UNIVERSITÀ DEGLI STUDI DI PALERMO

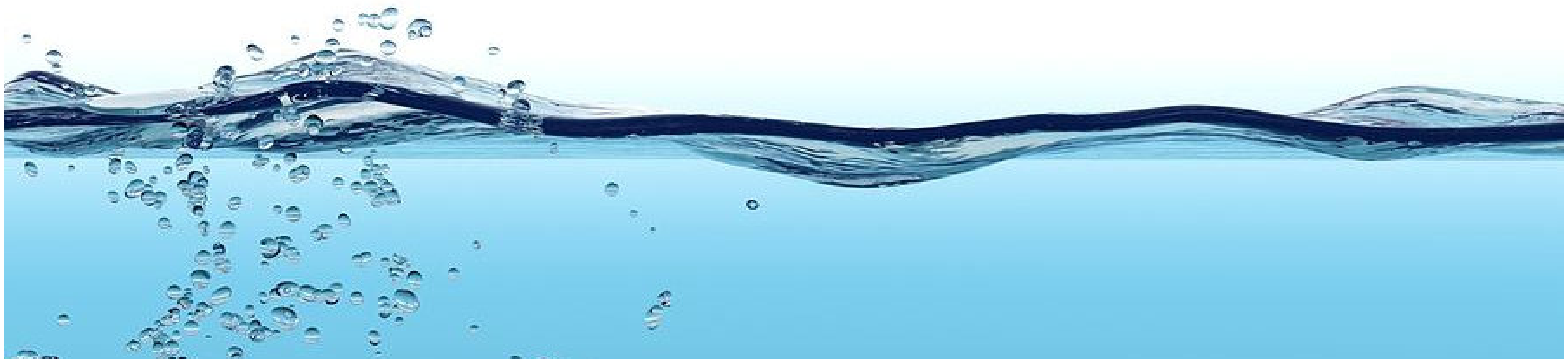
DICAM

New trends and research perspectives towards a more sustainable environment

Palermo 14 Marzo 2014

Energy saving strategies for wastewater treatment: PRIN 2009 project

Michele Torregrossa



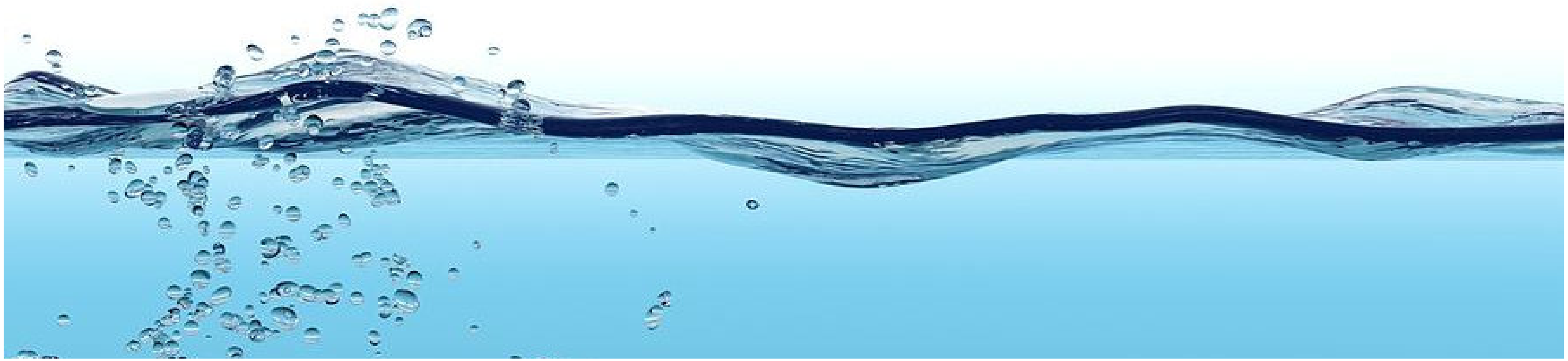
PRIN 2009:

“Microbiological, chemical, physical and kinetical characterisation of biomasses in wastewater treatment plant using Membrane Bioreactor (MBR) units, aimed at simulating removal processes and optimising plant management and exercise.”

Universities of Naples, Cassino, Palermo and CRN-IRSA (Roma)

Topic developed by the research unit of the University of Palermo

“Experimental analysis on MBR systems to study and to realize a model of fouling including the physical and microbiological features of sludge and the operational conditions that influence this phenomenon.”



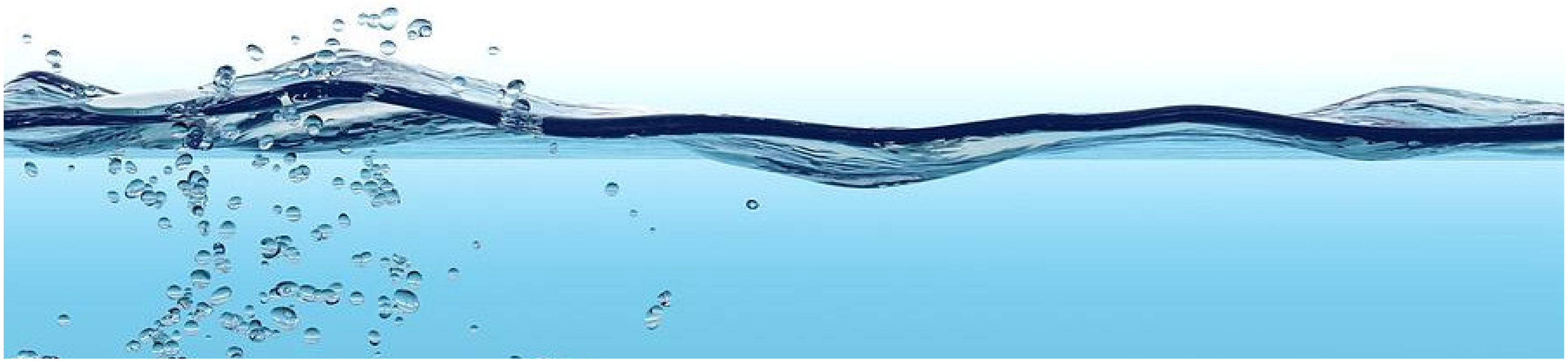
Configuration of experimental pilot WWTP :

Alternating anoxic/aerobic MBR for nitrogen removal

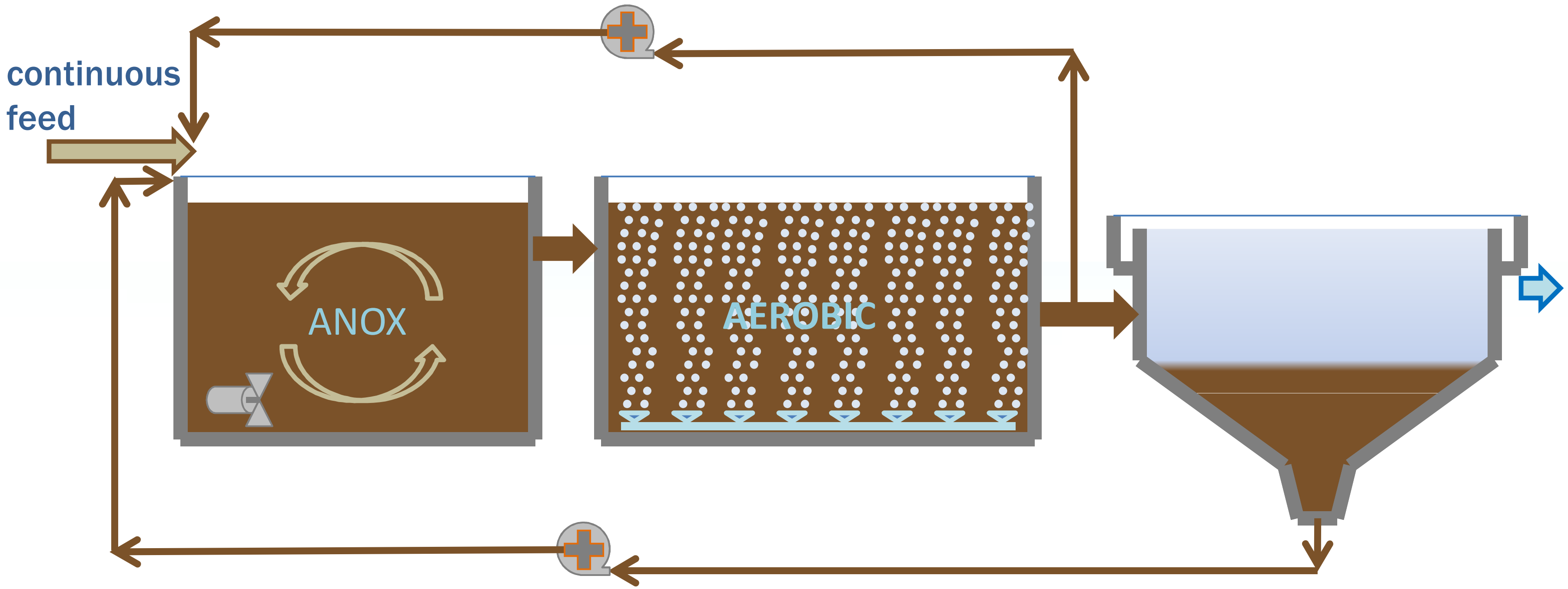
ADVANTAGES OF A PROCESS WITH ALTERNATING PHASES:

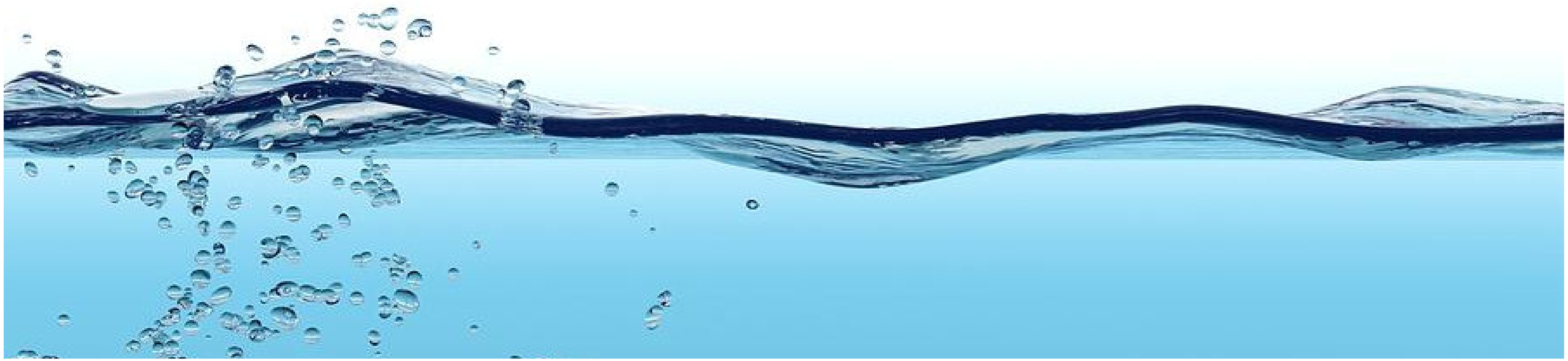
- Energy saving
- Effective removal of nitrogen
- Reduction of sludge production
- Partial biological reduction of phosphorus

- *the process does not require recirculation of mixed liquor*
- *the control of the aerobic phase reduces the supply of air to the specific needs of nitrification*
- *the control of the denitrification phase optimizes the consumption of nitrates*

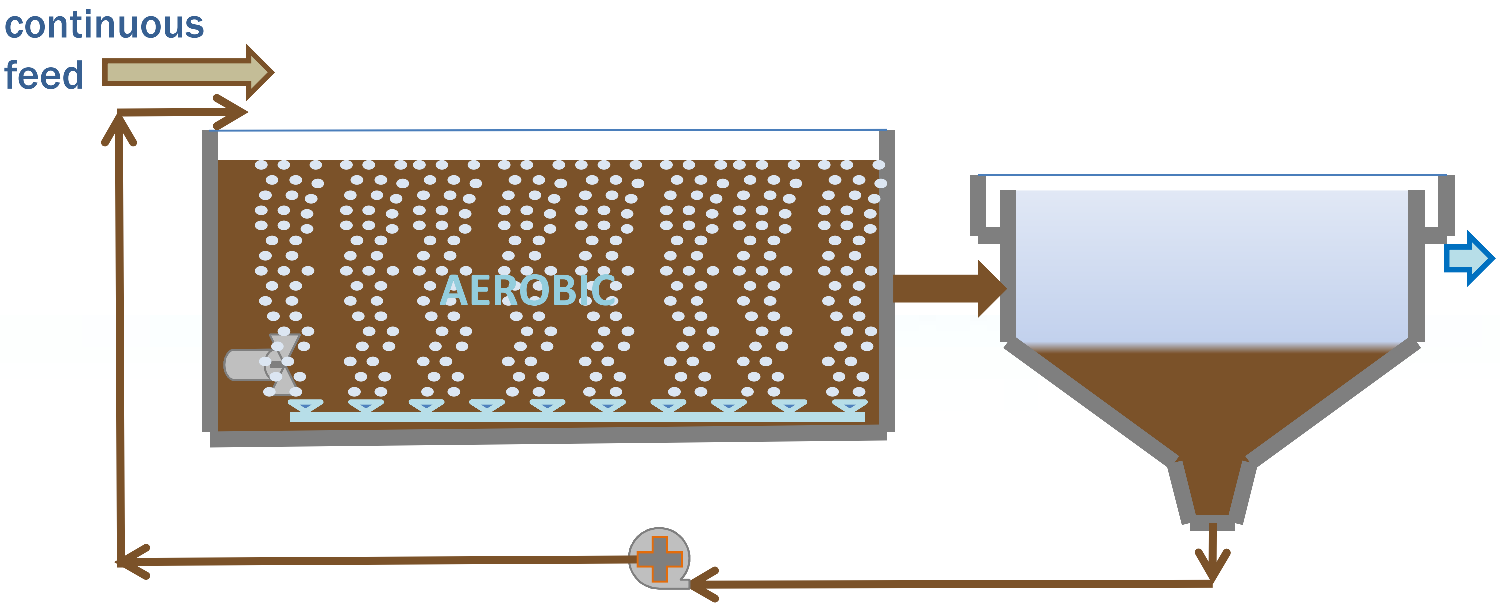


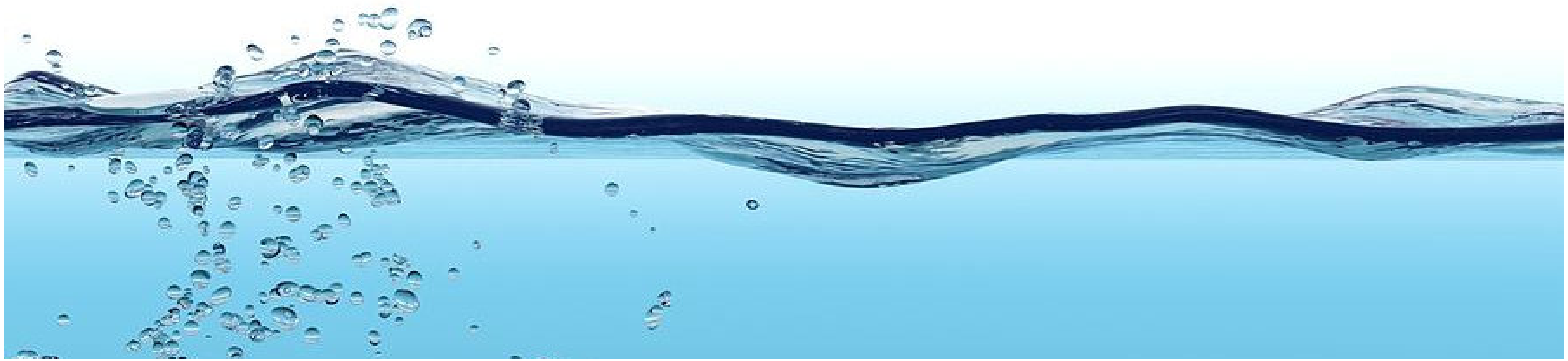
Conventional pre-denitrification/nitrification





Alternating nitrification/denitrification





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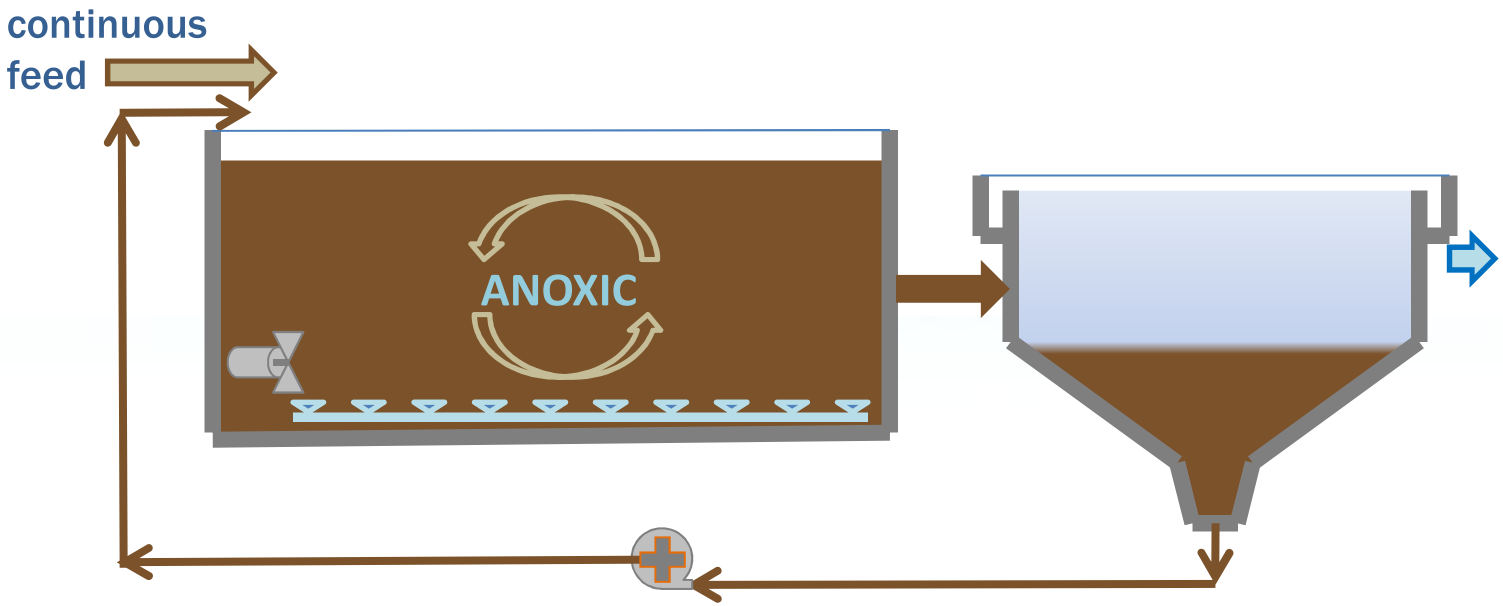

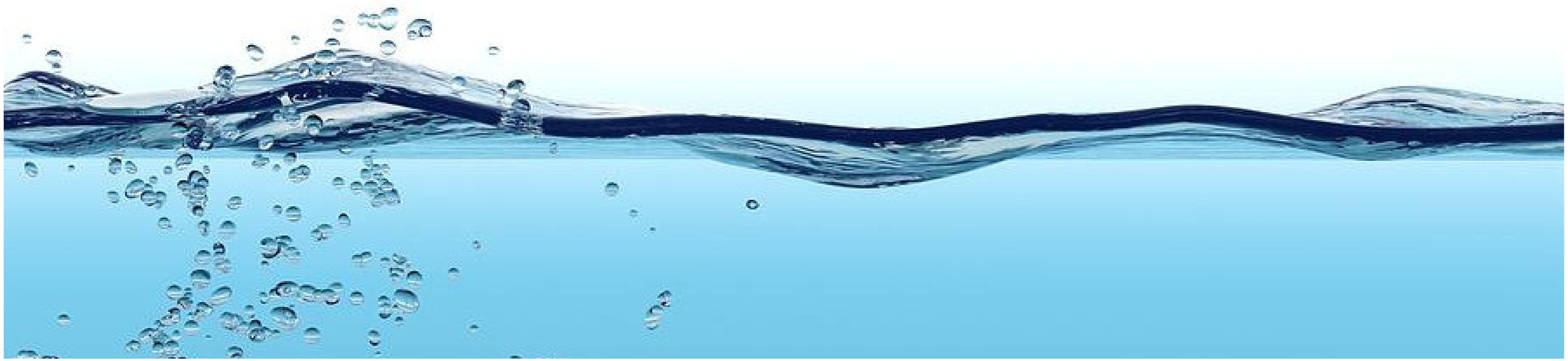

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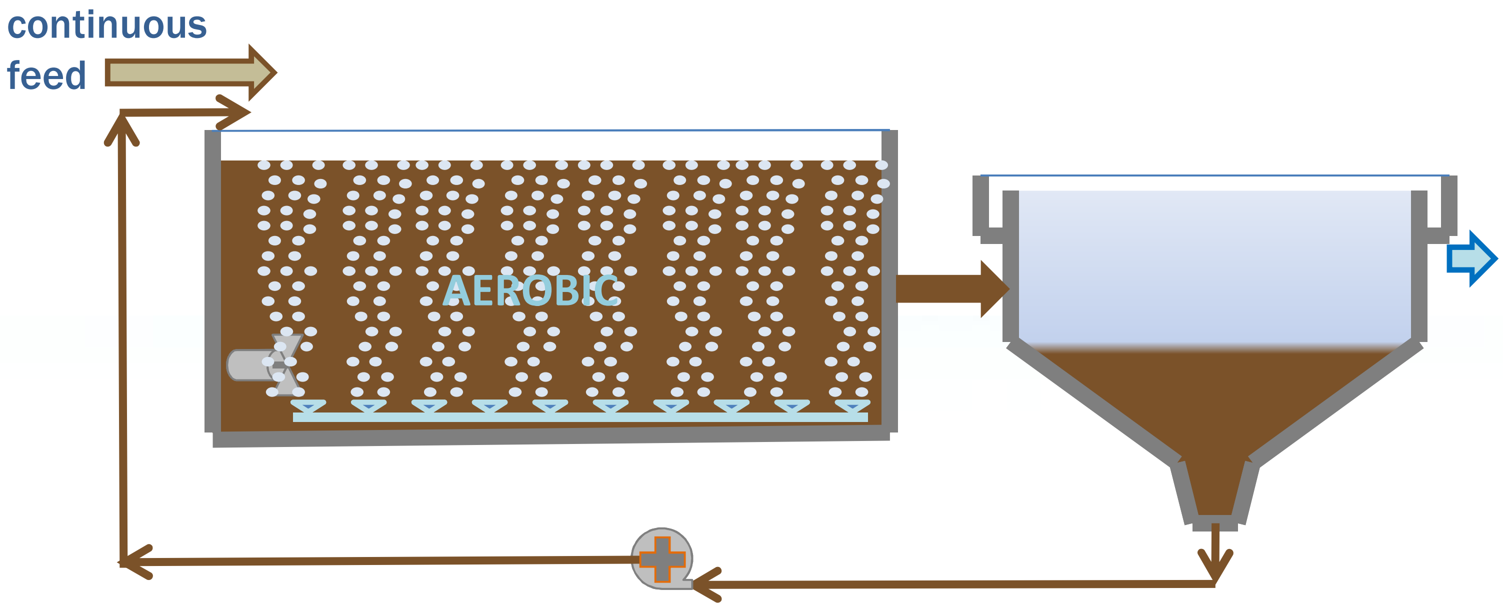
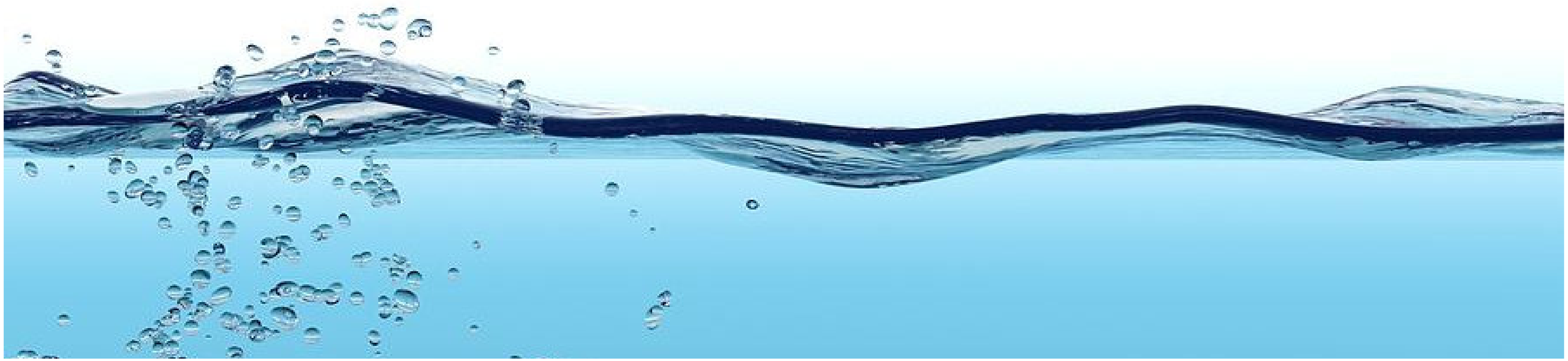
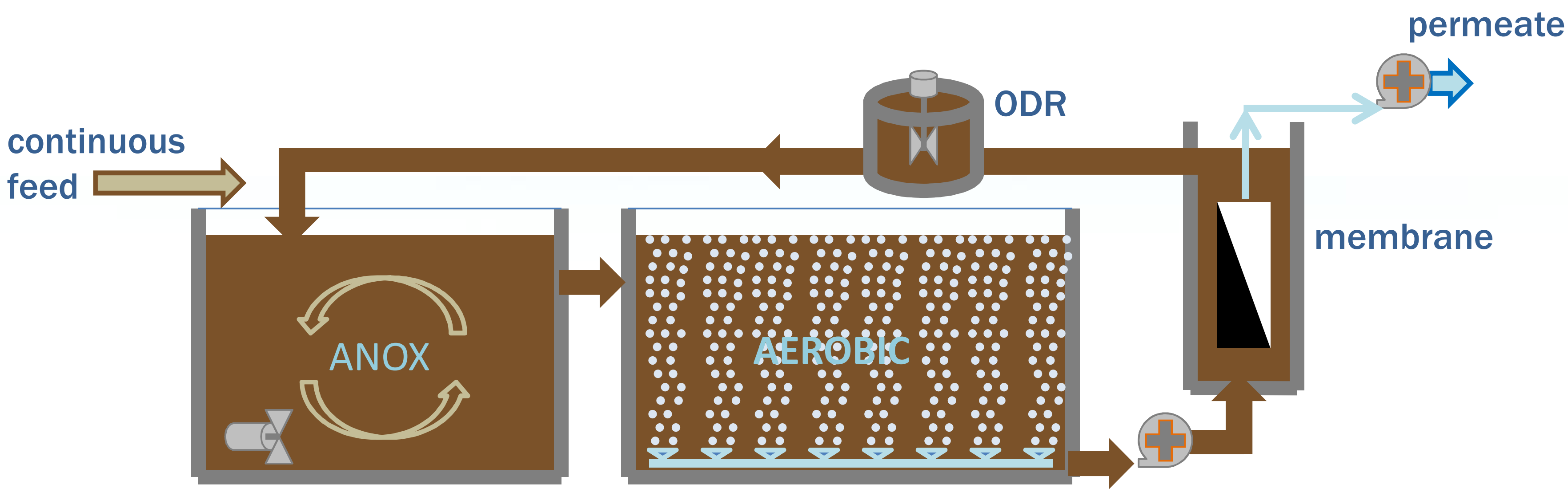




MBR - pre-denitrification/nitrification



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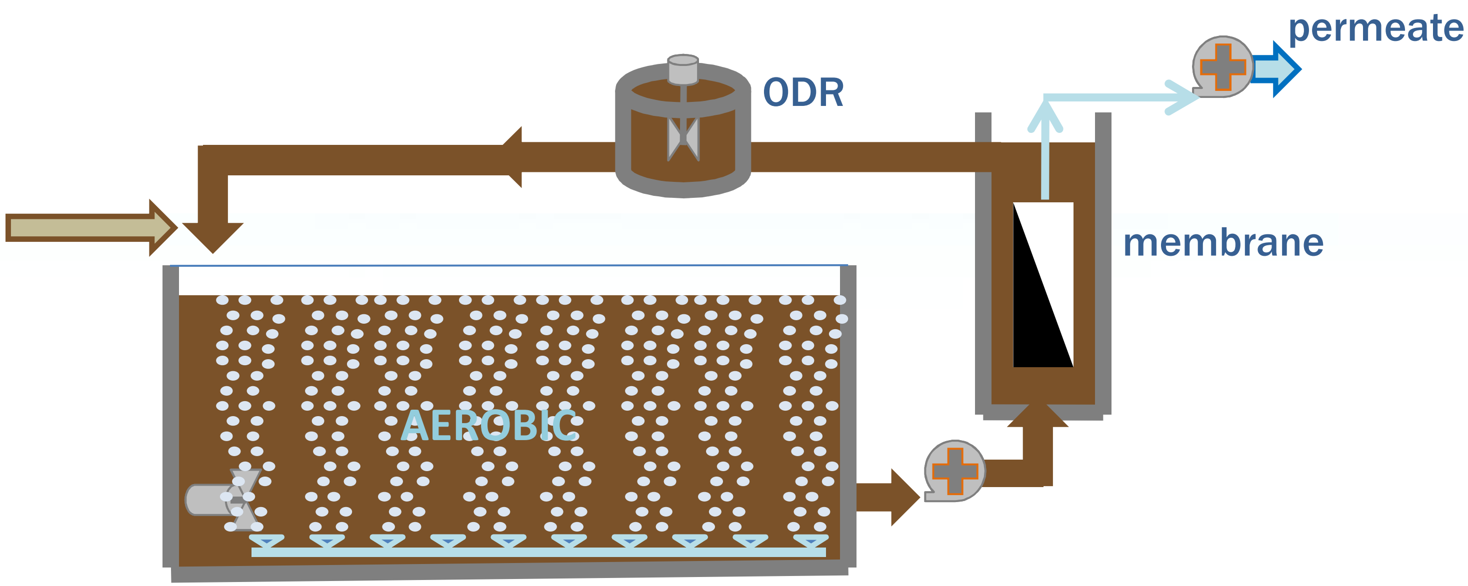

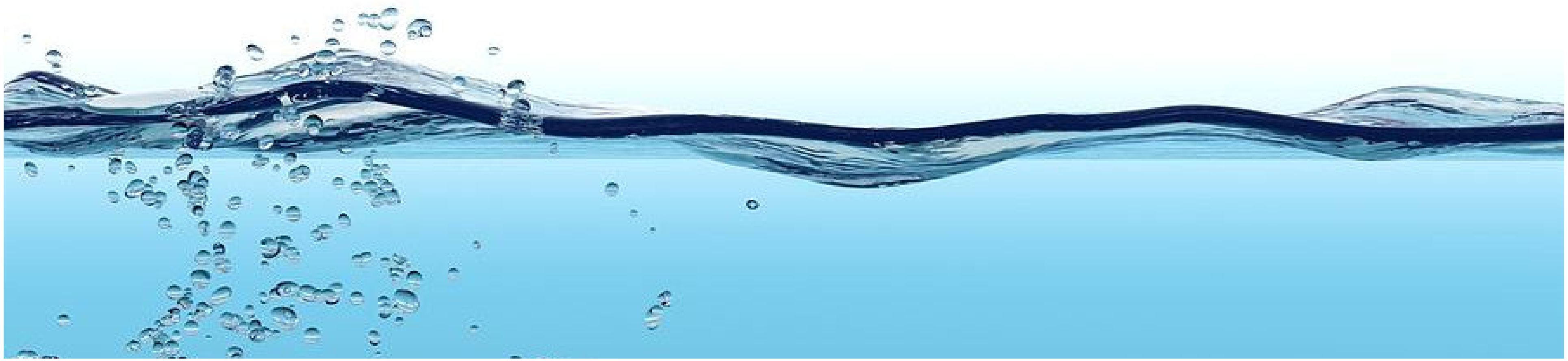

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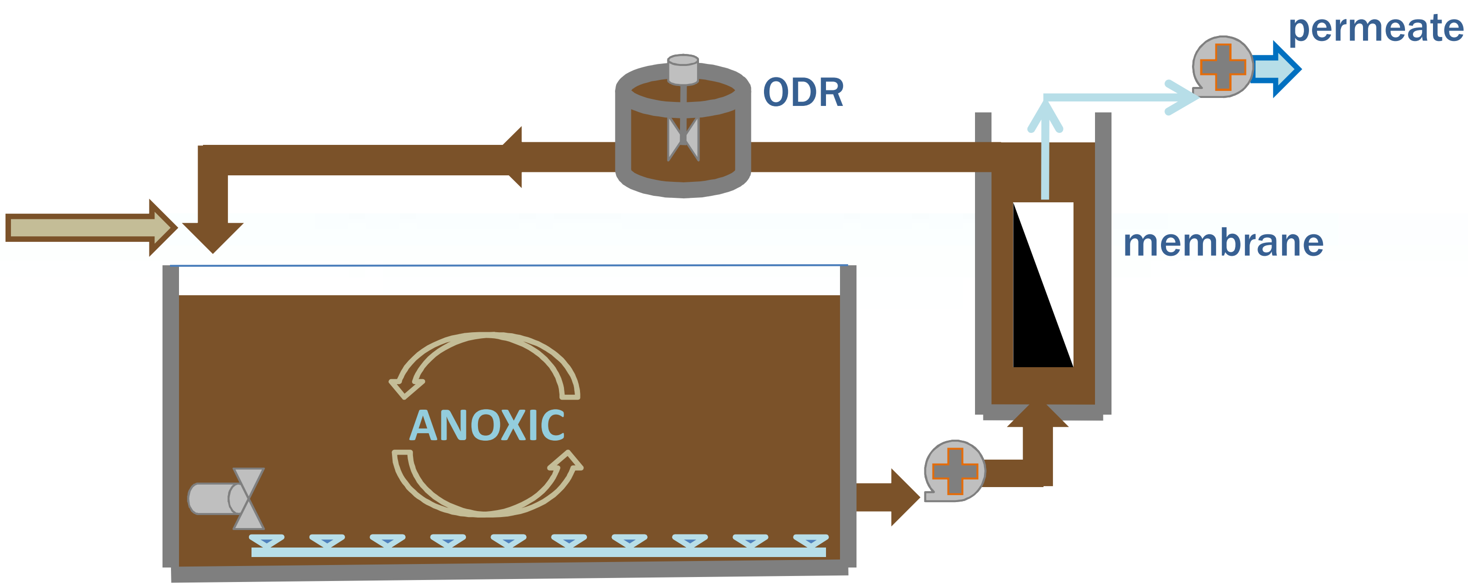

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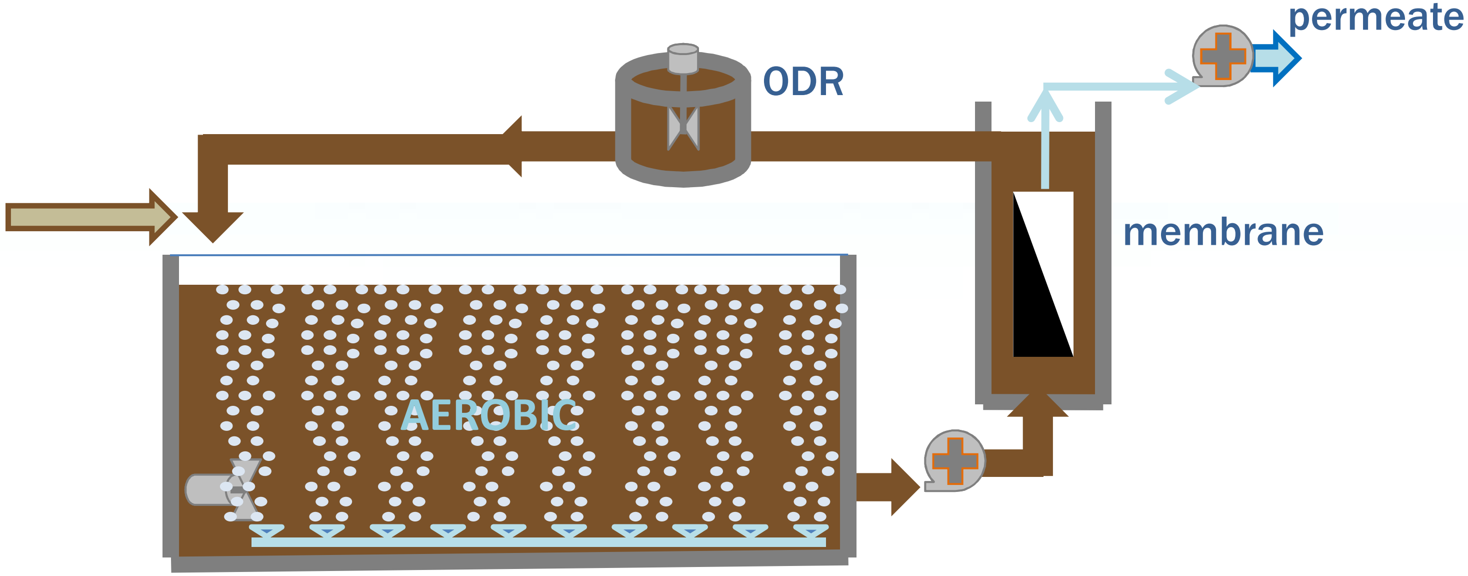
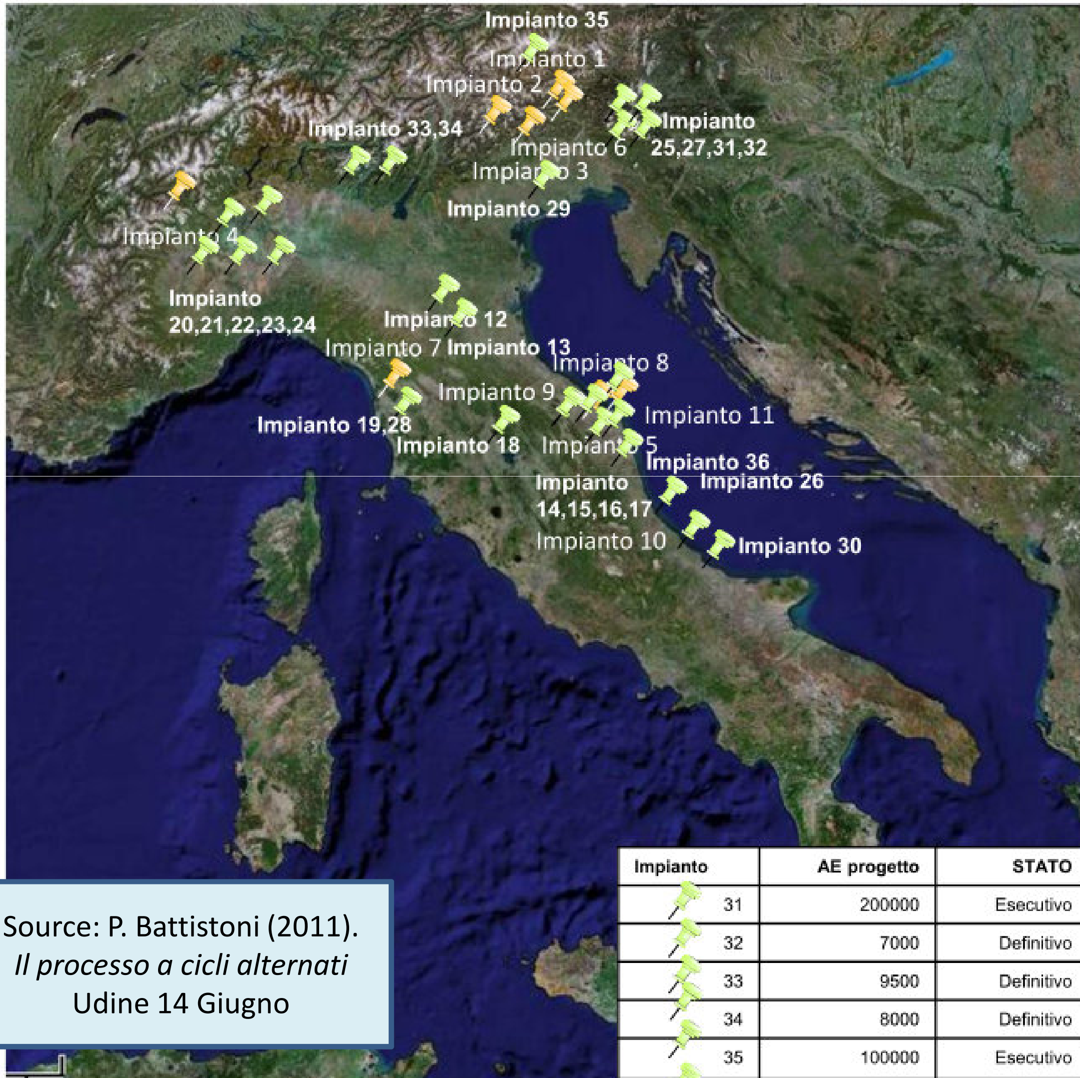


Italian WWTP operating with alternating cycles (at 2011):



Impianto	AE progetto	STATO
1	4500	CA attivi
2	5200	CA attivi
3	10000	CA attivi
4	25000	CA attivi
5	3500	CA attivi
6	35000	CA attivi
7	30000	CA attivi
8	Piattaforma REF	CA attivi
9	Piattaforma REF	CA attivi
10	30000	CA attivi
11	8000	CA attivi
12	10000	
13	6000	
14	8000	CA attivi
15	1500	
16	2500	
17	120000	
18	10000	
19	400000	Preliminare
20	7000	Preliminare
21	11000	Cantiere
22	10000	Preliminare
23	6200	Cantiere
24	7000	Definitivo
25	700000	Esecutivo
26	105000	Esecutivo
27	Piattaforma REF	Esecutivo
28	Piattaforma REF	Preliminare
29	60000	Definitivo
30	80000	Esecutivo

Impianto	AE progetto	STATO
31	200000	Esecutivo
32	7000	Definitivo
33	9500	Definitivo
34	8000	Definitivo
35	100000	Esecutivo
36	180000	Esecutivo

Source: P. Battistoni (2011). *Il processo a cicli alternati* Udine 14 Giugno

Italian WWTP with alternating cycles (at 2011-2012):

Impianto	Dimensione	STATO
San Giorgio in Nogaro (UD)	AE 700.000	Funzione 2010
San Benedetto del Tronto (AP)	AE 180.000	Funzione Maggio 2011
Grottammare	AE 30,000	Funzione Giugno 2011
Comacchio (FE)	AE 180.000	Funzione Giugno 2011
Pisticci (MT)	AE 55.000	Funzione 2011
Udine (UD)	AE 200.000	Gara
Biferno (CB)	AE 200.000	2012
Rovereto (RO)	AE 100.000	Funzione 2011
Trento Sud (TN)	AE 100.000*	Funzione 2011
Trento Nord (TN)	AE 120.000*	Funzione 2011
Carbonera (TV)	AE 60.000	Funzione 2012

Source: P. Battistoni (2011).
Il processo a cicli alternati
Udine 14 Giugno

ADVANTAGES OF A PROCESS WITH ALTERNATING PHASES:

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ADVANTAGES OF A PROCESS SYSTEMS ALTERNATING

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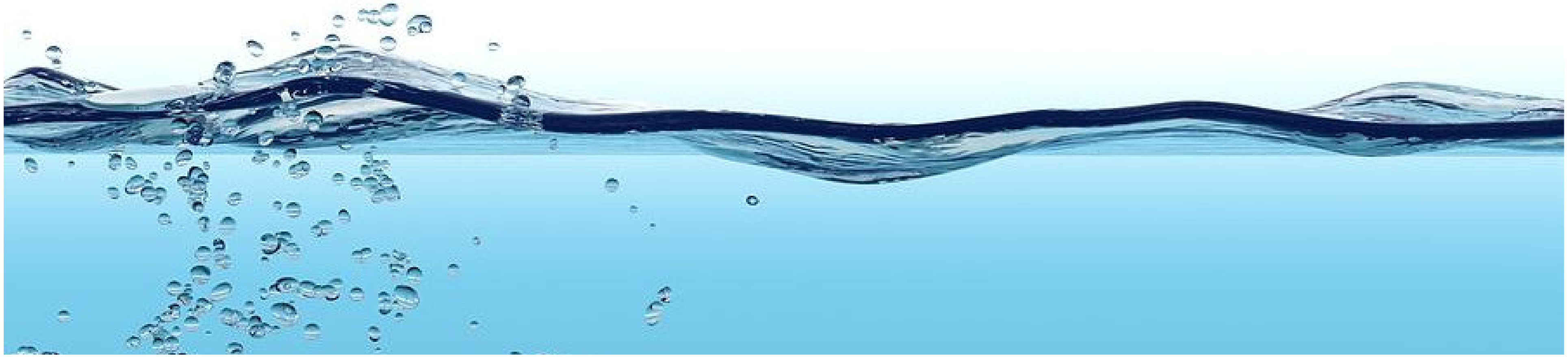
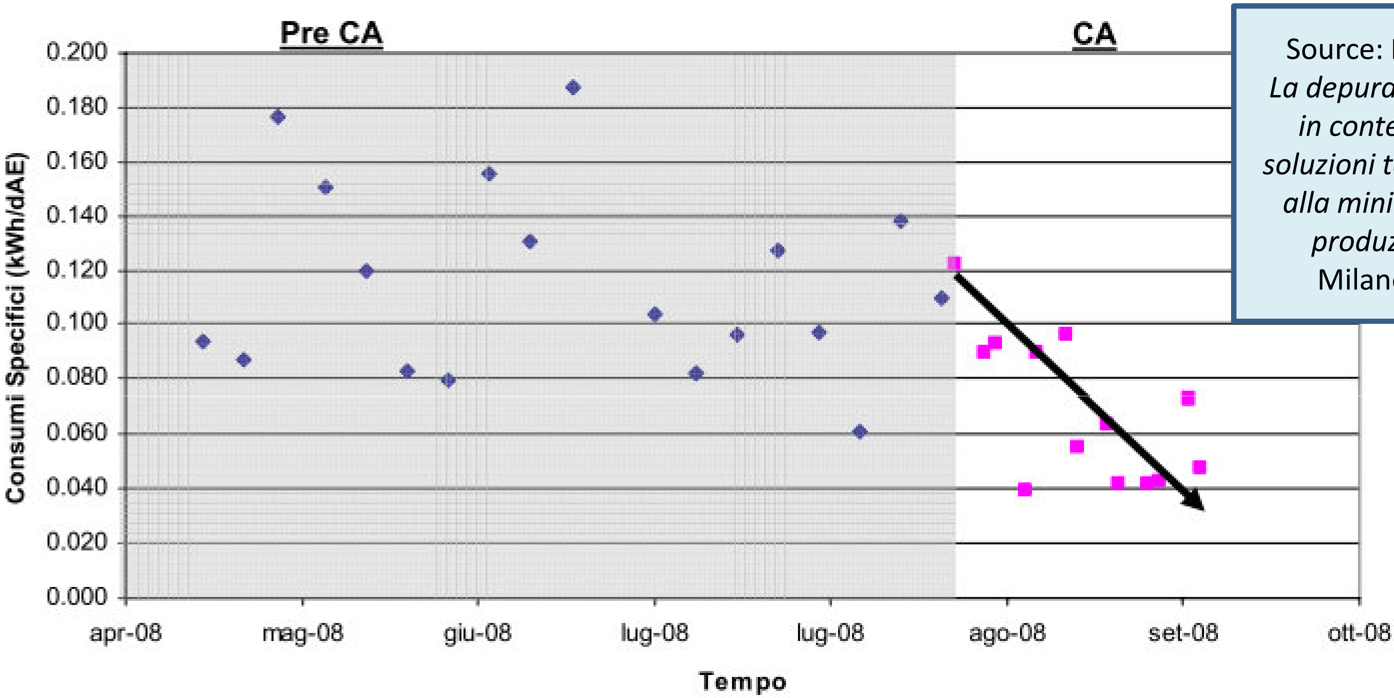


Examples of results obtained in actual wwtp:

Energy saving



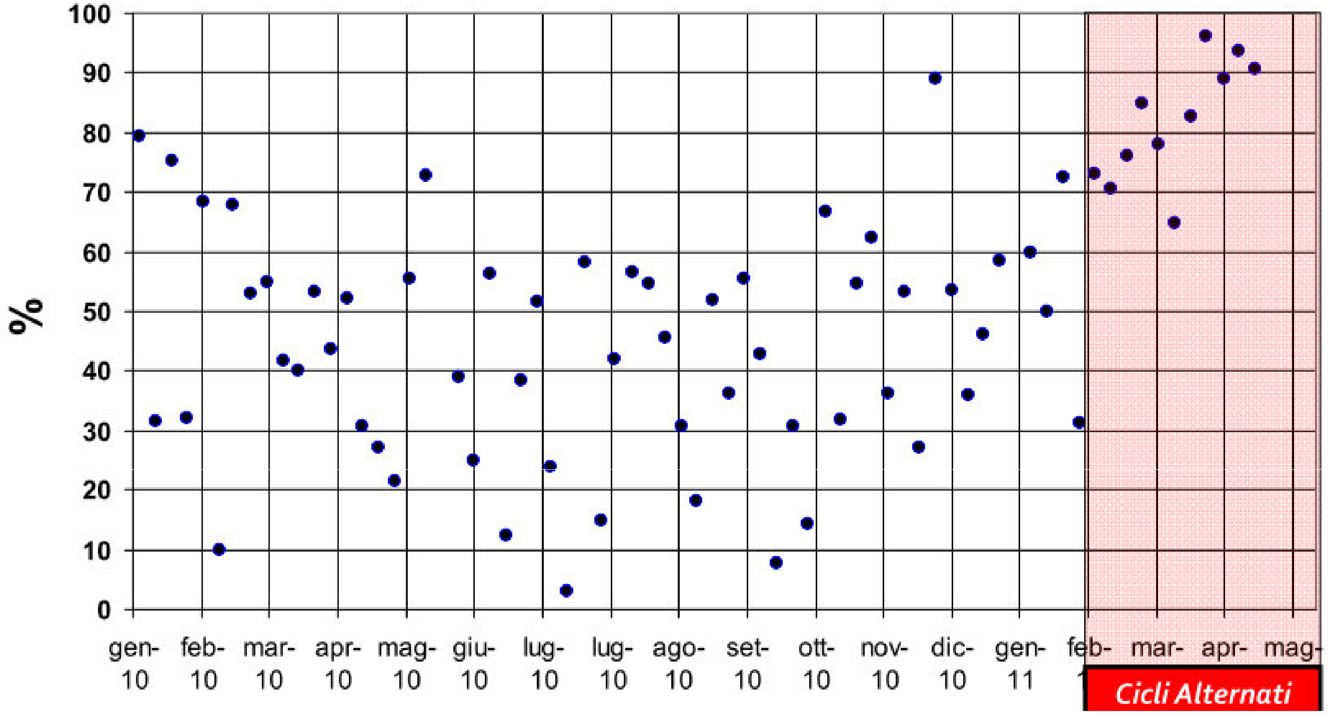
Source: F. Cecchi (2011). *La depurazione delle acque in contesti urbanizzati: soluzioni tecnologiche volte alla minimizzazione della produzione di fanghi* Milano 15/03/2011

Source: P. Battistoni (2011). *Il processo a cicli alternati* Udine 14 Giugno

Consumption reduction obtained: 8-36%

Examples of results obtained in actual wwtp:

N_{tot} removal



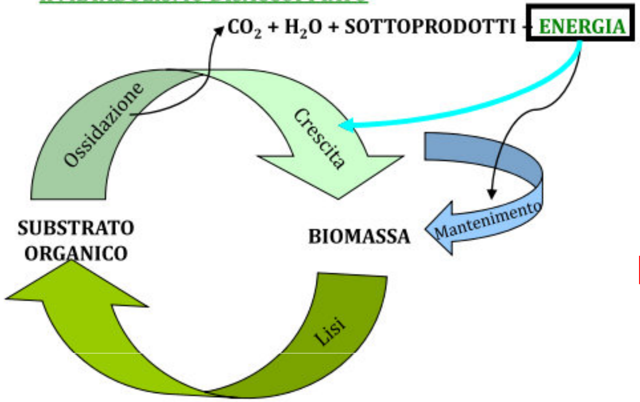
Source: P. Battistoni (2011).
Il processo a cicli alternati
Udine 14 Giugno

Rimozione
65 % ÷ 96 %

Examples of results obtained in actual wwtp:

Reduction of excess sludge production

Il METABOLISMO DISACCOPPIATO

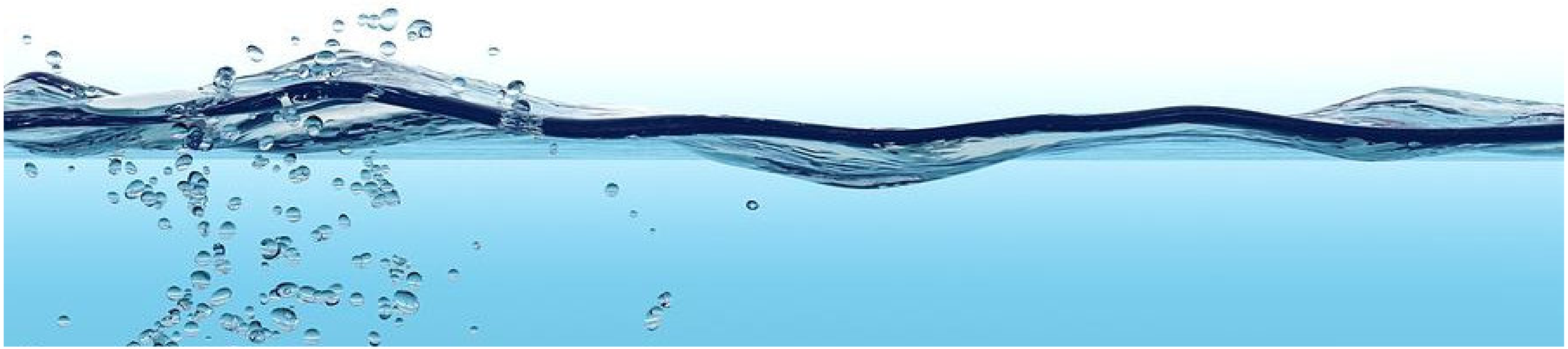


Principio: METABOLISMO DISACCOPPIATO

→ DIMINUZIONE DELL' ENERGIA PER LA CRESCITA (fase anabolica)

Reduction obtained: ≈ 25-30%

Source: P. Battistoni (2011).
Il processo a cicli alternati
Udine 14 Giugno



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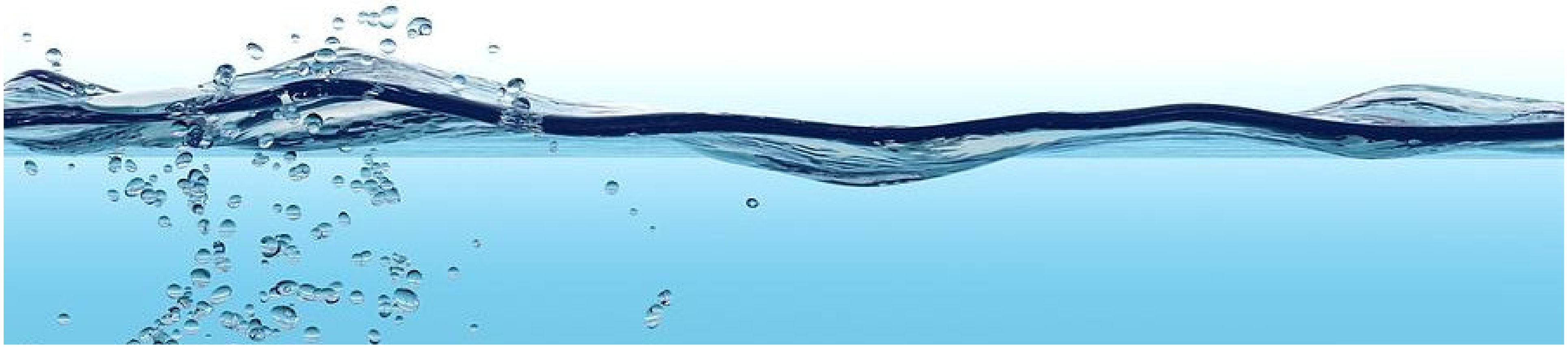

Configuration of pilot WWTP :

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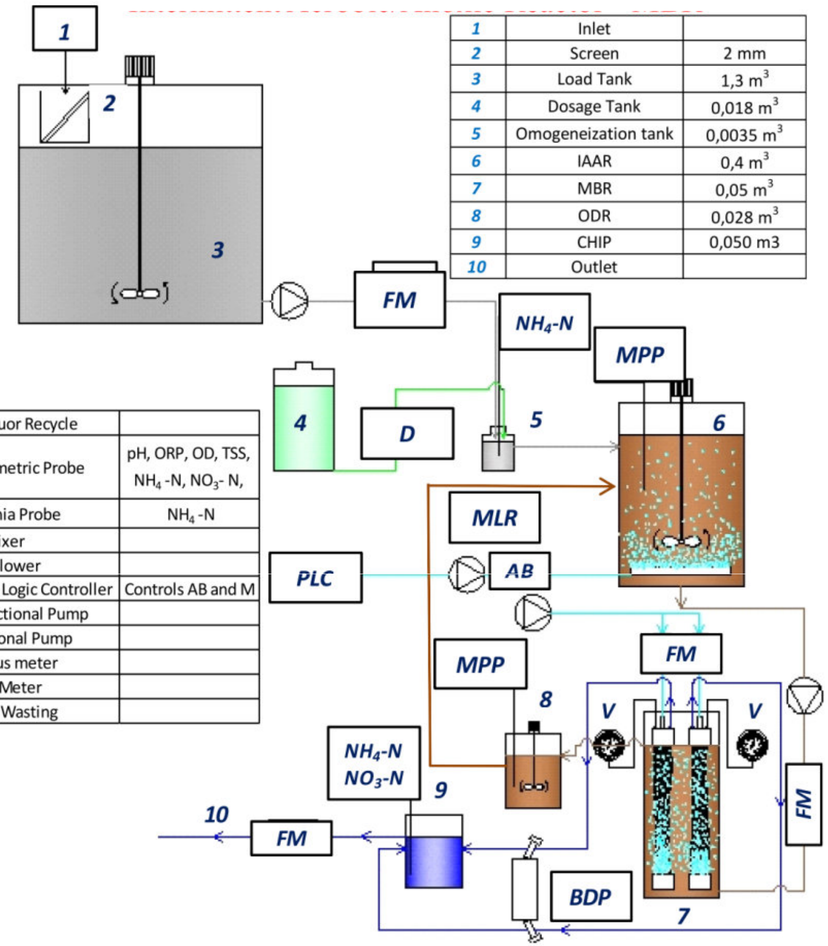
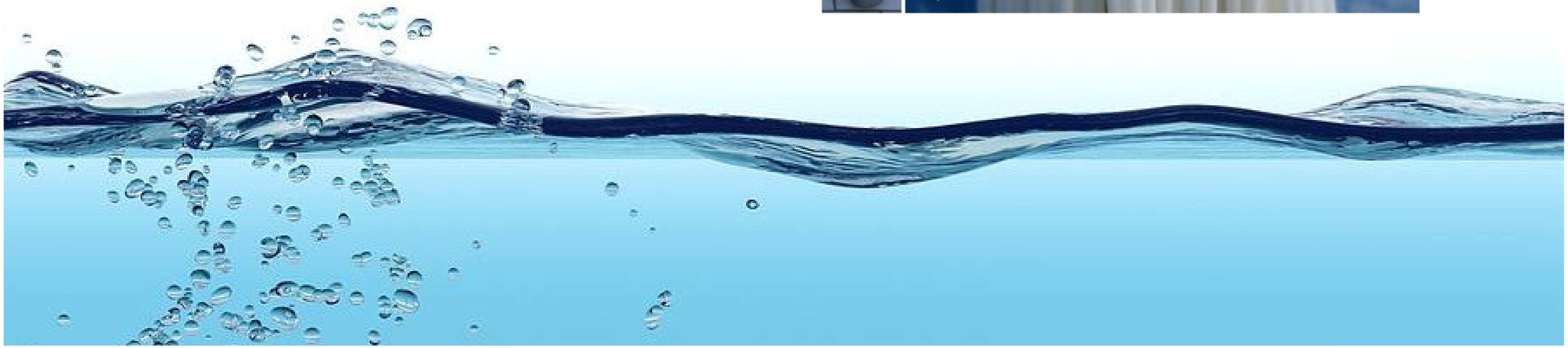


1	Inlet	
2	Screen	2 mm
3	Load Tank	1,3 m^3
4	Dosage Tank	0,018 m^3
5	Omogeneization tank	0,0035 m^3
6	IAAR	0,4 m^3
7	MBR	0,05 m^3
8	ODR	0,028 m^3
9	CHIP	0,050 m3
10	Outlet	

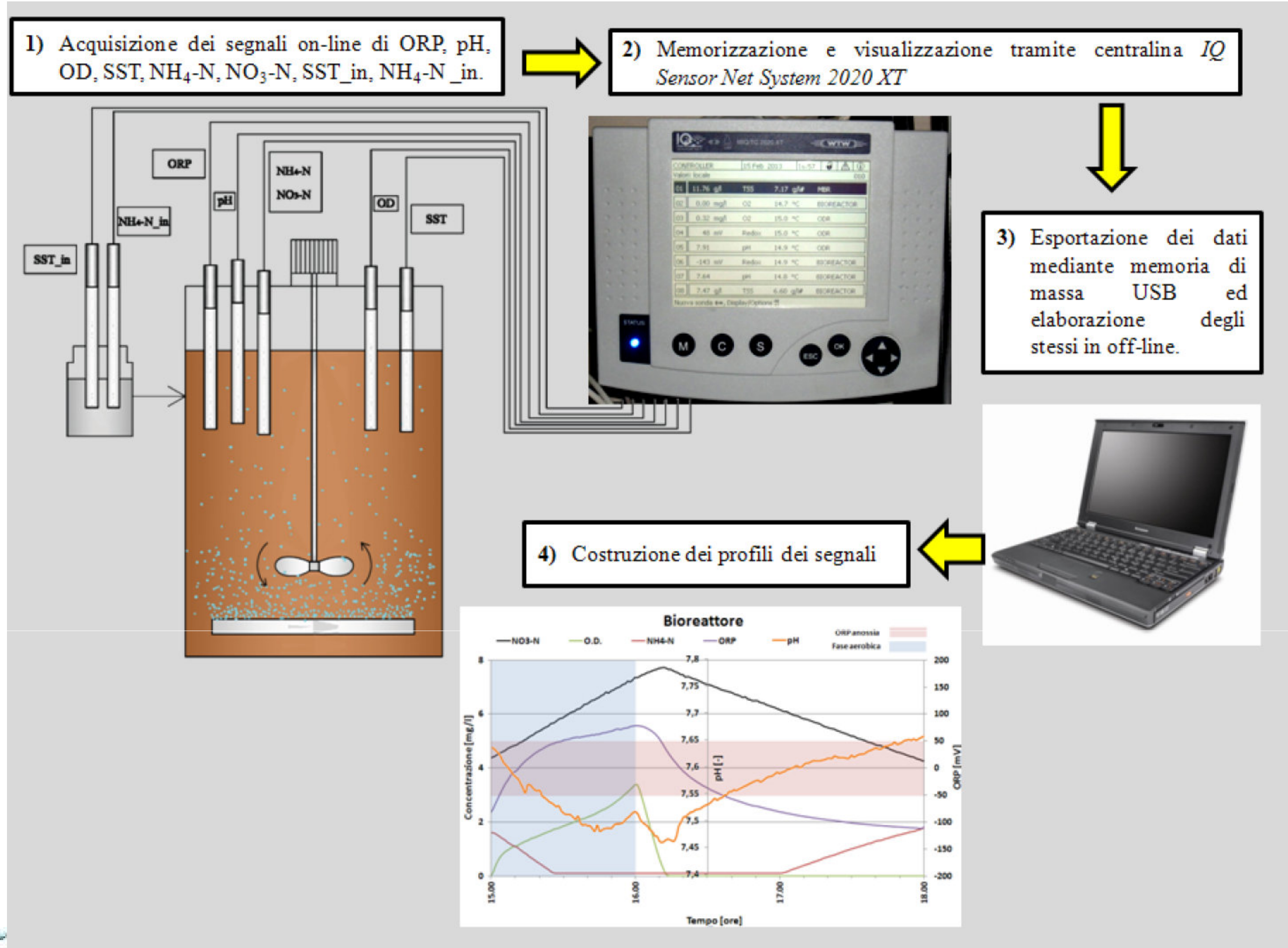
MLR	Mixed Liquor Recycle	
MPP	Multi Parametric Probe	pH, ORP, OD, TSS, NH_4 -N, NO_3- N,
NH4-N	Ammonia Probe	NH_4 -N
M	Mixer	
AB	Air Blower	
PLC	Programmable Logic Controller	Controls AB and M
MDP	Mono-Directional Pump	
BDP	Bi-Directional Pump	
V	Vaquous meter	
FM	Flux Meter	
SW	Sludge Wasting	

Pilot WWTP : operating condition and features

Parametro	U.M.	Periodo I (60/60)			Periodo II (60/120)			Periodo III (80/100)			Periodo IV (30/60)		
		Max	Min	Media	Max	Min	Media	Max	Min	Media	Max	Min	Media
Q in	l/h	18	15	17	35	29	32	32	28	29	30	26	28
Q r	l/h	150	97	126	145	42	128	140	58	121	140	122	137
MLSS	mg/l	5502	4700	5020	6588	1318	3574	6978	5234	6093	5712	5123	5304
MLSSV	mg/l	3313	2906	3122	3313	2906	3122	4776	3785	4368	4254	3359	3857
C_F	Kg BOD_5/(Kg SST* giorno)	0,06	0,01	0,02	0,30	0,03	0,11	0,12	0,02	0,06	0,06	0,04	0,05
HRT	h	33	28	30	17	14	16	18	16	17	19	17	18
$T_{bioreattore}$	°C	14,80	13,90	14,27	17,43	12,90	15,23	23,90	19,40	21,60	26,65	22,60	24,70



Pilot WWTP control:



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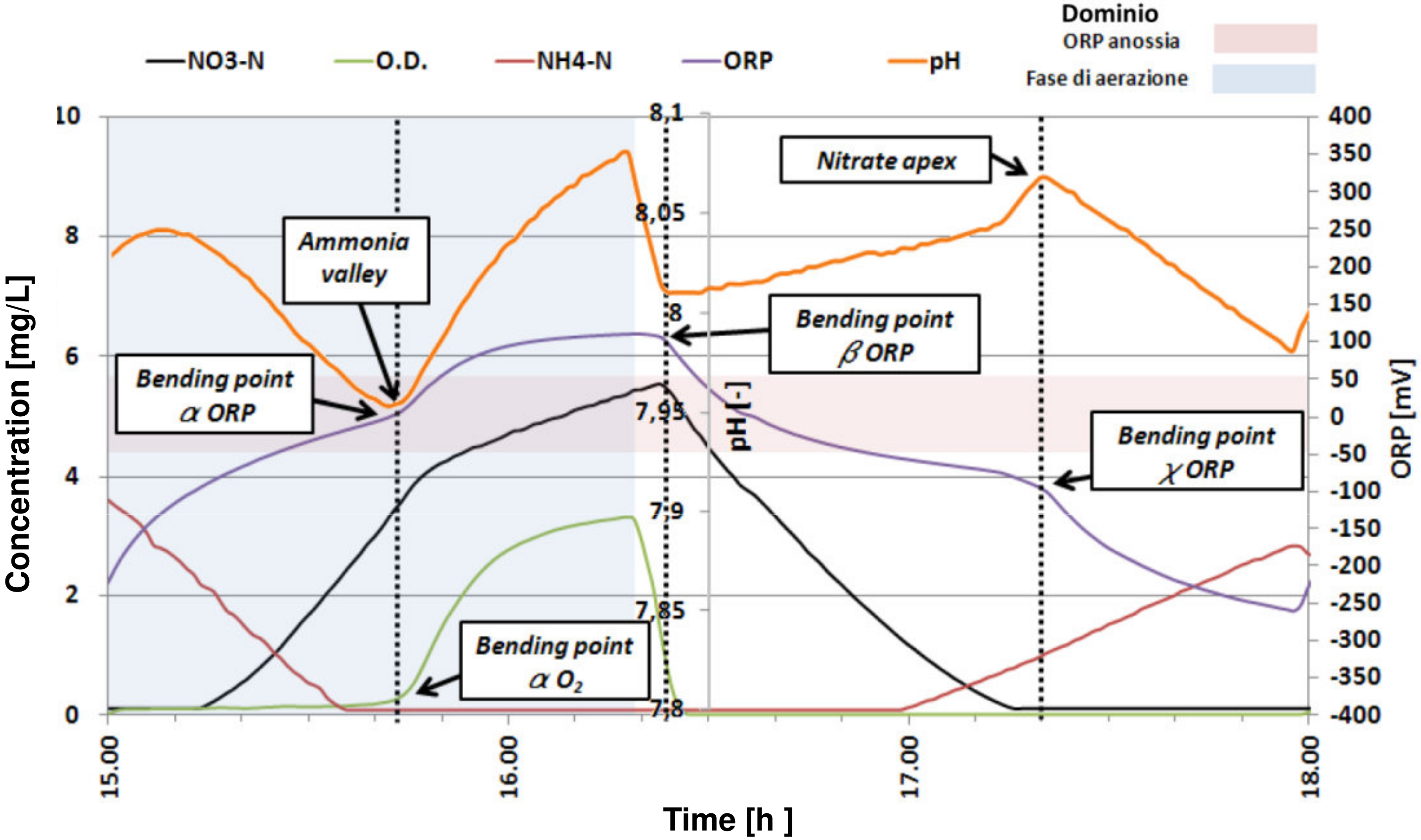


Aim of the research:

to study possible factors of criticality due to the alternation of phases.

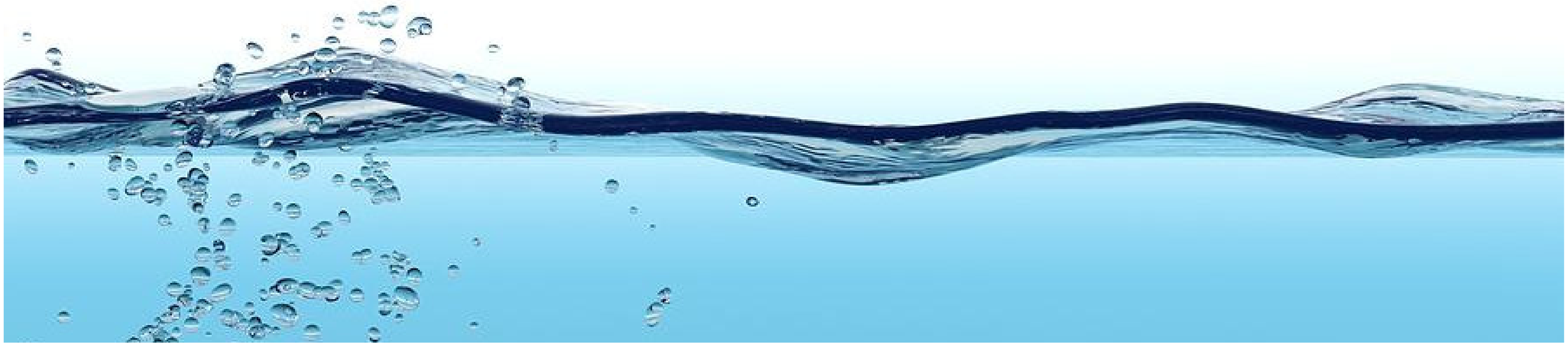
Identified factor:

EPS and SPM production

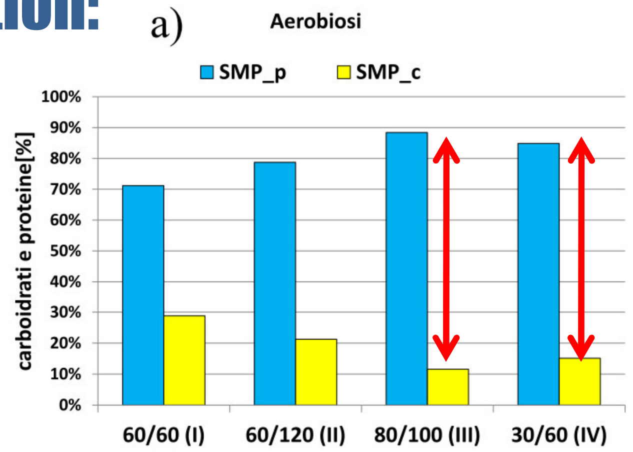
fouling of membrane

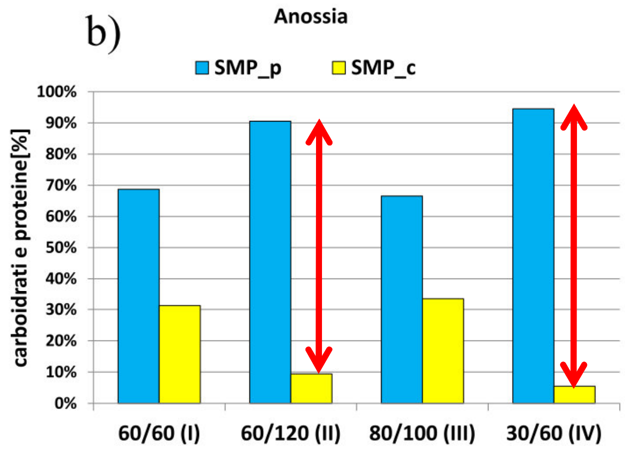
Four experimental peridods:

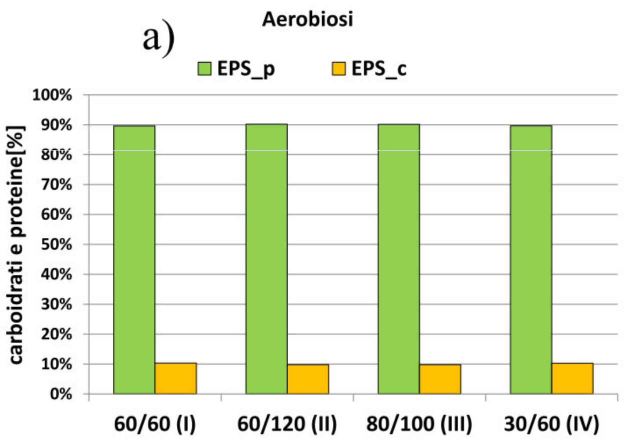
Period	Days	Cycle duration [h]	Aerobic/Anoxic Time [min/min]	Aerated fraction
I	28	2	60/60	0.50
II	67	3	60/120	0.33
III	46	3	80/100	0.44
IV	14	1.5	30/60	0.33

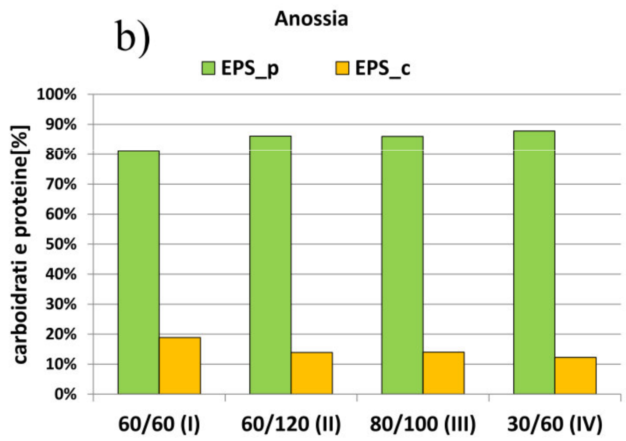


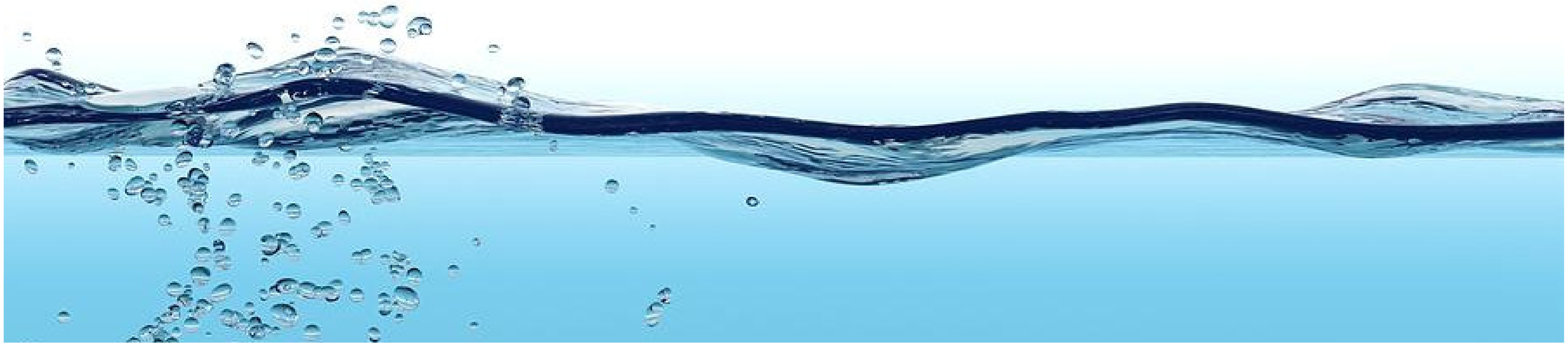
EPS and SPM production:





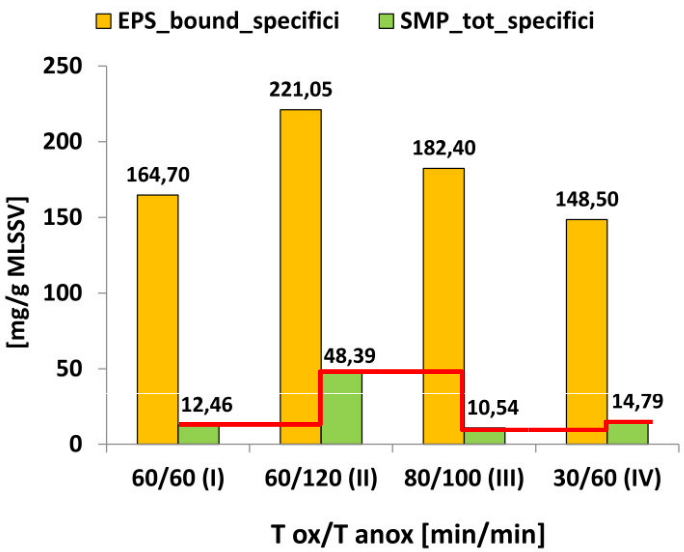




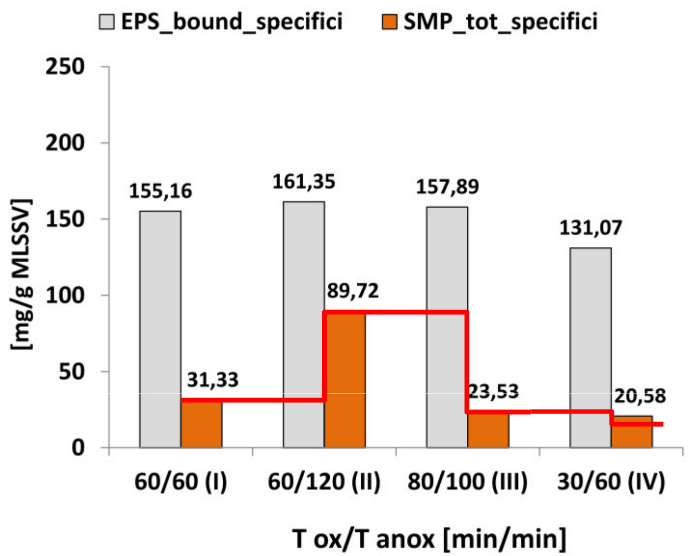


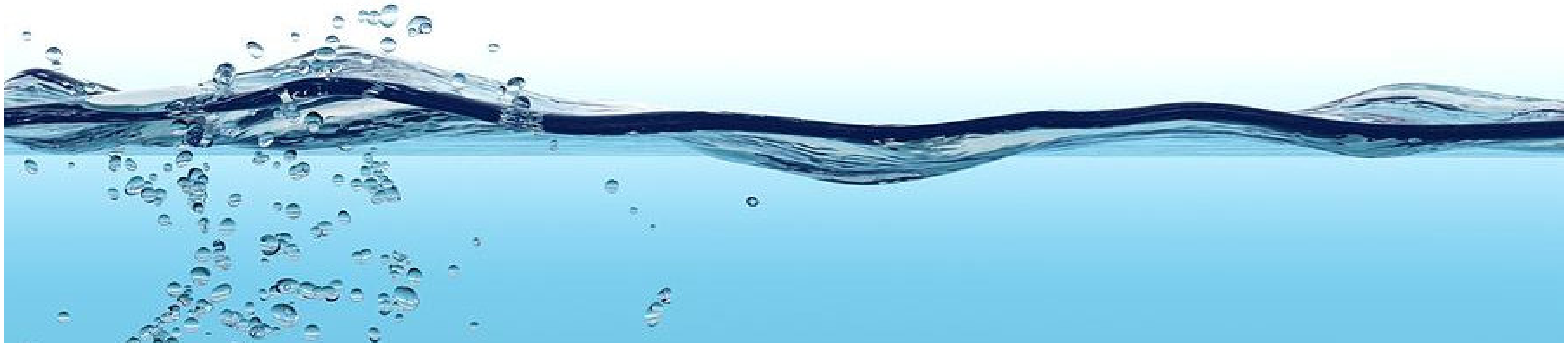
EPS and SPM production:

a) Aerobic phase



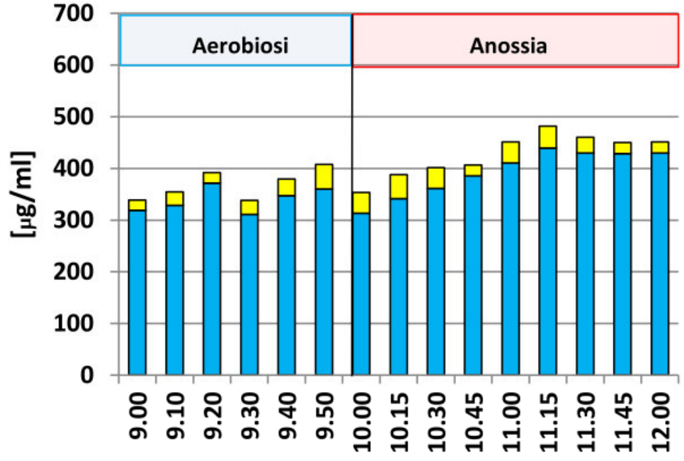
b) Anoxic phase



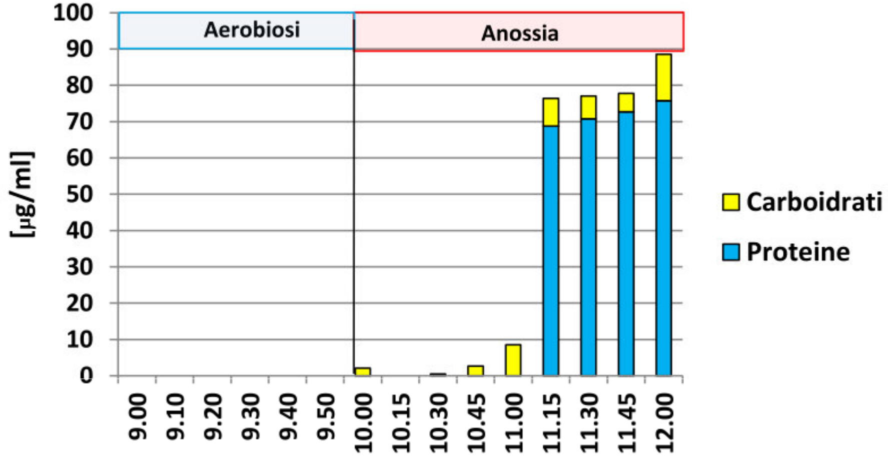


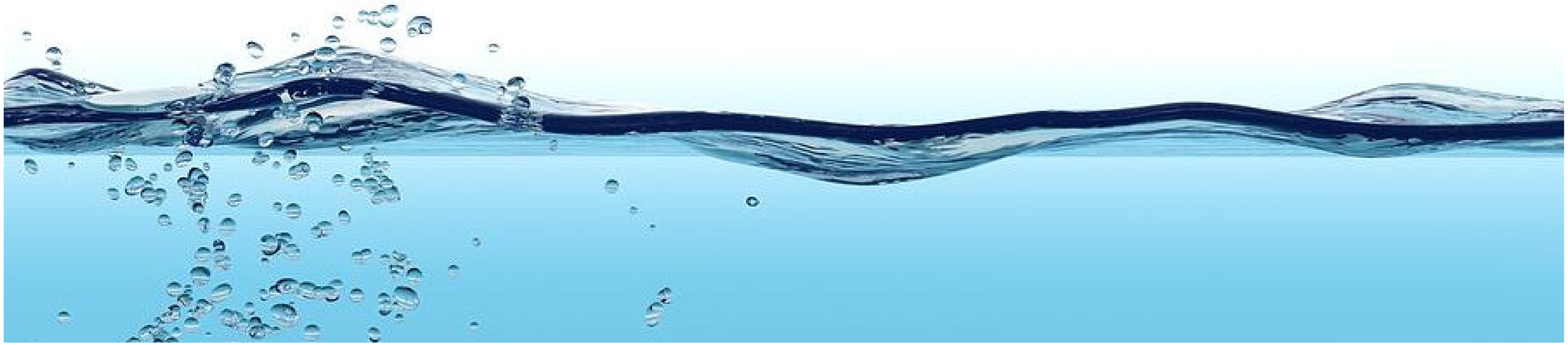
EPS and SPM production:

a) EPS_{bound} producted in a cycle



b) SMP producted in a cycle





Conclusion:

Literature data show that an high SMP concentration in the mixed liquor leads to an increase of fouling rate.

Data obtained seem to confirm that:

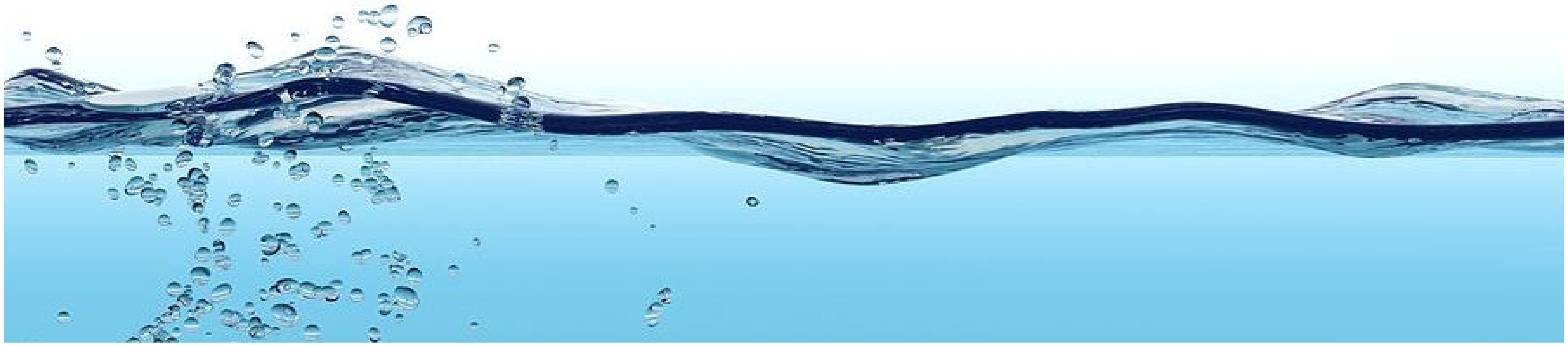
- alternating cycles process can be optimized increasing the anoxic phase duration;

- during the anoxic phase the SMP production increases.

This fact seems to provide a worrying factor (disadvantage) in the application of these systems!

Indeed, this influence has to be balanced with the several advantages of alternating cycles process in terms of energy saving.

Our research team is processing a lot of collected data, especially within individual cycles monitored in order to reach a determination in this regard.



Thanks for your attention

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