Reuse of urban reclaimed water in industries: LIFE WIRE R&D project

O. Ferrer[1], M. Pastur[1], M. Aceves[2], C. Gómez[3], A. M. Mateo[4], A. Ayuso[5], C. Mesa[6], A. Vega[6]

[1] CETaqua, Water Technology Centre, [2] Àrea Metropolitana de Barcelona; [3] ECOIMSA; [4]ARCHROMA; [5] TACSA; [6] Aigües de Barcelona

LIFE WIRE

Water Cycle Efficiency Improvement by Boosting Industrial Water Reuse

www.life-wire.eu

Content

- Introduction
- Objectives
- Materials and methods
  - Prototype plant
  - Monitoring plan
- Results
  - Adsorbent performance
  - Reverse osmosis performance
  - Permeate quality
  - Substitution feasibility
  - Application: liquid waste disposal industry
- Conclusions

Introduction

- Water use has been growing at **more than twice** the rate of population increase in the last century (FAO, 2007)

- In Europe, 1/3 of countries are considered to be affected by **water scarcity** (EC, 2012)

Water reuse as a water conservation strategy

- Wastewater reuse reclamation and reuse is considered to present a **lower environmental impact** and potentially lower cost than other alternative water supplies (California Energy Commission, 2005).

- Water use within **industries** accounts for **18%** of drinking water consumption in Europe (EEA, 2004). Only **0.7%** of total treated wastewater in Spain is reused in industry (Iglesias, 2008). Spanish Royal Decree RD1620/2007 establishes the minimum quality requirements for different uses.

- Demonstrative projects are needed to prove the feasibility, reliability and competitiveness of this practice, and hence, to boost industrial water reuse

Title: Water Cycle Efficiency Improvement by Boosting Industrial Water Reuse

Duration: 01/10/2013 – 30/03/2017

Coordinator:

CETAQUA CENTRO TECNOLÓGICO DEL AGUA

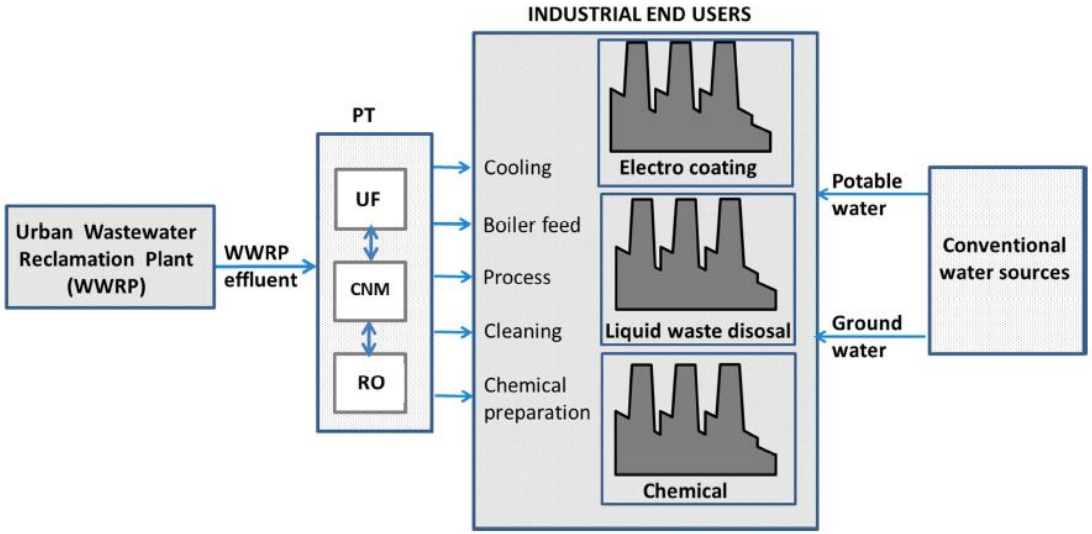
Partners:

TRADEBE, tacsa, ARCHROMA, AMB Àrea Metropolitana de Barcelona, Aigües de Barcelona

Budget: Total: 1.721.875 €
EC funding: 862.3 k€

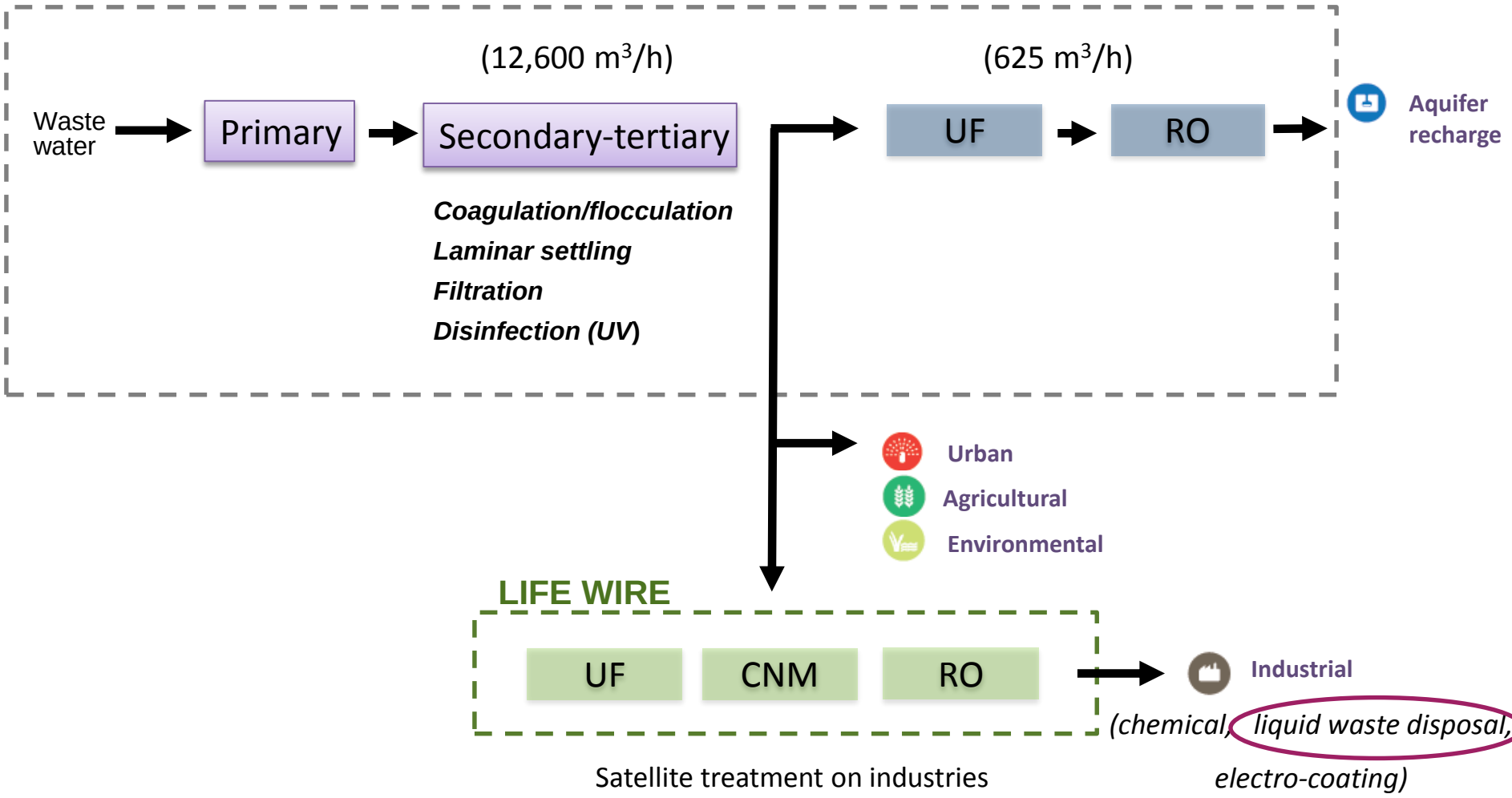
Objectives

- To demonstrate which **technological configuration/s between ultrafiltration (UF), high performance adsorption material (CNM) and reverse osmosis (RO) are technically viable** to polish reclaimed urban wastewater and efficiently reuse it in different industrial sectors



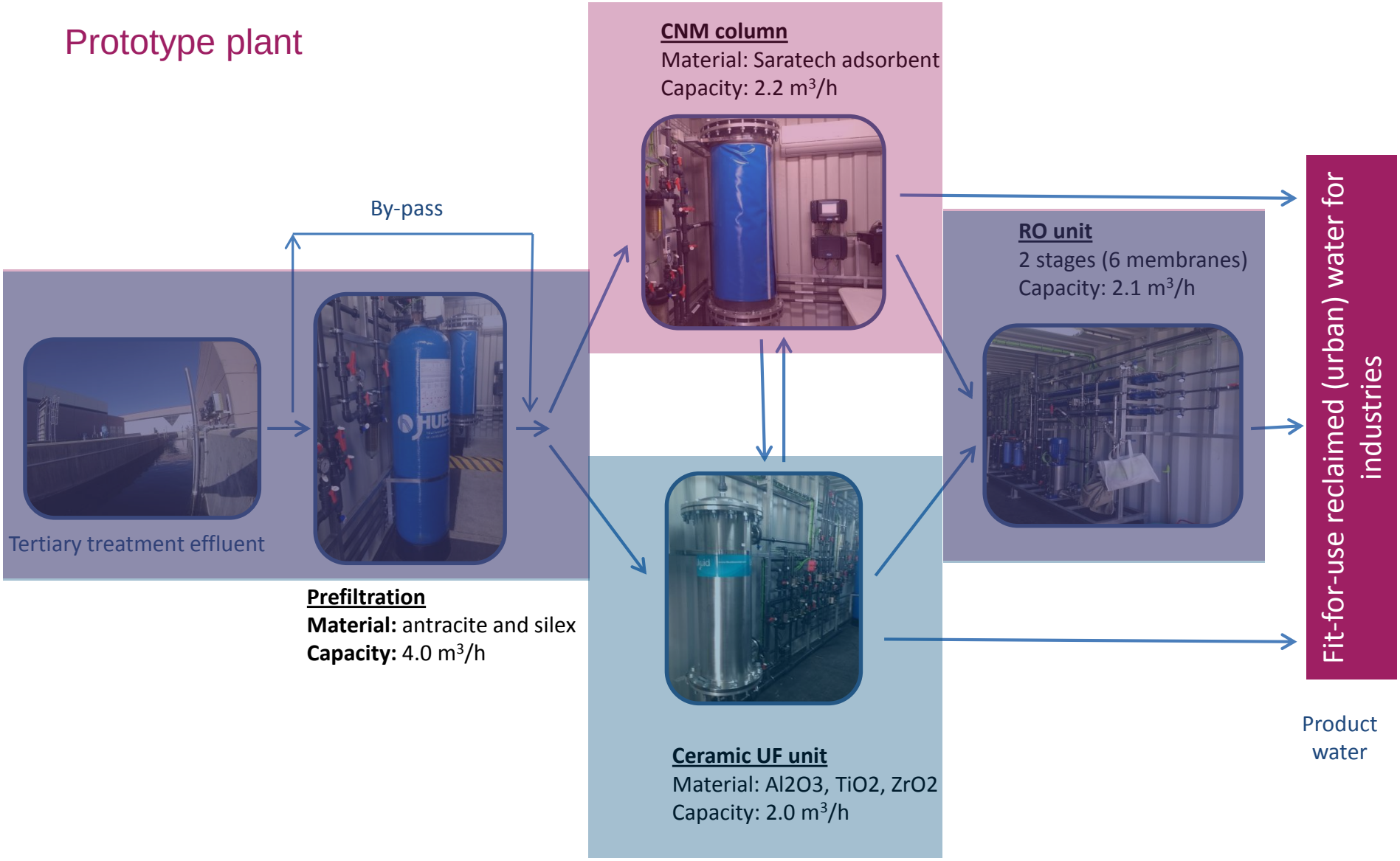
- To **optimise UF, CNM and RO operation** within each configuration tested in terms of **energy and chemicals' consumption as well as by-products generated**

WWRP El Baix Llobregat (Barcelona area, Spain)



Materials and methods

Prototype plant



Monitoring plan

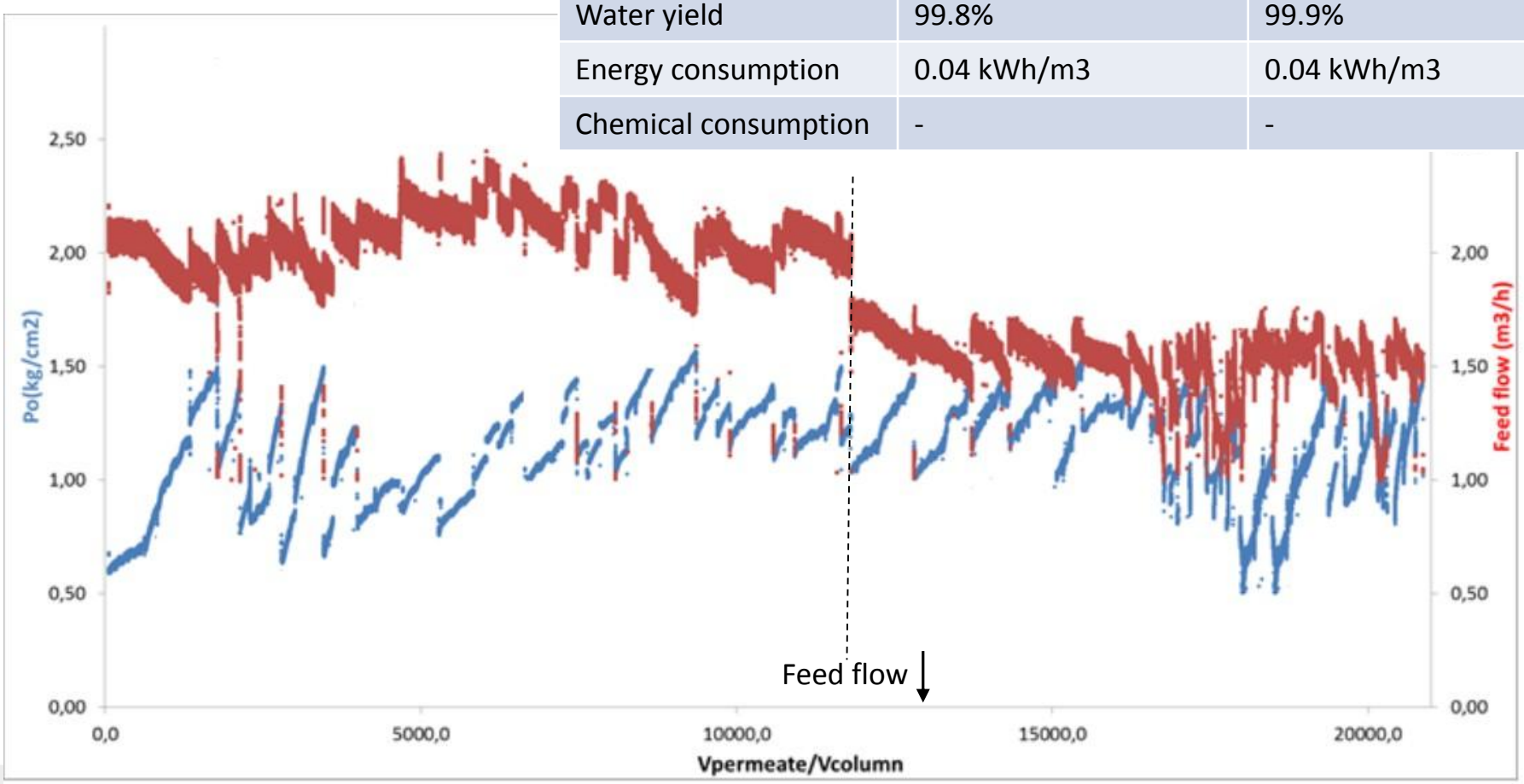
Parameter	Frequency
Hardness	Weekly
COD	Weekly
TOC	Weekly
pH	On line
Turbidity	On line
Conductivity	On line
Chloride	Weekly
Phosphate	Weekly
Ammoniacal nitrogen	Weekly
Kjeldhal Nitrogen	Weekly
Sulphate	Weekly
Metals screening	On line
Oils and grease	Weekly
Hydrocarbons	Monthly
Micropollutants	Monthly

Parameter	Frequency
E. Coli	Monthly
Total coliforms	Monthly
Aerobic bacteria	Monthly
Legionella spp	Monthly
Enterococcus	Monthly
Helmint eggs	Monthly
Clostridium perfringens	Monthly
Bacteriophages	Monthly

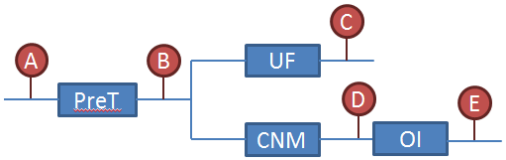
Influent & effluent of each unit

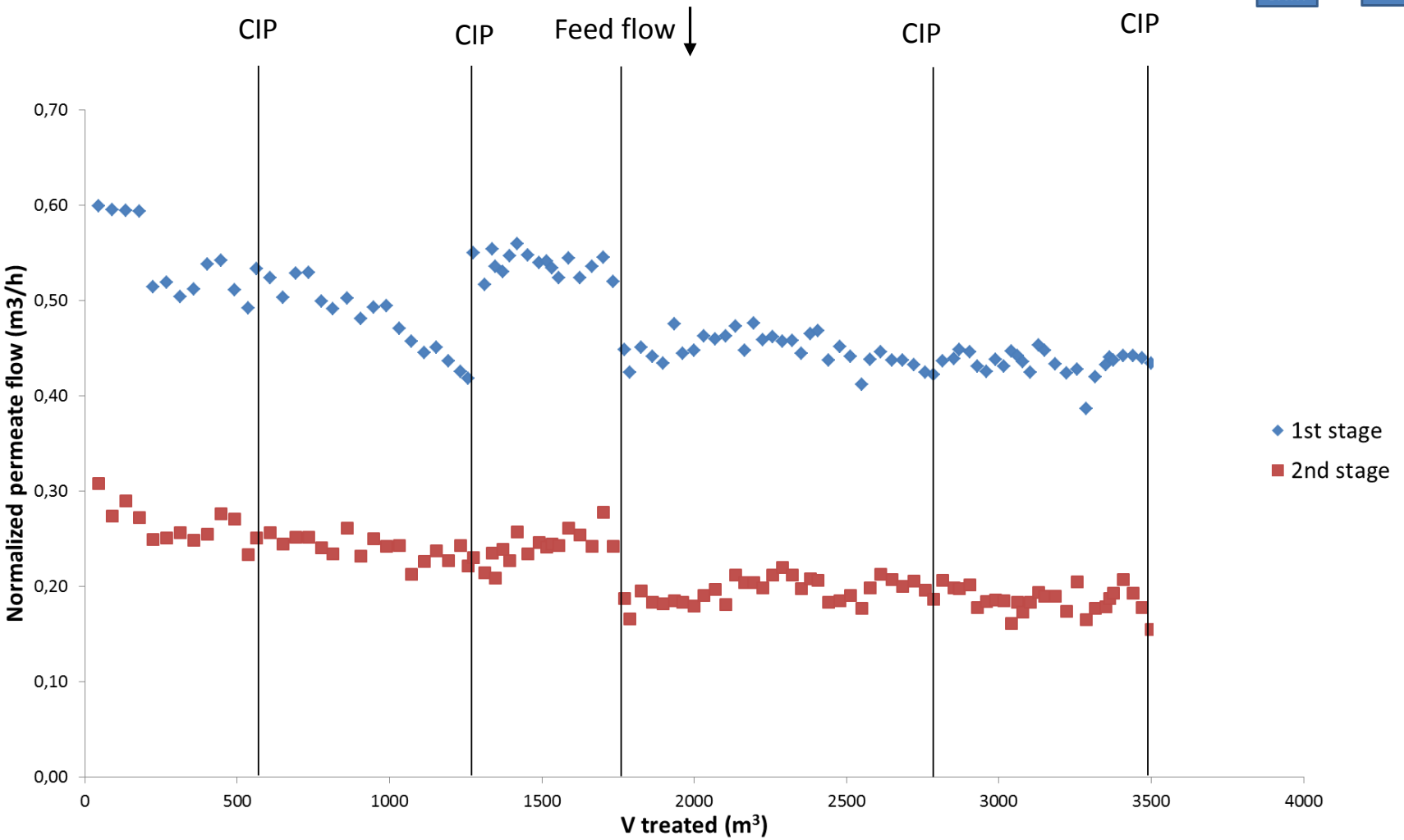
Adsorbent material (CNM) performance

Operating conditions	02/11/15 – 04/03/16	04/03/16 -30/08/16
Feed flow	2.0 – 2.2 m^3/h	1.6 – 1.7 m^3/h
BW frequency	Every 3 days (150 m^3)	Every 7 days (250 m^3)
Water yield	99.8%	99.9%
Energy consumption	0.04 kWh/m3	0.04 kWh/m3
Chemical consumption	-	-



Reverse osmosis (RO) performance



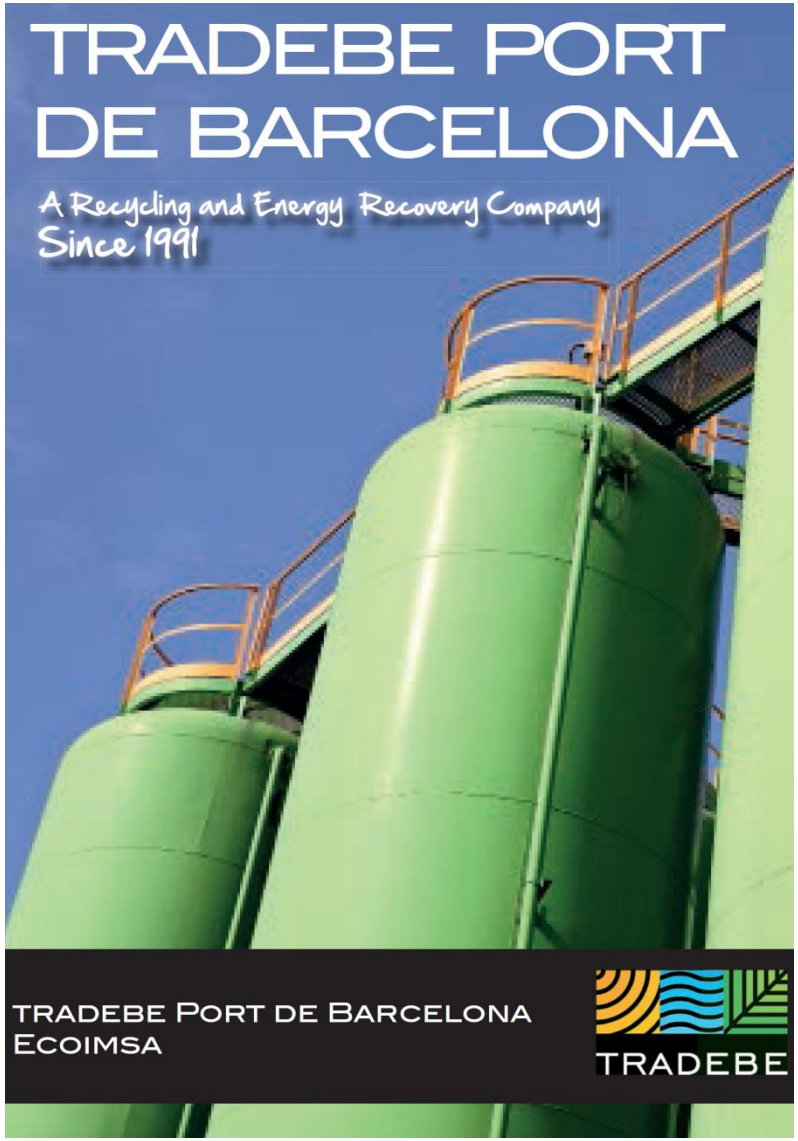


Reverse osmosis (RO) performance

Operational conditions	First conditions tested	Second conditions tested
Feed flow (m^3/h)	2.1	1.5
Recovery (%)	41.0	41.0
Salt passage (%)	0.9	1.3
P_{feed} (bar)	9.0	7.4
Pressure drop (bar)	0.9 (1st stage)	0.8 (1st stage)
CIP requeriments	Every 513 m^3 (no flushing) Every 737 m^3 (1 flushing/day)	Every 510 m^3 (no flushing) Every 1083 m^3 (1 flushing/day)
Energy consumption (kWh/m^3 permeate)	0.9	0.7
Chemical consumption Genesys RED (mL/m^3) Genesys LF (mL/m^3) NaOH (L/CIP) HCl (L/CIP)	 3.31 2.98 0.48 2.80	 5.27 2.22 0.48 2.80

Removal (%)	Min	Ave	Max
COD	64	76	83
TOC	58	81	95
Ammoniacal nitrogen	88	96	100

Application: liquid waste disposal industry



- Leader in industrial waste management in Spain, the United Kingdom, the United States, with subsidiaries in France and Brazil.
- **More than 60 treatment plants** in Spain (25), the United Kingdom (26) France (2) the United States (17) and Brazil (1)
- With sales of **€393M** and approximately 2,000 employees worldwide

TRADEBE PORT DE BARCELONA ECOIMSA

- Experts in MARPOL services
- Collection, treatment and valorisation, and waste valorisation

Categories of valorisation and treatment:

- Valorisation of hydrocarbons
- Valorisation of organic/inorganic waste
- Physic-chemical and biological treatment
- Treatment by evaporation
- Collection and treatment of RPQs and laboratory reagents

Application: liquid waste disposal industry

Water uses and important parameters:

ECOIMSA

Cooling tower.
Nematodos, E.coli, Legionella, TSS, Turbidity

Biological control, conductivity, TDS, Hardness, pH, conductivity, Ca, Fe, Cl, Turbidity, aerobic bacteria, legionella, T

Potable water *(120m3/d)* →

- Cooling tower (48 *m3/d)*
- *Process (reagents and other, 33m3/d)*
- *Cleaning (24 m3/d)*
- *Other uses (domestic) (15m3/d)*

Legionella

Process & Cleaning.
E.coli, Legionella, TSS, Turbidity

Water quality requirements: definition of baseline conditions

Usos	Ecoimsa				
		Proceso			
	Refrigeración	Preparación reactivos	Reposición agua calderas planta	Agua proceso motor cogeneración	Limpiezas
pH	6,5 - 9	7 a 9	> 7	> 7	
SS (mg/l)		Calidad agua de red			
Turbidez (UNF)	< 15				
Cloro residual (Cl2) (mg/l)	0,3 - 0,8	Calidad agua de red			
Fe (mg/l)	< 2		< 0,3	< 0,3	
Ca (mg/l)		Calidad agua de red			
Cu (mg/l)			< 0,05	< 0,05	
Fosfato total (mg P2O5/l)	Calidad agua de red				
Fosfato (PO4) (mg/l)			10 a 30	10 a 30	
Bicarbonato (mg/l)	Calidad agua de red				
Carbonatos (mg/l)	Calidad agua de red				
Sólidos disueltos (mg/l)		Calidad agua de red			
Dureza cálcica (TH Ca) (ºhf)	Calidad agua de red				
Dureza total (ºhf)		Calidad agua de red	< 0,1	< 0,1	
Alcalinidad total (meq/l)	1 a 15	1 a 15	1 a 15	1 a 15	
O2 (mg/l)			< 0,05	< 0,05	
Conductividad (µS/cm)	700	700	700	700	
Sílice (SiO2) (mg/l)			30 - 160	30 - 160	
Tª	Calidad agua de red	Calidad agua de red			
Aerobios Totales a 36 ºC (ufc/ml)	< 1000	< 1000	< 1000	< 1000	< 1000
Legionella (ufc/l)	< 100	< 100	< 100	< 100	< 100
Residual Biocida B-90 (mg/l)	10 a 30	10 a 30	10 a 30	10 a 30	10 a 30
Aceites y grasas (mg/l)			< 1	< 1	

Application: liquid waste disposal industry

Water quality requirements vs achieved water quality

Uso	Refrigeración	Proceso			Limpiezas	CNM	CNM+RO
		Preparación reactivos	*Reposición agua calderas planta*	*Agua proceso motor cogeneración*			
pH	6.5-9	7.0-9.0	>7	>7		**7.51±0.18**	**5.78±0.17**
SS (mg/L)		Agua de red				**<3**	**<3**
Turbidez (NTU)	<15					**0.38±0.11**	**0.05±0.06**
Cloro residual (mg/L)	0.3-0.8	Agua de red				**<0.1**	**<0.1**
Fe (mg/L)	<2		<0.3	<0.3		**0.03±0.01**	**<0.006**
Ca (mg/L)		Agua de red				**119±10**	**<0.5**
Cu (mg/L)			<0.05	<0.05		**<0.002**	**<0.002**
Fosfato (PO4) (mg/L)			10 a 30	10 a 30		**4.34±2.05**	**0.10±0.06**
Bicarbonato (mg/L)	Agua de red					**318±28**	**6.36±1.48**
Carbonatos (mg/L)	Agua de red					**<0.5**	**<0.5**
Sólidos disueltos (mg/L)		Agua de red				**<3**	**<3**
Dureza cálcica (TH Ca) (ºHF)	Agua de red					**29.8±2.3**	**<0.125**
Dureza total (ºHF)		Agua de red	<0.1	<0.1		**45.7±4.1**	**0.10±0.09**
Alcalinidad total (meq/L)	1 a 15	1 a 15	1 a 15	1 a 15		**2.61±0.23**	**0.05±0.01**
Conductividad (uS/cm)	700	700	700	700		**2088±91**	**24.8±5.5**
Sílice (SiO2) (mg/L)			30-160	30-160		**9.3±1.1**	**<0.02**
Temperatura	Agua de red	Agua de red					
Aerobios Totales a 36 ºC (ufc/mL)	<1000	<1000	<1000	<1000	<1000	**226±192**	**21.2±20.2**
Legionella (ufc/L)	<100	<100	<100	<100	<100	**<100**	**<100**
Residuo Biocida B-90 (mg/L)	10 a 30	10 a 30	10 a 30	10 a 30	10 a 30		
Aceites y grasas (mg/L)			<1	<1		**<0.5**	**<0.5**

Water quality requirements vs achieved water quality

Use	Refrigeración	Proceso			Limpiezas
		Preparación reactivos	*Reposición agua calderas planta*	*Agua proceso motor cogeneración*	
CNM	✗	✗	✗	✗	✓
CNM+RO	✓	✓	✓	✓	✓
33% CNM + 67% RO	✓	✓	✗	✗	✓

- Most water uses requirements can be fulfilled by CNM-RO
- Some water uses requirements can be fulfilled by CNM

Conclusions

- The prototype plant has been able to work continuously, polishing reclaimed urban wastewater
- The water quality produced is stable → reliable technologies
- The water produced (CNM+RO & UF+RO) is stuitable for most of the uses envisaged (liquid waste disposal, chemical, electro-coating)
- The hydraulic performance (water yield, chemical consumption,..) of CNM+RO is competitive with other polishing technologies
- The results could be applicable in other indsutrial sectors (e.g. pulp & paper) with similar quality requirements (refrigeration, boiler, etc.).
- Other configurations are being assessed (until March 2017), in order to meet other industrial requirements
- Full scale projections of the implementation of the most convenient treatment schemes will be conducted before the end of the year (CAPEX, OPEX)

LIFE WIRE

Water Cycle Efficiency Improvement by Boosting Industrial Water Reuse

www.life-wire.eu

With the financial support of the LIFE+ Program of the European Commission

LIFE12 ENV/ES/000545 WIRE

Thanks for your attention

Claudia Gómez (claudia.gomez@tradebe.com)
Olga Ferrer (oferrer@cetaqua.com)

CETAQUA CENTRO TECNOLÓGICO DEL AGUA · TRADEBE · tacsa · ARCHROMA LIFE ENHANCED · AMB Àrea Metropolitana de Barcelona · Aigües de Barcelona