Integrated Pilot-Scale Anaerobic Membrane BioReactor and acidogenic Sludge Fermentation to treat Low-Loaded Municipal Wastewater

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SMART-Plant

Scientific and technological progress

Goals

CELLULOSE and BIOPOLYMER

MATERIALS RECOVERY AND BIOBASED PRODUCTS

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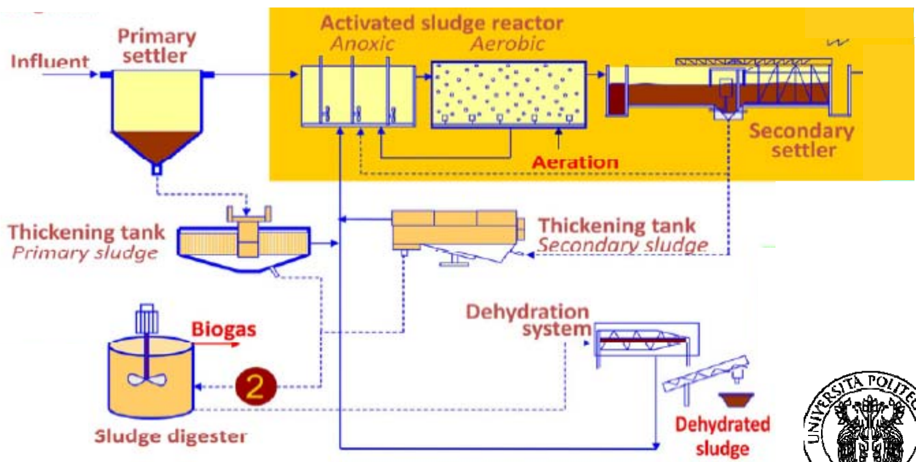
Water 2014 Works

PIONEER_STP

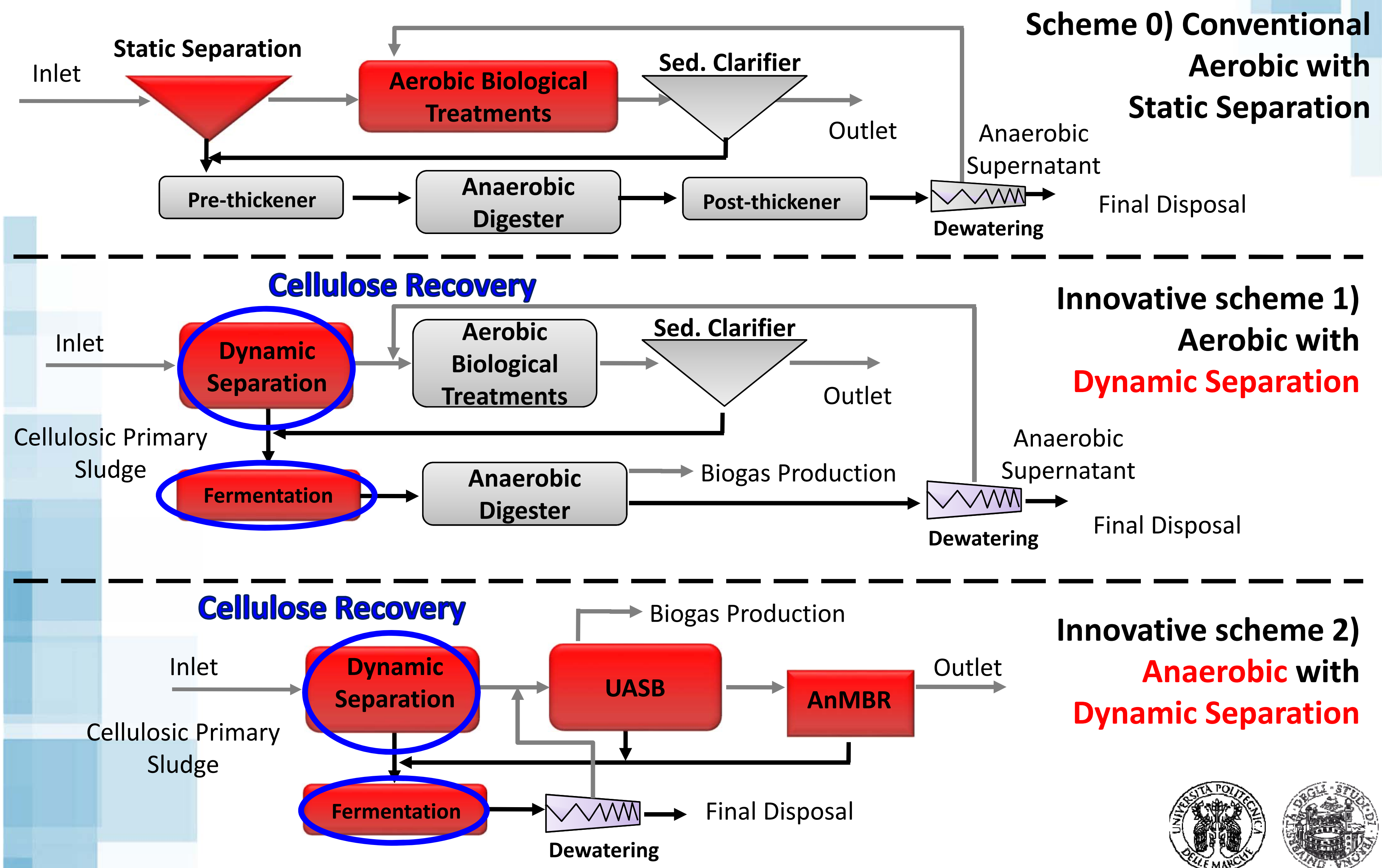
PROCESS OPTIMIZATION TOWARDS Z.E.P.

Zero Energy Plant

CIRCULAR ECONOMY

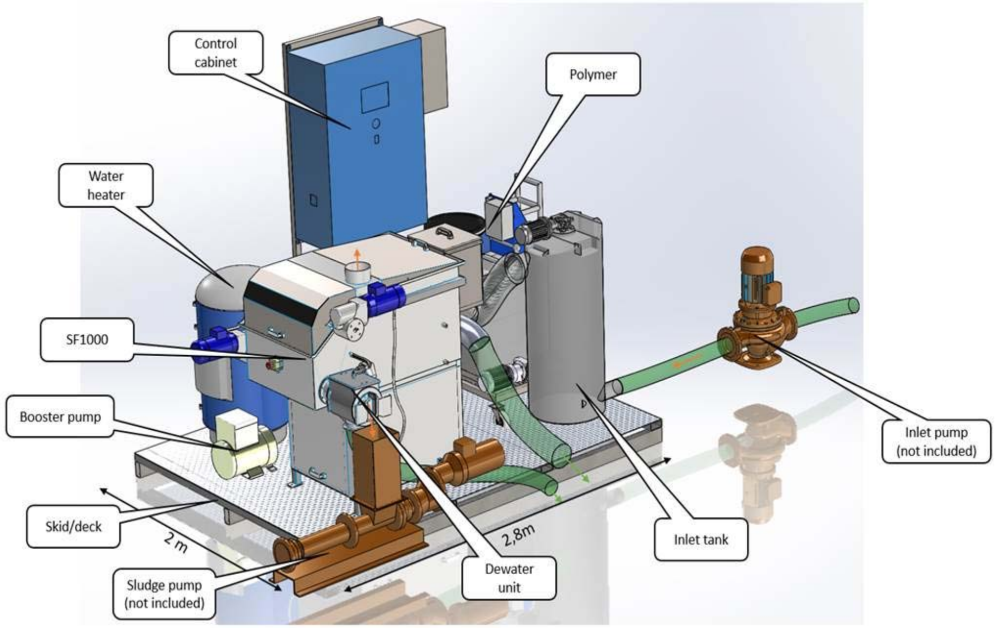


Conventional VS Innovative Technologies



Set up and Wastewater Parameters

- **Falconara WWTP DEMO SITE 1**



	Operational flow rate	TSS	COD	TKN	NH_4	P_{tot}	PO_4
	m^3/h	mg/l	mgO2/l	mgN/l	mgN/l	mgP/l	mgP/l
Falconara	15-50	132±65	251±118	22±10	16±7.5	2.9±1.0	1.4±0.5

Dynamic Separation in Pilot Hall

Pilot Hall UNIVPM

• Falconara Demo Site 1
Dynamic Separation

PLC Panel

Manual/Automatic mode
automatica to change screw,
belt and blower settings

Polimer dose station
and hot water boiler
for belt washing

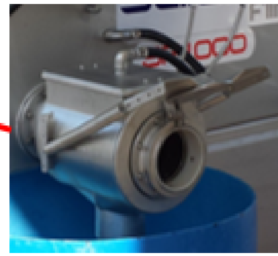
100 l Drinking water
tank for belt washing

Filter Belt Meshes: 500, 350, 250, 158, 90 µm

Screw

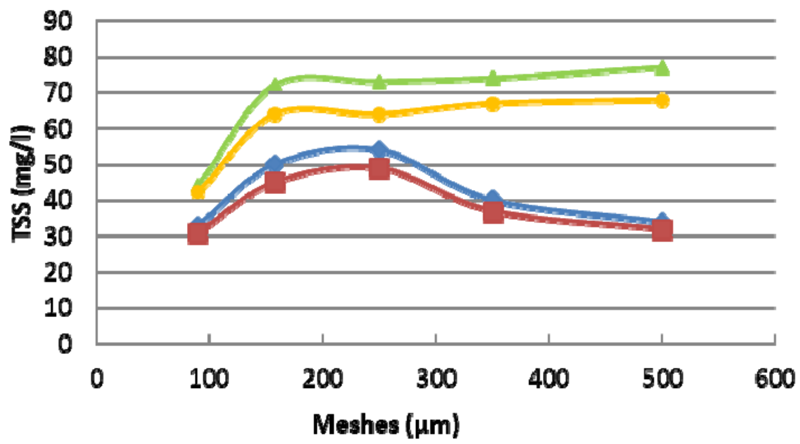
Cellulosic Sludge

Dewatering Unit



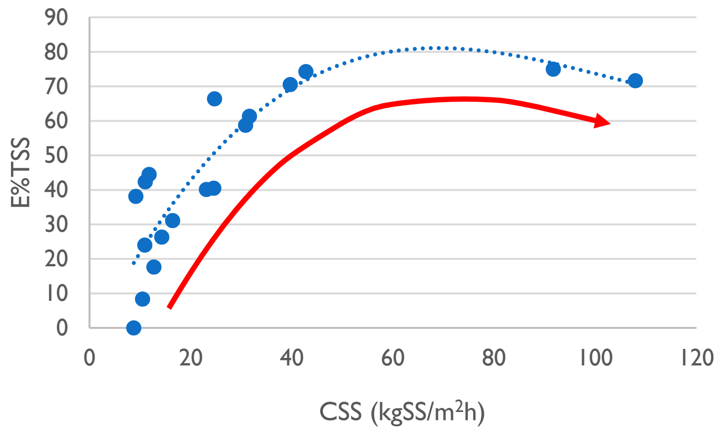
Dynamic Separation-Preliminar Test

Experimental Test



Preliminar Static Sieving Tests

Higher solids load:
the better removal efficiency



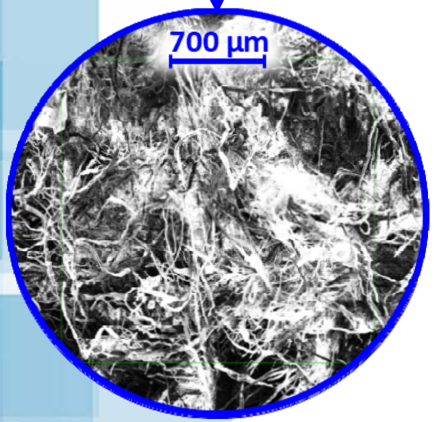
- The TSS removal ranged between 8-75% and influent hydraulic and solid loading rates strongly affects the solid removal.

Cellulosic Sludge Production & Cellulose Recovery

Pilot Hall UNIVPM

•Falconara Demo Site 1 - Dynamic Separation
Test at 30÷50 m^3/h without Polymer at different mesh

How much cellulose can we recover?

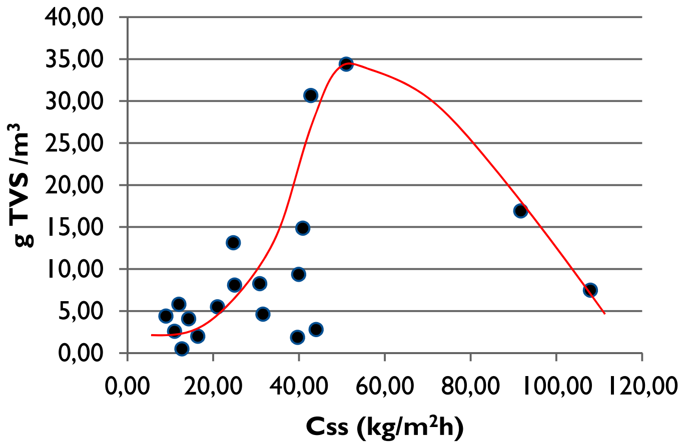


MAX at 90 µm

Primary Clarifier	Dynamic Separation
gTVS/m^3	gTVS/m^3
17,7	34,4

Composition	No washed	Washed
	% dry	% dry
Lipids	12	6,1
Ashes	11,5	4
Hemicellulose	4,2	5,9
Cellulose	**31**	**51,3**
Lignine	14	18,8
TOTAL	72,7	86,1

Specific Production of recovered cellulosic sludge?



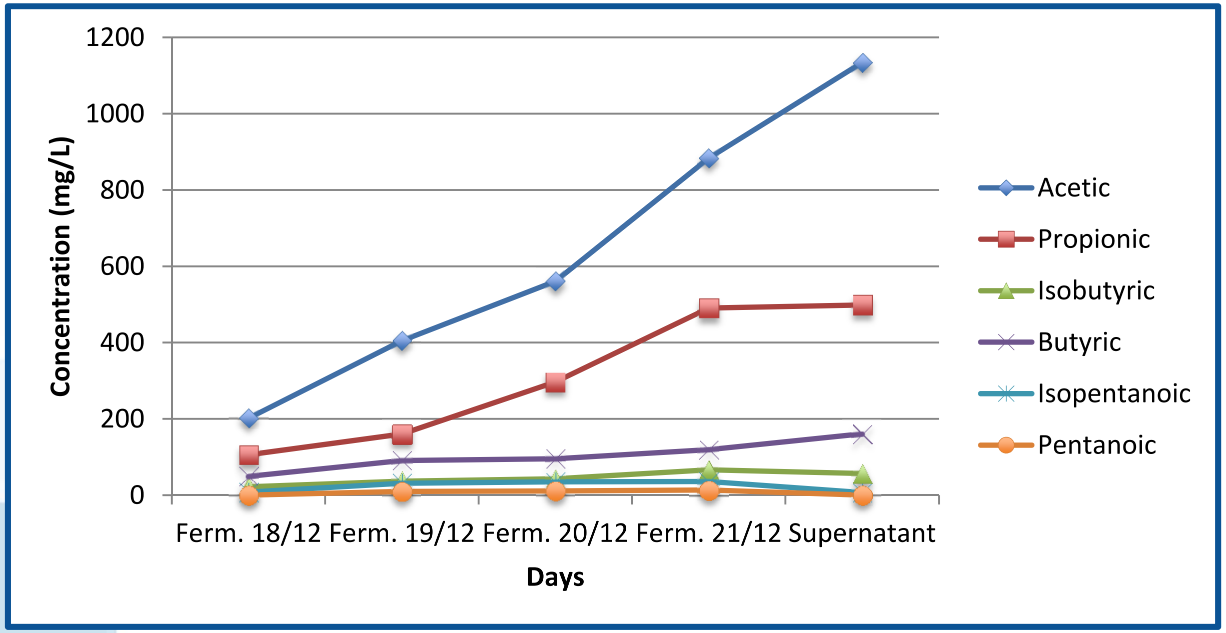
Fermentation and VFAs production

Fermentation		Pilot -scale			
Substrate		**Cellulosic Primary Sludge**			Primary Sludge
Mesh	µm	350	350	90	-
Temperature	°C	30	40	30	30
HRT	d	6	6	6	6
VFAs yield	mgCOD/ gTVS	136	123	**254**	105

Reference Yield
from literature

mg COD/ g TVS
340*

**Font: Crutchik D., Frison N., Eusebi A.L., Fatone F.*



VFAs production during fermentation.

Example with Sludge separated at 350 µm

Anaerobic Treatments on Urban Wastewater

UASB + anMBR (UF)

Time Line

Configuration	**UASB**	**UASB**	**UASB + AnMBR**
Period	1) 50 d	2) 115 d	3) 100 d
Vup	1 m/h	1 m/h	1 m/h
OLR	START UP	OLR 1 = 1.1 KgCOD/m3/d	OLR = 1.7 kgCOD/m3/d
Task	START UP*	NO **EXTERNAL CARBON SOURCE**	DOSAGE of **LIQUID FRACTION of FERMENTED SLUDGE** as CARBON SOURCE

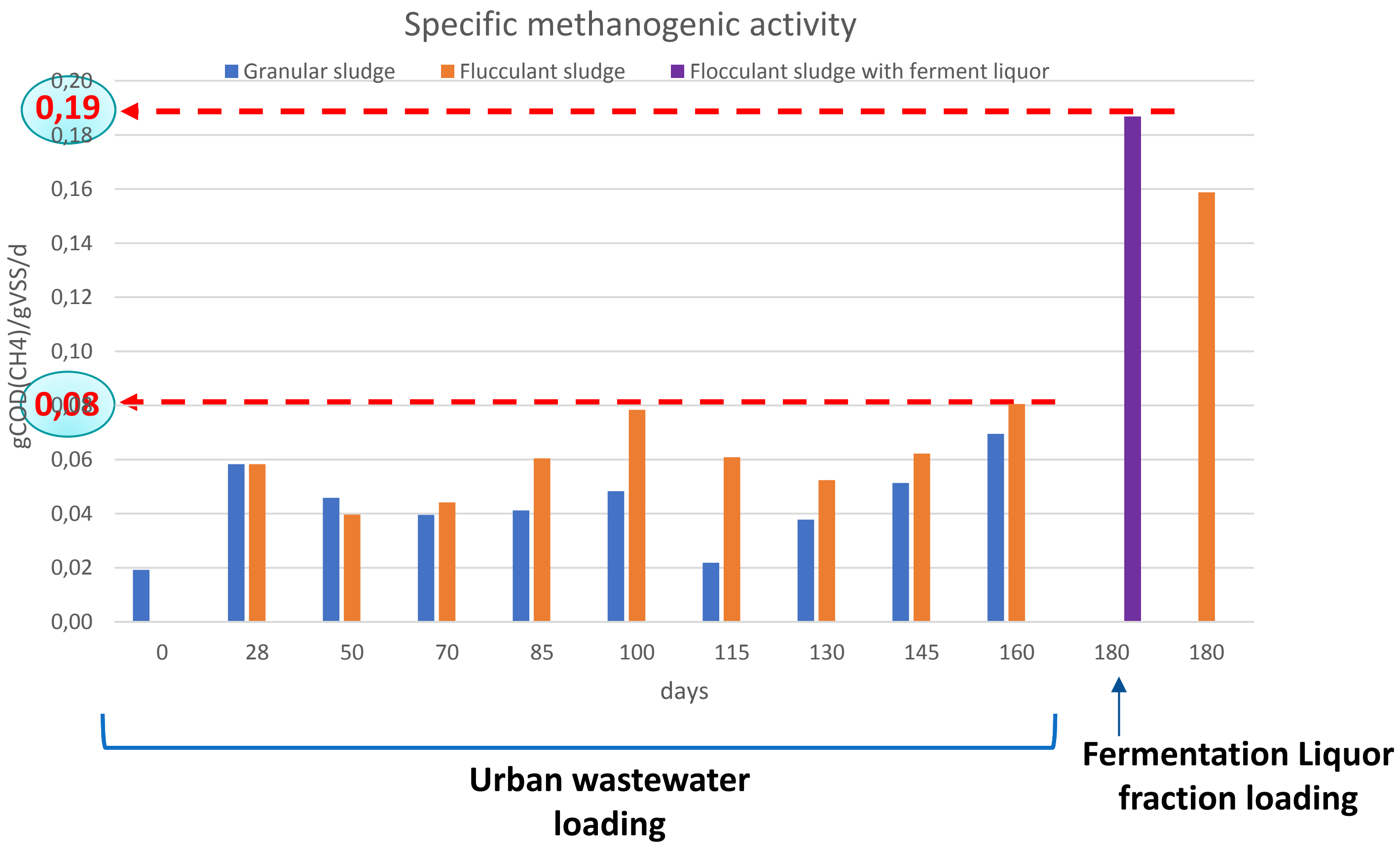
Operating parameters

Qin	l/h	3
HRT	h	5
OLR	$kgCOD/m^3/d$	1 ÷ 2
Vreactor	l	16.6
Temp.	°C	30

*inoculum with granular/flocculant sludge coming from paper industry

Specific Methanogenic Activity tests Results

INFLUENT	pH	alk.	TSS	COD	CODs	CODp	NH4-N	TKN	Cl	SO4	PO4-P	TP
	-	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
MEDIA	**8**	**321**	**207**	**218**	**59**	**160**	**25**	**41**	**276**	**135**	**3**	**5**
DEV. STD	0,3	91	216	76	24	75	5	18	105	52	1	1
CV%	3%	28%	104%	35%	40%	47%	19%	43%	38%	39%	20%	18%



Effects of organic load variations

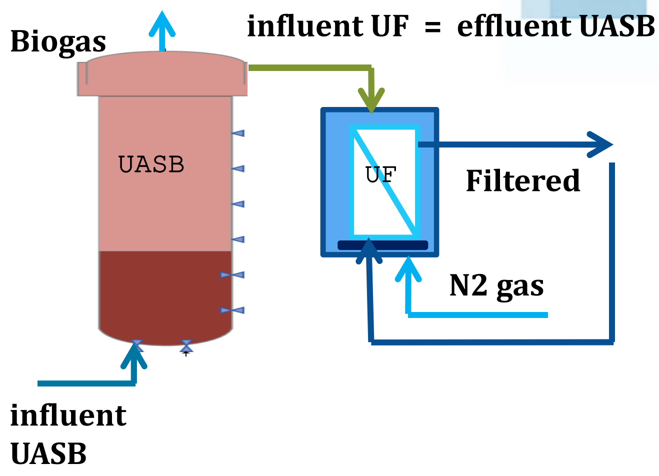
LOW LOADED URBAN WASTEWATER

Biogas Production

	Flow	CH_4
	L/d	%
MEDIA	0,44	33,2
DEV. STD	0,22	6,1
CV%	51%	18%

Removal Efficiency

	E%COD	E%CODs	E%TSS
	%	%	%
MEDIA	65%	55%	85%
DEV. STD	13%	28%	9%
CV%	20%	51%	11%



FERMENTATION LIQUOR FRACTION

Biogas Production

	Flow	CH_4
	L/d	%
MEDIA	3,9	>50%
DEV. STD	3,7	-
CV%	94%	-

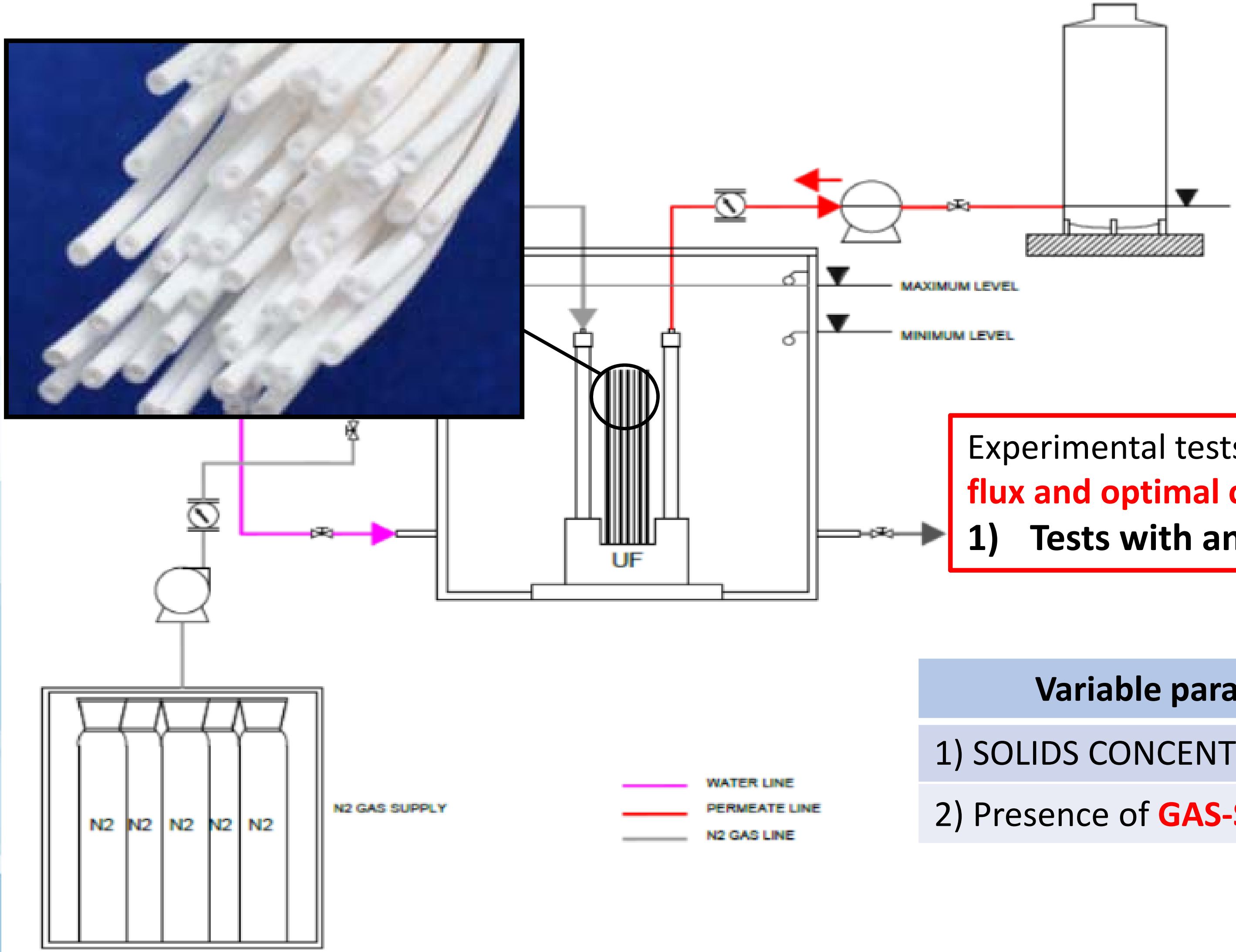
Removal Efficiency

	E%COD	E%CODs	E%TSS	E%COD AnMBR	Coli log Removal
	%	%	%	%	-
MEDIA	60%	64%	27%	85%	6,5
DEV. STD	17%	13%	20%	6%	-
CV%	29%	20%	73%	7%	-

UF Permeate → Fertirrigation purpose

EFFLUENT	pH	alk.	TSS	CODs	NH4-N	TKN	Cl	SO4	PO4-P	TP	E.Coli
	-	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	Ufc/ml
MEDIA	**8,2**	**481**	**0**	**50**	**40**	**49**	**460**	**70**	**5,2**	**5,8**	**4,8**
DEV. STD	0,2	96	-	15	21	27	479	32	3,9	4,3	7,1
CV%	2,5%	20%	-	29%	52%	54%	104%	46%	75%	74%	148%

AnMBR: UF Membrane Start up



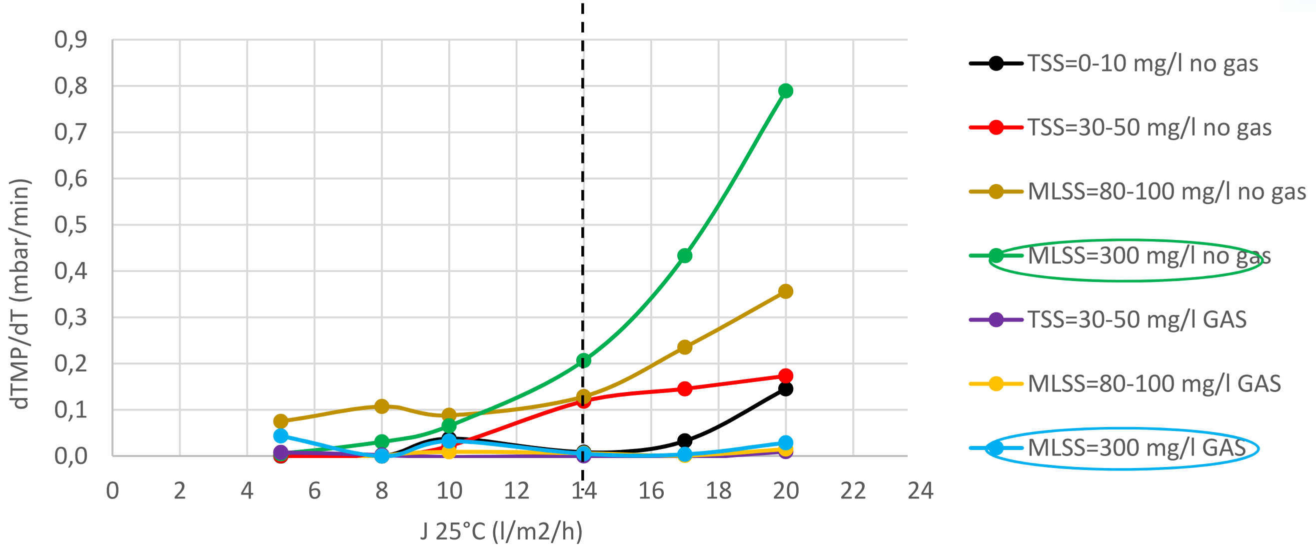
Experimental tests to search **critical flux and optimal conditions** of work:

1) Tests with anaerobic effluent

Variable parameters of tests
1) SOLIDS CONCENTRATION (**TSS/MLSS**)
2) Presence of **GAS-SPARGING** or **NOT**

Critical Flux Determination by flux-step Method

Critical flux at 300 mgSS/L with gas sparging



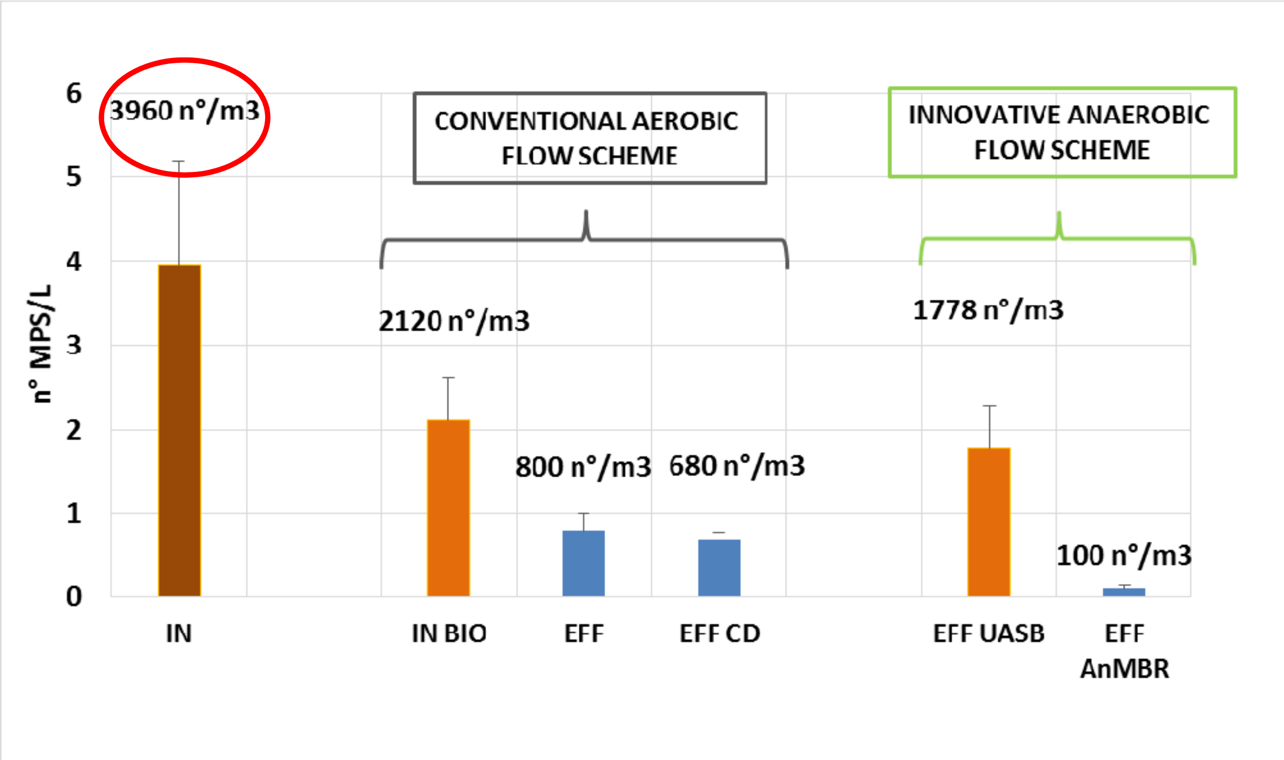
START-UP conditions

Input Flowrate UASB	Q_{in}	l/h	3
Imput TSS	**TSS**	**mg/l**	**150**
Flux	**J**	**l/m²/h**	**8**
Time on	on	min	9
Time off	off	min	1
Q backflush	Q_b	l/h	5.8
Gas sparging on	N_2 on	s	10
Gas sparging off	N_2 off	s	120
Q Nitrogen	Q_{N2}	m³/h	1

< 300 mg/l

< 14 l/m²/h

ANAEROBIC vs CONVENTIONAL AEROBIC FLOW SCHEME: MICROPLASTIC IMPACT AND DESTINATION!



Fiber MPS influent (□39% of Total MPS) are mainly constitued by polyester
>> WASHING MACHINE SOURCE!!

ANAEROBIC vs CONVENTIONAL AEROBIC FLOW SCHEME: MICROPLASTIC IMPACT AND DESTINATION!

		n°MPS/m3	n° MPS/d	E%	
CONVENTIONAL AEROBIC FLOW SCHEME	INFLUENT	3960	7.73E+07		
	INFLUENT BIOLOGICAL REACT	2120	4.14E+07	46	
	EFFLUENT	800	1.56E+07		
	EFFLUENT AFTER CHEMICAL DISINFECTION	680	1.33E+07	36	83
INNOVATIVE ANAEROBIC FLOW SCHEME	INFLUENT	3960	7.73E+07		
	EFFLUENT AFTER UASB	1778	3.47E+07	55	
	EFFLUENT AFTER AnMBR	100	1.95E+06	42	97

PHYSICAL PRE-TREATMENT/SETTLING EFFECT

BIOLOGICAL EFFECT

GLOBAL REMOVAL

Conclusions

- Dynamic Separation allows to separate a higher solids fraction than static separation to increase the recovery of cellulose and VFAs production by fermentation of the separated sludge

- Dynamic Separation + anMBR is an optimal strategy to increase yields of biogas production

- Compatibility for reuse in irrigation

- UASB process control to avoid high frequency of chemical cleaning of UF and maintain low TMP

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Thank you for your attention

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