphorus and PHA recovery pilot plant at the Carbonera WWTP (owned by Alto Trevigiano Servizi Srl)
- Performance of the dynamic rotating belt filter for the recovery of cellulosic primary sludge;
- Selection of PHA storing bacteria during the via-nitrite nitrogen removal from anaerobic reject water (aerobic feast and anoxic famine);
- Mass balance around the system

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

Fermentation unit for VFAs production from CPS

- Volume: 3.0 m^3
- Operating Temperature: 37°C
- HRT: 4-5 days
- SRT: up to 9 days (with ceramic membrane for the separation of the fermentation liquid)
- Probe for the monitoring of the influent TSS concentration

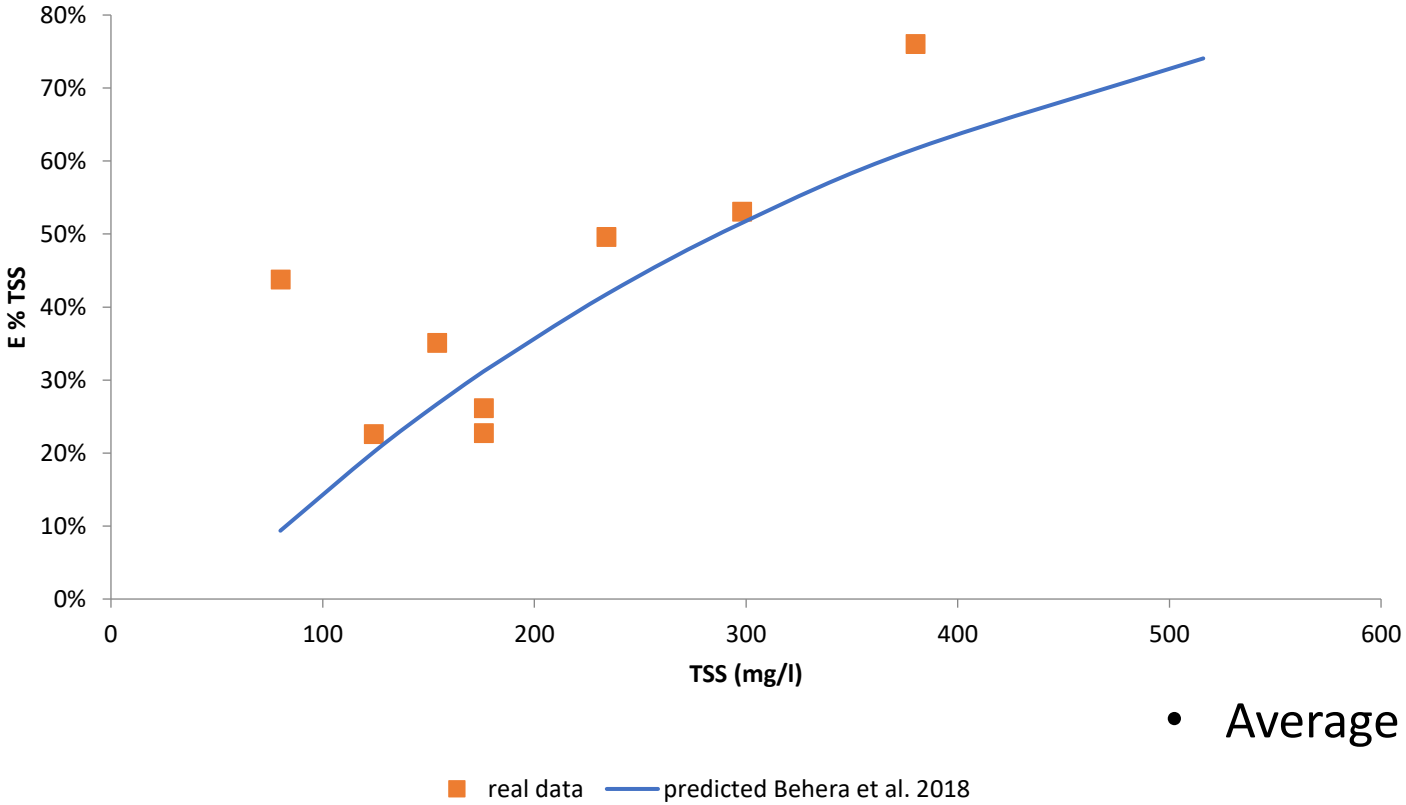
Short-cut enhanced phosphorus and PHA recovery (SCEPPHAR)

WW characteristics after degritting treatment

	pH	TSS	VSS	COD	TKN	NH_4-N	P_{tot}	PO_4-P
Unit	-	mg/l		mgO_2/l	mgN/l		mgP/l	
Average	7.6	258	196	603	42	34	6.9	4.4
St.dev	0.3	156	108	316	11	9	2.7	1.5
Minimum	7.3	80	138	144	25	18	3.4	2.2
maximum	8.4	640	490	1405	72	52	13	6.4

- COD:N:P ≈ 100:7:1
- %VS/TS ≈ 76%
- Significant diurnal fluctuations of the suspended solids concentration

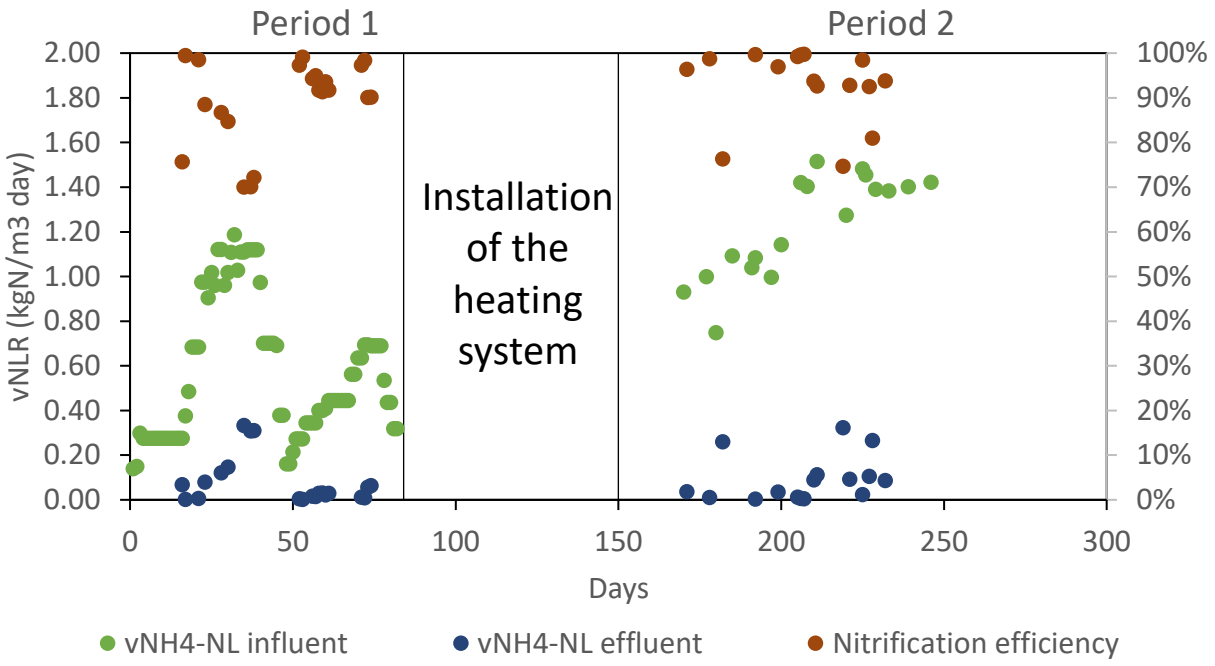
Dynamic sieving



- Average TSS removal = 41%
- tCOD removal= 26%
- Cellulose content in CPS= 41%

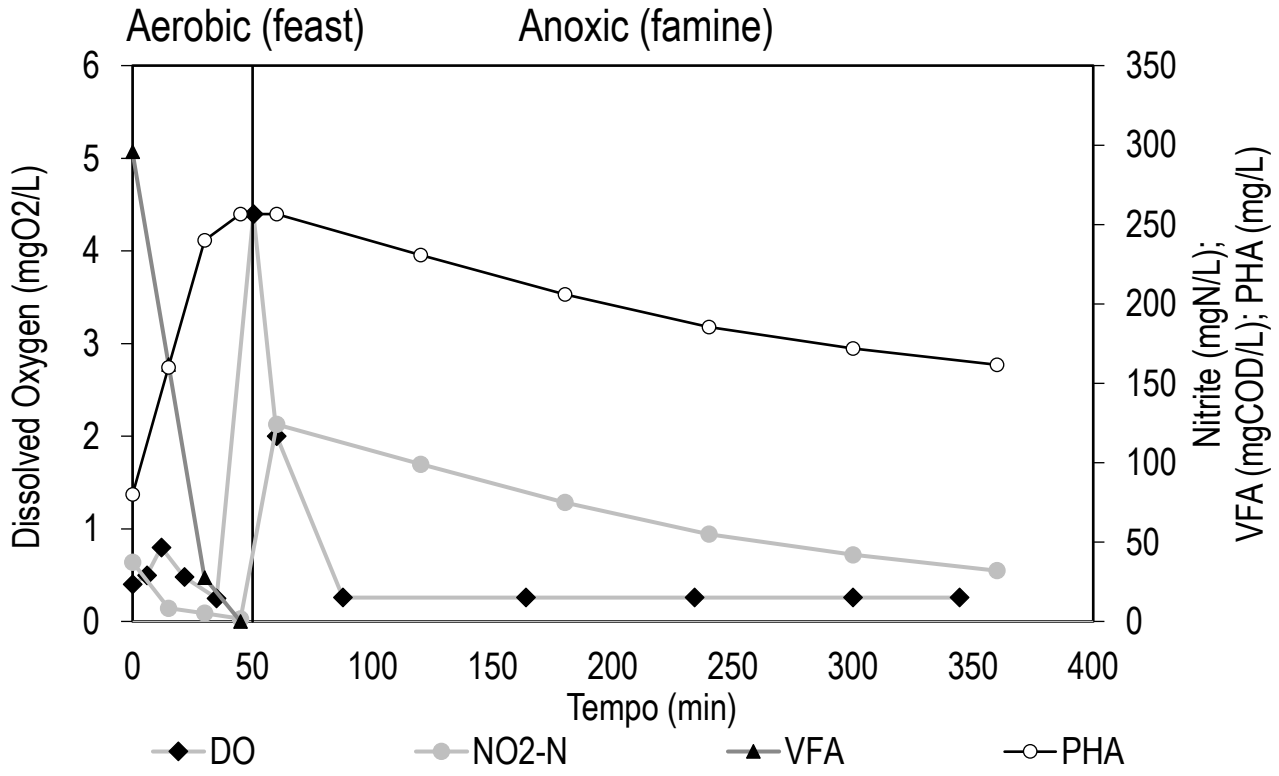
The sieving of the wastewater is driven by the TSS concentration

Nitritation SBR



- In Period 2 the vNLR was increased up to 1.55-1.60 kgN/m^3 day;
- In Period 2 the observed nitritation rate was 55-60 mgN/L h;
- The nitritation efficiencies was around 80-90%

Typical cycle profile of the selection SBR



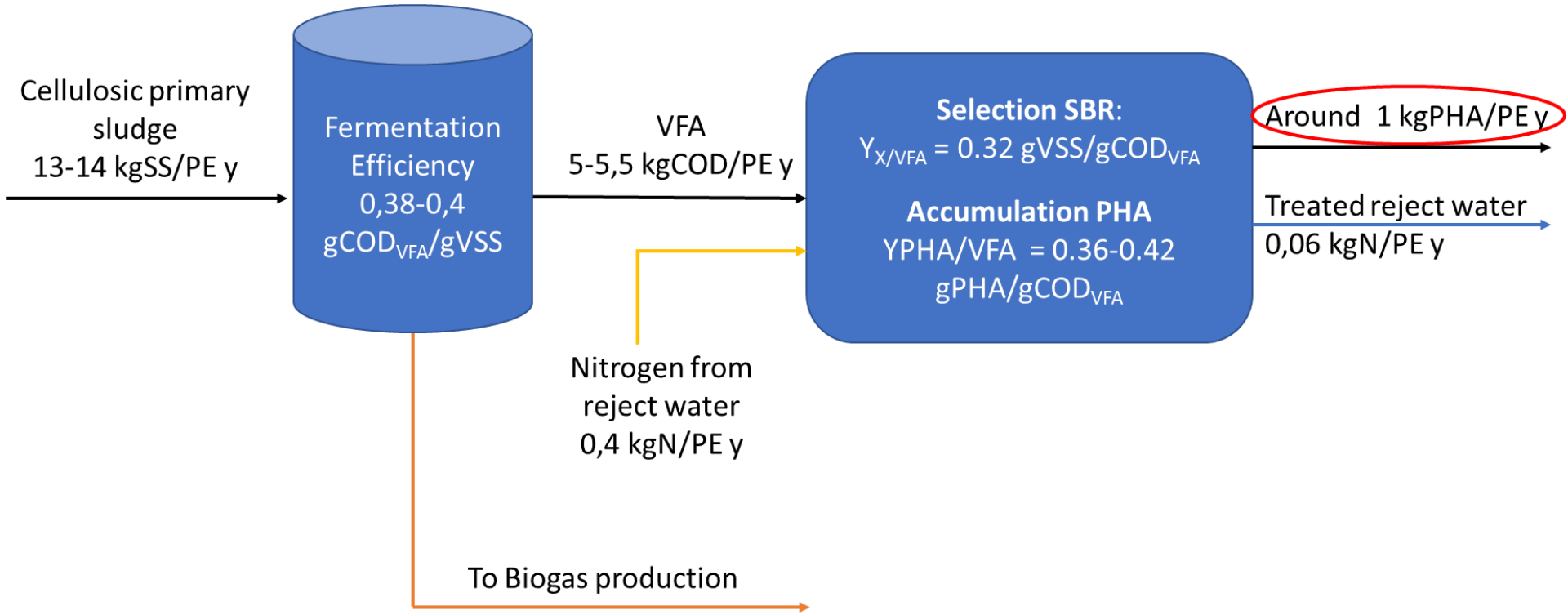
- Nitrite removal efficiency around 85%;
- The kd (@20°C) was 8-10 mgN/gVSS h (driven by PHA degradation)
- In Period 2, the feast/famine ratio was 0,15-0,20

Accumulation batch

Data	Type of CS	COD(VFA) fed	PHA production	Observed PHA Yield	-qVFA	-qPHA
		kgCOD added	kgPHA produced	kgPHA/kg COD(VFA)	mgCOD/ gVSS h	mgCOD/ gVSS h
26/09/17	Ac. Acid	2,00	0,75	0,37		
03/10/17	Ac.Acid	2,50	0,93	0,37	806	301
27/02/18	Ac. Acid	3,50	1,14	0,32	1142	370
20/03/18	Cell Prim Sludge	3,36	0,87	0,26	452	117
23/04/18	Cell Prim Sludge	2,63	0,94	0,42	584	209

- **Up to 45% (dw) of PHA content in biomass cells;**
- **Around 60% of HB and 40% of HV**

Mass balance around the system



Conclusions

- Cellulosic primary sludge is suitable for the production of VFAs at high rate (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;
- The nitrogen removal efficiency was around 85%
- The yields obtained observed in Period 2 resulted in a PHA production of around 1 kg of PHA/PE y. The productivity will be validated during the two years of Smart-Plant Project.

THANK YOU !

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