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Characterising, treating and reusing grey water in hotel facilities and assessment of small scale MBR

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Overview

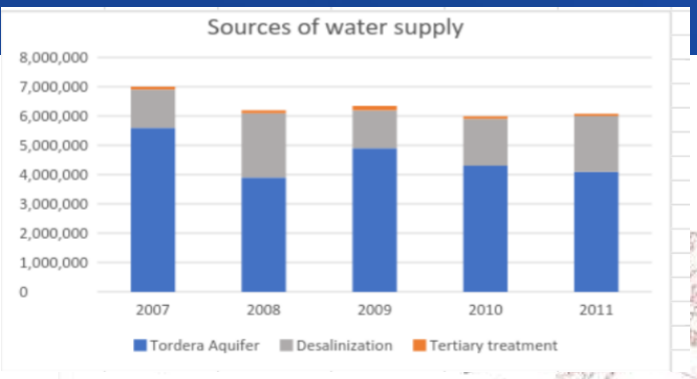
- Grey water in touristic cities in Mediterranean
  - Costa Brava and Lloret de Mar
  - Hotel Samba
- Goals and methodology
- Characterisation of GW in hotel Samba
- Small scale MBR performance: water quality and energy

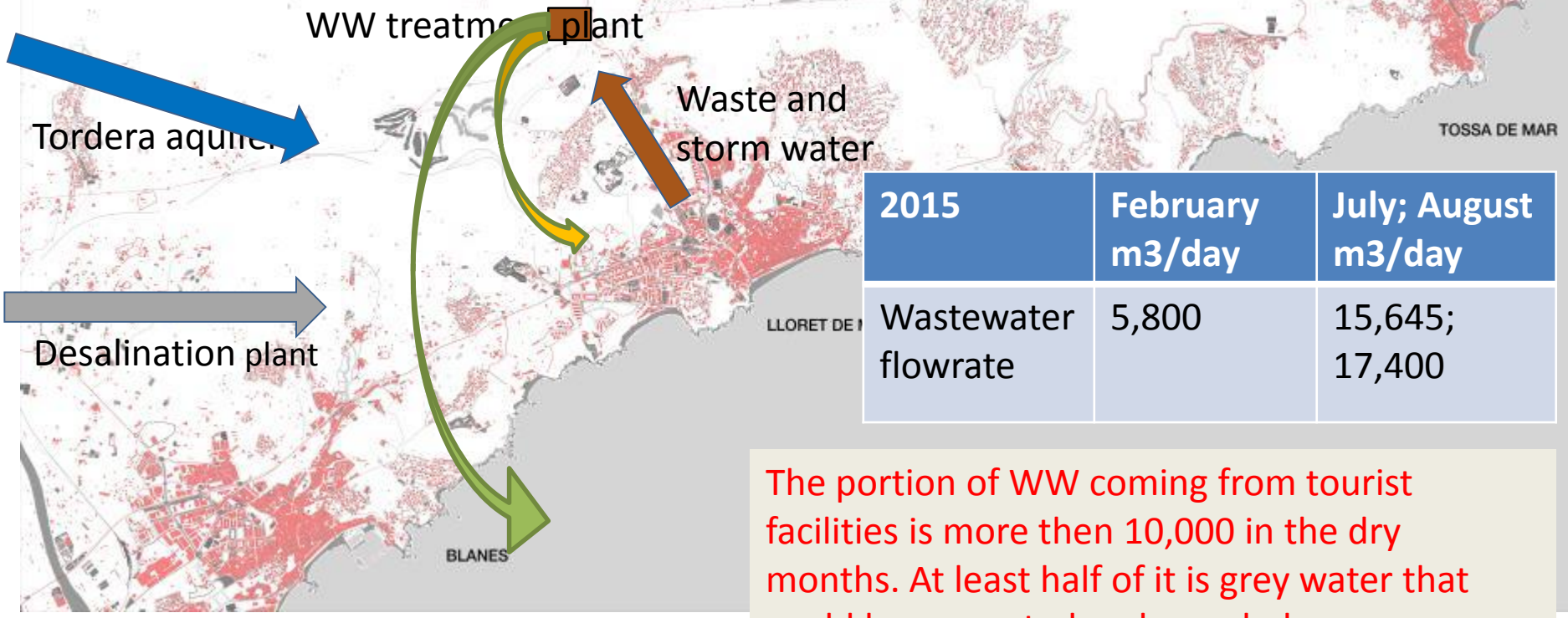
Introduction

The Costa Brava (NE, Spain) is an important Spanish and European holiday destination.

Lloret de Mar, is the largest resort on the Costa Brava, (40,000 inhabitants, up to 200,000 in summer). In 2013 Lloret had 1.5 million visitors and 5 million overnights. Its hotel capacity is 30,000 beds (compared to 64 000 in Costa Brava) and more than 120 establishments.

Introduction: water resources in Lloret de Mar





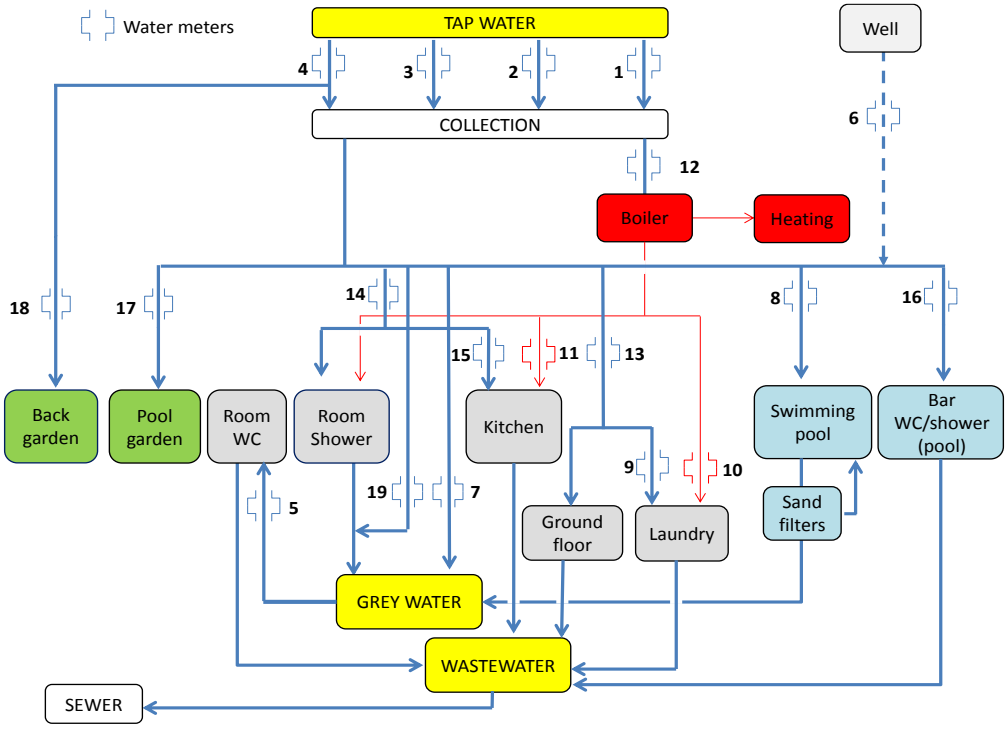
2015	February m3/day	July; August m3/day
Wastewater flowrate	5,800	15,645; 17,400

The portion of WW coming from tourist facilities is more then 10,000 in the dry months. At least half of it is grey water that could be separated and recycled

Water quantities in hotel Samba

Samba Hotel is a large resort (441 rooms), green areas and exterior pools, conference room, bar and restaurant.

- Water use from 25,000 to 34,000 m^3/year (100 to 135 l/PE/day)
- Grey water system for water closets



	June 2014 m3/day	Nov 2014 m3/day
Total tap water	120	66
Room shower	44	15
Room WC	50	33
Wastewater	70	50

Goals and methodology of the research

- Characterisation: four sampling campaigns of GW have been performed in the high season and in the low season.
  - June 2014
  - November 2014
  - February 2016
  - June 2016
- Based on this campaigns synthetic grey water was fed to lab scale MBR to characterise its potential biodegradability
- MBR was set at hotel Samba to treat real GW and its performance assessed and optimized for energy use
  - 7 months monitoring 3x a week
  - Energy: control system for optimizing the air scour was applied during 4 months

Characterisation of RGW: sampling campaigns

		Shower				Laundry	Guideline for reuse in Spain RD 1620/2007
CHEM. PARAMETERS	unit	Jun-14	Nov-14	Feb-16	Jun-16	Jun-14	
TKN	mg N/L	9.9	10.1	15.8	7.3	3.4	<10
P-PO4	mg P/L	0.5	0.5	1.0	0.6	7.2	<2
COD	mg O2/L	223.6	219.3	208.7	136.1	175.3	125
BOD5	mg O2/L	159.7	193.4	128.6	88.4	75.1	25
TSS	mg/l			51.1	39.3	75.6	5
MICROBIOLOGY							
Total count	CFU/ ml	1,1*10^6			0,15*10^6		
Total coliforms	CFU/100 ml	5,8*10^3			14*10^3		
Intestinal nematodes	eggs/10L	absence			absence		1
E-coli	CFU/100 ml	absence			1300		0

Characrterisation: biodegradability

Labscale MBR was run to determine fractions of COD

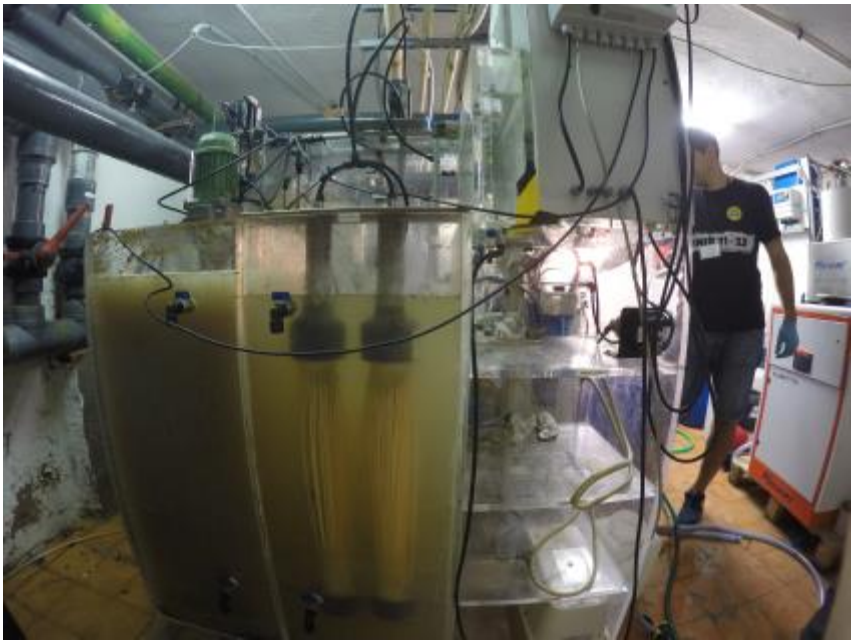
- Based on intensive campaigns synthetic GW was fed to the MBR
- Input and output water quality was monitored

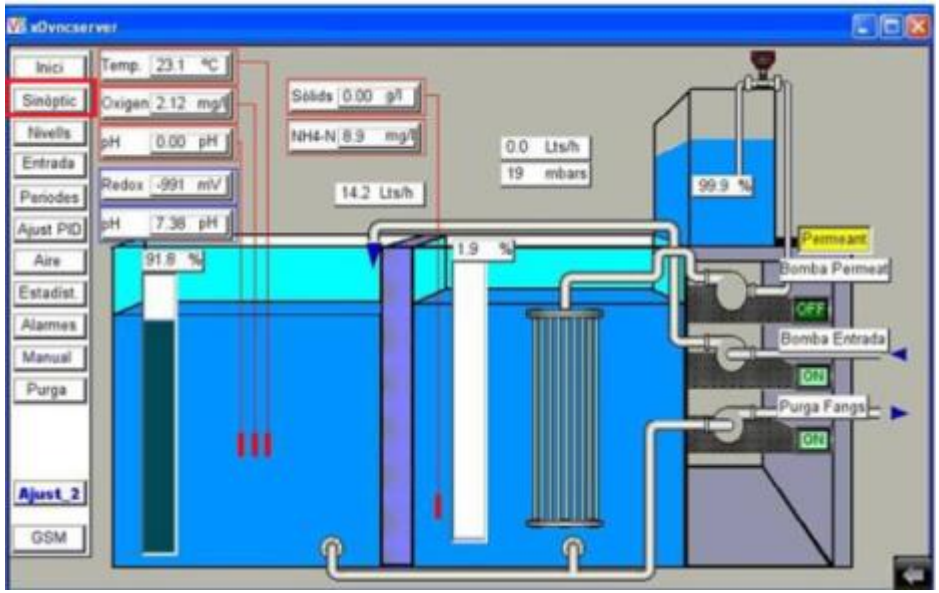
Input flow	37.5 L/d
Purge flow	0 L/d
Airflow	2.16 m^3/h
Cycles	10 minutes permeate (20L/h); 1 minute relaxation
Flux	20 LMH
Net flux	17.1 LMH
HRT	4.16 h

	SAMBA hotel-shower	SAMBA hotel-laundry	Grey (Hocaoglu et al., 2010)	Domestic (Tas et al., 2009)
Total COD, CT, mg/ L	179.5	168.3	275	450
Biodeg. COD: CS/CT , %	95	94	93.5	77.3
Read.biod. S_S/CT, %	51	32	29.3	22.2
Slowly biod. X_S/CT, %	44	62	64.2	29.3
Sol. inert S_I/CT , %	4	8.3	5	7.1
Part. inert, X_I/CT , %	1	1	1.5	15.6

Inert soluble COD:
$S\_I = 0.9*COD\_eff;$
Readily biodegradable COD
$S\_S = BOD5\_inf - S\_I - BOD5\_eff$
Slowly biodegradable
$X\_S = BOD_{20} - S\_S;$
Inert particulate matter
$X\_I = COD\_inf - S\_I - X\_S - S\_S$

The pilot MBR at hotel Samba





Smart Air MBR
Air-scour Control System

Ferrero *et al.* ES2333837
Spanish Patent, 2010

Innovation: air-scour control system based on permeability trend. Results demonstrate energy savings (up to 22%) while minimizing fouling and keeping or improving nutrient removal efficiencies

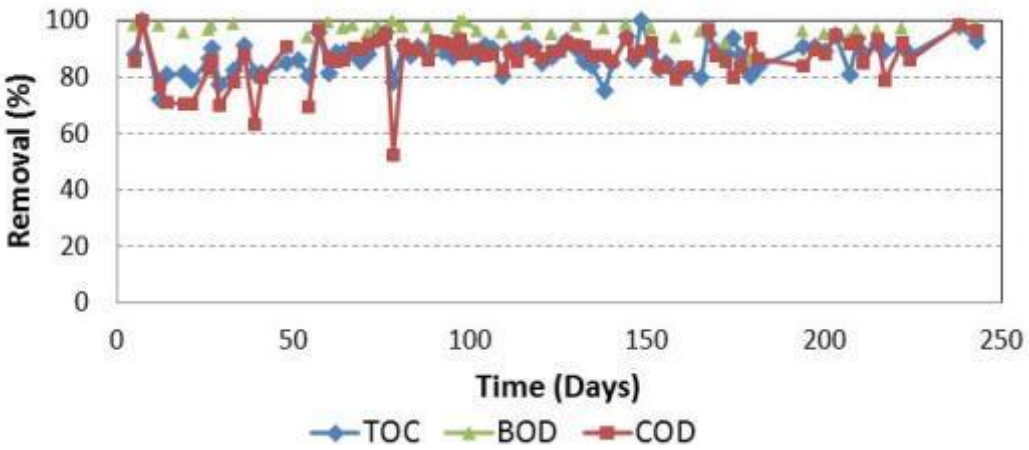
Tested for wastewater but not yet for greywater treatment

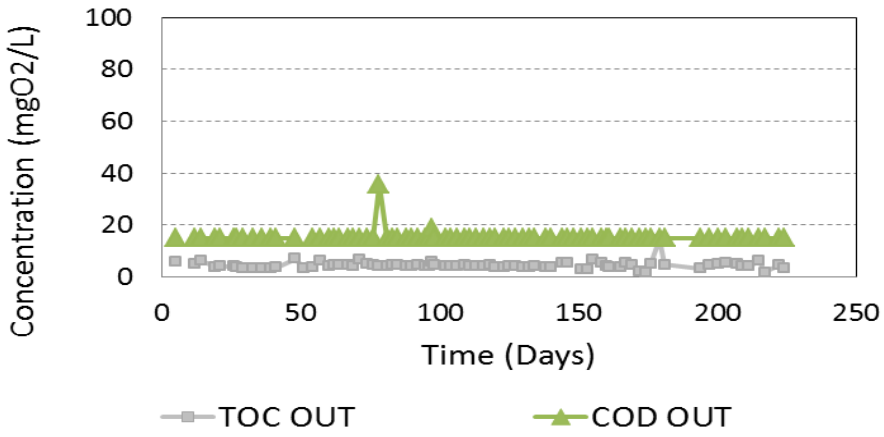
Operation period: full operation 1 m3/day from jan to July. Routine sampling campaign

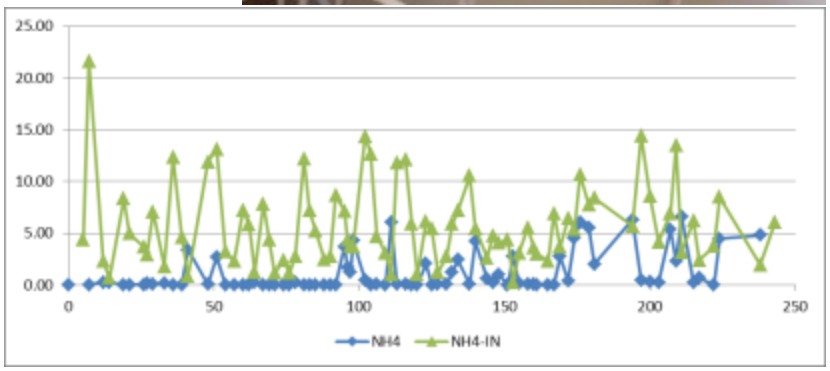
MBR operational parameters

Parameter	
Membrane cut-off	0.04 μm
Membrane surface	0.93 m^2 * 2 modules
Cycles	10 minutes permeate 1 minute backwashing
Input flow	20-30-40 L/h or 0.5-1 m^3/day (cca. 15 PE)
Flux	10-15-20 LMH
HRT	8-4 h
SRT	~ 20-22 days
Purge flow	7-8 L/d
Air flow	from 3.5 optimized to 0.5 m^3/h

MBR performance: effluent quality







		MBR OUT
Total count	CFU/ml	1600
Total coliforms	CFU/100 ml	210
Intestinal nematodes	eggs/10L	0
E-coli	CFU/100 ml	5

Energy

- Fouling is main disadvantage of MBR, which is minimised by air scouring and backwashing cycles or relaxation modes to clean the membranes.
- Membrane aeration represents between 35 and 50% of operational costs
- SAD: specific aeration demand ($m^3/m^2/h$)

SAD (m3/m2 h)	Type of water	Scale	Ref
0.63	Grey water	Pilot (600 l), flat sheet – microfiltration plate	Atasoy et al., 2007
0.44	Black water	Pilot (600 l), flat sheet – microfiltration plate	Atasoy et al., 2007
0.37	Municipal WW	Full scale, hollow fiber	Monclus et al., 2015
1	Grey water	Pilot (630 L), flat sheet	Hocaoglu et al., 2013

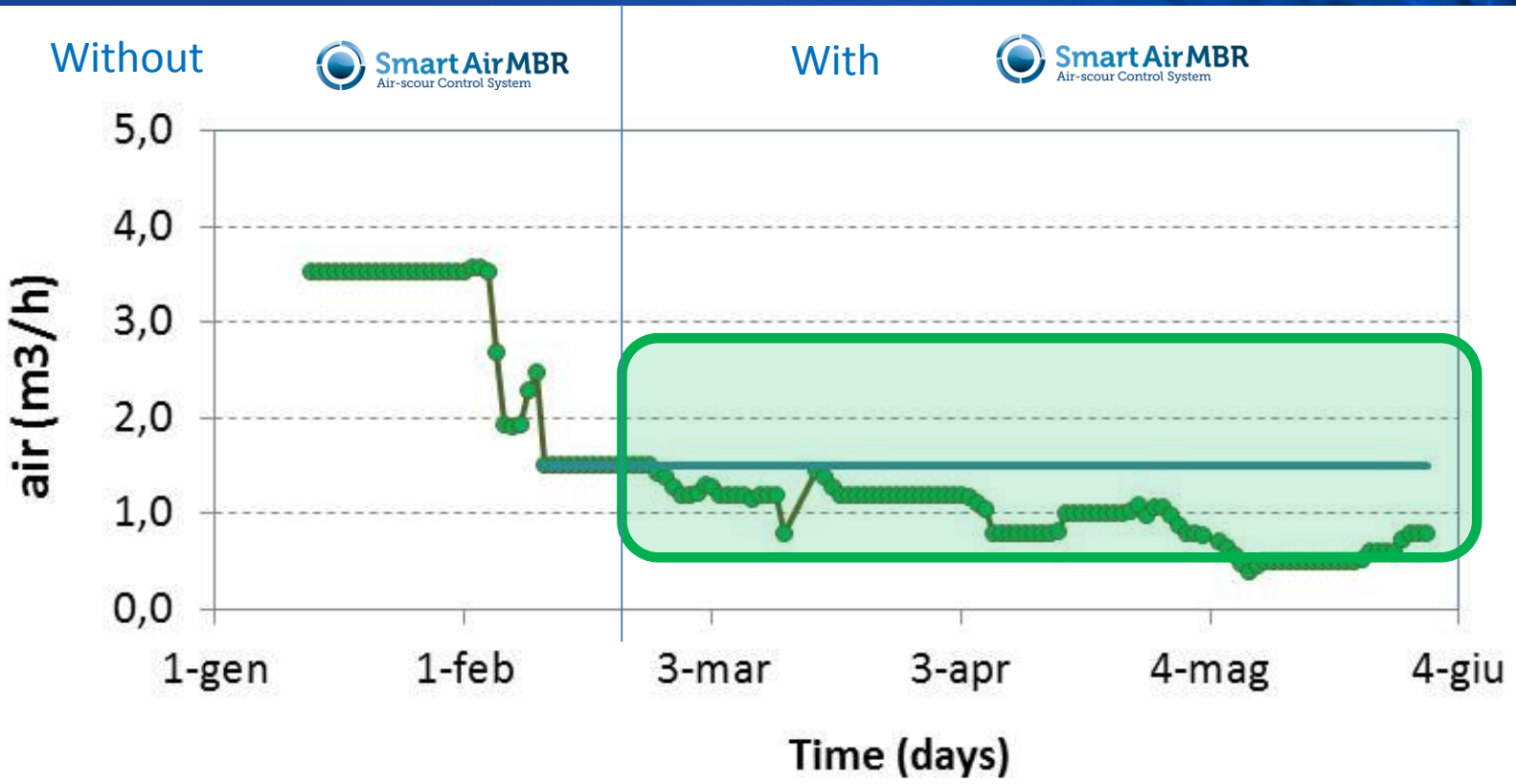
Recommendation for the pilot was SAD of 0.75

Smart Air MBR
Air-scour Control System

was applied to optimize the amount of the air scour flow

It reduces the air flow based on the ratio between the long term and short term calculations of the permeability from historic data

Energy: air-scour control system



- ✓ On average 32.6 % of air saving (without affecting the standard parameter removal)
- ✓ (two membranes with total surface of 1.86 m^2): SAD was reduced from 0.75 to a range of [0.27 to 0.45]

Conclusion

- Grey water reuse in touristic cities can significantly reduce the water stress in Mediterranean and other arid and semi-arid areas.
- Places like Lloret de Mar (densely urbanized) are particularly suitable for such interventions.
- Small scale MBR can be a good compact option for high quality reclaimed water.
- Optimization of energy costs is feasible and on-going which makes MBRs more competitive option for greywater treatment and reuse

Acknowledgements

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