



Wastewater reclamation and reuse in Costa Brava (1989-2009)

Lluís Sala
lsala@ccbgi.org

Workshop “The value of the Waterharmonica for Waternet”
Amsterdam, 24 April 2009



Why I'm here?



The Tenerife Conference

Increasing the natural values of treated waste water



Efficient use and management of water for urban supply

Tenerife

2 - 4 April 2003



The Tenerife Conference

**ENERGY BALANCE IN THE
WATER CYCLE IN SEVERAL
MUNICIPALITIES ON THE COSTA
BRAVA (GIRONA, SPAIN)**

Manel Serra & Lluís Sala
Consorci de la Costa Brava

*2nd International Conference on Efficient Use and
Management of Urban Water Supply - Efficient
2003
2-4 April 2003, Tenerife, Canary Islands, Spain*

Energy balances

Type and source of water	Range of energy consumption (a) kWh/m ³
<i>Drinking water supply (pumping to the main municipal storage tanks included)</i>	
Surface water	0.0002 – 1.74
Groundwater	0.37 – 1.32
Desalination	3.94 – 4.41
<i>Biological wastewater treatment</i>	
Activated sludge	0.43 – 1.09
Extended aeration	0.49 – 1.01
Waste stabilisation ponds	0.05
<i>Reclamation treatment for public health protection (b)</i>	
Chlorination	0.001
Direct filtration (pulsed bed filters) + disinfection (UV + chlorine)	0.18
Direct filtration (pressure filters) + disinfection (UV + chlorine)	0.60
"Title-22" + disinfection (UV + chlorine) (c)	0.20 – 0.63

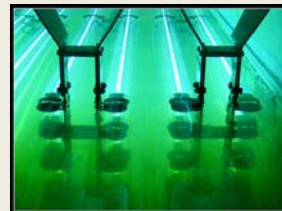
- (a) Some of the figures presented in 2003 have been updated according to recent information
 (b) Consumption of the reclaimed water distribution not included due to the great variability of situations according to the users' location
 (c) "Title-22" here is used to describe the full treatment defined in the Californian regulations consisting in coagulation, flocculation, sedimentation and filtration as the chain of processes previous to disinfection

What do energy balances tell us?

- Ecological footprint of the different parts of the water cycle
- Water reclamation and reuse leads to energy savings where drinking water requires high energy consumption:
 - Surface water transported to large distances and/or high altitudes
 - Groundwater transported to large distances and/or high altitudes
 - Desalinated, in any of the distribution situations
- New criteria to decide where to promote water recycling – step towards a greater sustainability
- Advantages:
 - Tool for a totally objective assessment
 - Independent of prices, taxes and subsidies
 - Applicable to any technology
 - Universal



Blanes desalination plant. Picture by courtesy of Catalan Water Agency.



UV disinfection system

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Blanes desalination plant. Picture by courtesy of Catalan Water Agency.



UV disinfection system

Why?

- Better service to our municipalities
- Environmental awareness
- Will to improve – scientific & technical challenges
- Young and dedicated team



Some recent work

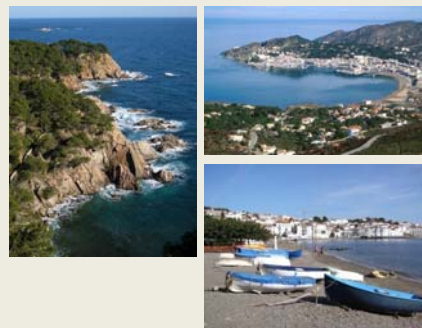
6th Conference on Wastewater Reclamation and Reuse for Sustainability, October 9-12, 2007, Antwerp, Belgium



- L. Sala, A. Angelakis and V. Lazarova: **Good practice examples in Southern Europe**. Workshop: *European experience and priorities: The initiative of the EU-MED Water Directors*. Antwerp, Belgium, 9 October 2007
- G. Borràs, M. Soler and L. Sala: **Summary of data concerning the quality of the reclaimed water produced at the Blanes Reclamation Plant (Costa Brava, Girona, Catalonia)**.
- L. Sala and S. Romero de Tejada: **Use of reclaimed water in the recreation and restoration of aquatic ecosystems: practical experience in the Costa Brava region (Girona, Spain)**.
- M. Montemayor, A. Costan, F. Lucena, J. Jofre, J. Muñoz, E. Dalmau, R. Mujeriego and L. Sala: **The combined performance of UV light and chlorine during reclaimed water disinfection**
Presentació [1.3Mb]
- A. Costan, M. Montemayor, F. Lucena, J. Jofre, J. Muñoz, S. Quintana and L. Sala: **Microbiological water quality improvement from reclaimed water discharges into Ridaura River (Costa Brava, Girona, Spain)**
Presentació [8.6Mb]
- J. Muñoz and L. Sala: **Environmental criteria for alternative nutrient removal in treated wastewater**. (Best poster award of the conference)
- R. Kampf, L. Sala, H. Van der Geest, A. Romani, J. Comas, T. Claassen, S. Gerbens, R. Neef, W. Menkveld: **Biological filtration of treated wastewater by Daphnia: An alternative for technical filtration, or an addition?**
- L. Sala, T. Claassen, R. Kampf, J. Sala, D. Boix, H. Van der Geest: **Trophic webs from discharges: Nature enhancement through the waterharmonica concept**

The Costa Brava

- Name given to the coastal strip of the Girona province, in NE Spain
- Mediterranean climate: hot, dry summers, mild winters and usually wet autumns and springs
- Rugged coastline, with beautiful beaches, tourism-oriented area
- Resident population, approx. 240,000 inhabitants. Maximum population in summer estimated at over 1 million inhabitants



The Consorci de la Costa Brava (I)

- Water agency created in 1971 by the 27 municipalities of the coastal area of Girona's province.
- Deals with the whole water cycle:
 - Wholesale purveyor of drinking water to 14 municipalities (3 of them external to CCB) - 19 million m³/year in 2007
 - Biological wastewater treatment to 28 municipalities (2 of them external to CCB) in 18 WWTP – 30.1 million m³/year in 2007. The 2 remaining municipalities to be connected to WWTP by 2010.
 - Reclamation and reuse of treated wastewater for non-potable purposes since 1989 - 5.5 million m³/year in 2007 produced in 14 facilities
- Construction, operation and maintenance of water treatment facilities funded by the Catalan Water Agency (regional water authority)



The Consorci de la Costa Brava (II)

- Facilities operated by CCB (as of 2009)

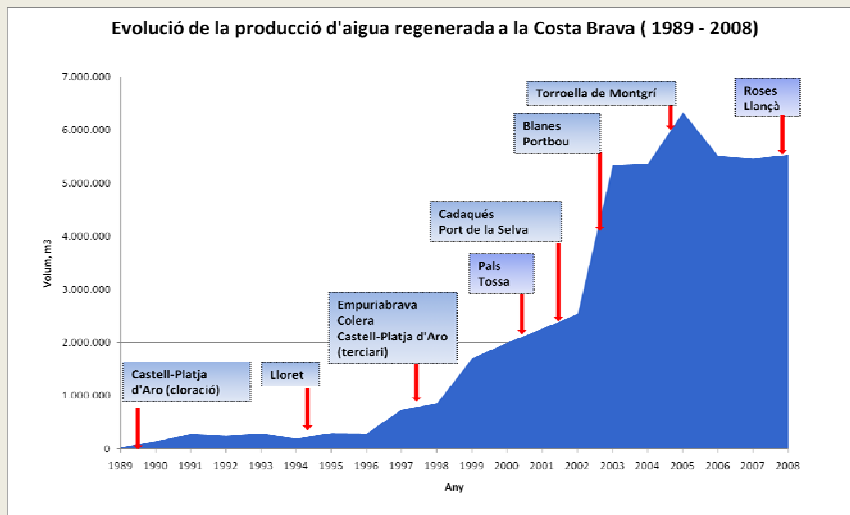


The Consorci de la Costa Brava (III)

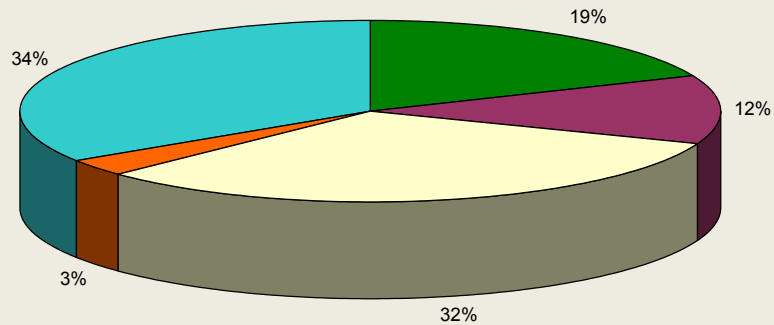
- Volumes treated and reclaimed (2008)

Operational area	Number of WWTP	Volume of wastewater treated in 2008, million m ³ /year	Number of reclamation facilities	Volume of reclaimed water produced in 2008, million m ³ /year	Percentage of water reclamation, %
Northern	9	6.6	7	1.1	18
Central I	4	4.2	2	1.1	26
Central II	2	11.1	2	0.8	7
Southern	3	9.1	3	2.5	27
Total	18	31.0	14	5.5	18

Evolution of reclaimed water production



Breakdown of uses in 2008



Reasons to reuse

- Over-extraction, depletion and pollution of the small coastal aquifers
- Increase in non-potable urban demand (golf courses, private and municipal gardens)
- Significant investment for an adequate supply of drinking water (water transfers and desalination)
- Significant investment in wastewater collection and treatment to biological, secondary level. Effluent discharged into the sea through submarine outfalls
- An additional treatment (reclamation) produces safe water to cope with non-potable demands = more logical resources management in the area

Reclaimed water quality

- Influenced both by kind of biological and reclamation treatments

Kind of facility (between brackets, year of construction)	Reclamation plant							
	Empuriabrava		Pals (c)		Castell-Platja d'Aro		Blanes	
Wastewater treatment	Extended aeration (1995)		Extended aeration (1995)		Conventional activated sludge (1983)		Extended aeration (1998)	
Reclamation treatment	Constructed wetlands (1998)		Chlorination (2000)		Filtration, disinfection (1998)		"Title-22" (d) (2002)	
Volume treated in 2008, m ³	1,027,000		440,000		786,000		2,127,000	
Statistical parameters (a)								
	Average	P90	Average	P90	Average	P90	Average	P90
Suspended solids, mg/L	8.5	18.9	3.5	5.0	5.4	7.8	1.7	2.4
Turbidity, NTU	2.5	3.6	1.3	1.9	2.7	4.2	1.7	2.2
<i>Escherichia coli</i> , cfu/100 mL	35	180	< 1	< 1	2	19	3	6
Total nitrogen, mg N/L (b)	1.5	2.4	5.9	11.4	35.9	52.0	10.4	13.2
Total phosphorus, mg P/L	5.0	6.9	4.3	6.0	4.1	5.7	1.3	1.8

(a) Annual arithmetic averages for all parameters, except for the *Escherichia coli* concentrations, which are geometric averages. P90 is the percentile 90 of the annual set of data.

(b) In the Empuriabrava case, organic nitrogen (ammonia + nitrite + nitrate)

(c) Water at the inlet of the storage pond at Golf Serres de Pals

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Types of reuse according to reclaimed water pricing

- Non-billable:** reclaimed water is used in the public interest. Expenses covered by the Catalan Water Agency. 79% of the reclaimed water produced in 2008. Non-demand dependent. Examples:
 - Aquifer recharge for resource augmentation in Blanes
 - Seawater intrusion control in Llançà and Port de la Selva
 - Environmental reuse at the Aiguamolls de l'Empordà (Empordà Marshes) Nature Reserve
 - Agricultural irrigation for users who have had their resources reduced to favour the production of drinking water (Torroella de Montgrí)
- Billable to a private end user:** 21% of the reclaimed water produced in 2008. Written agreements – contracts-. Demand dependent. Average price: 0.12 €/m³. Examples:
 - Golf courses (6) & Pitch & Putt facilities (2)
 - Corn fields (2) and fruit and vegetable orchards (1)
 - Wineries (1)



Irrigation

- Main billable supply
- Concentrated in the summer months – perfect match with water availability
- Nutrient recycling (see *Environmental Criteria for Alternative Nutrient Removal in Treated Wastewater* - J. Muñoz and L. Sala at http://www.ccbgi.org/docs/antwerp_2007/poster2007.pdf):
 - Fertilizer savings – nutrient contributions by irrigation water to be measured
 - Basin protection – lesser discharges and lesser new fertilizers being used
 - Net CO₂ uptake – Kyoto protocol!



Paradox

- Quality of river water used for agricultural irrigation wouldn't comply with Spanish regulations for water reuse

Percentile 90 year 2007

Parameters	Reclaimed water Torroella plant	Ter river in Torroella de Montgrí	Spanish regulations RD 1620/2007
Number of samples	20 (SS and <i>E. coli</i>), 44 (Turbidity)	9 (summer, irrigation season)	1/week
SS, mg/L	6,6	33,2	20
Turbidity, NTU	2,3	19,3	10
<i>E. coli</i> , cfu/100 mL	27	38.000	100

Reclaimed water from
the Torroella de
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22/July/2005



Water from the Ter river in
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Reclaimed water from the Torroella
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Officially,
nobody cares!!

Water from the Ter river in
the Torroella de Montgrí
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Still... satisfied customers!



Still... satisfied customers!



Caves Castell de
Peralada
D.O. Empordà
85% Syrah, 15%
Cabernet
Sauvignon
PVP 100€

[http://www.castilloperelada.com/
ing/vinos_interior.php?proid=25](http://www.castilloperelada.com/ing/vinos_interior.php?proid=25)

Still... satisfied customers!



Drought-proof agriculture for small farms
Business as usual during the droughts of 2005 and 2007-2008

More satisfied customers



Sustainable supply for golf courses
Business as usual during the droughts of 2005 and 2007-2008

Non-billable uses



Treating water to a superior level has proven environmental benefits

The Blanes Reclamation Plant

- Extended aeration biological plant with chemical phosphorus removal
- Title-22 tertiary treatment (700 m³/h), with coagulation, flocculation, sedimentation, filtration and a wide range disinfection, performed by a combination of UV (maximum UV dose estimated at 189 mJ/cm²) and chlorine (210 min contact time at peak flow)
- In operation since 2003
- Current disinfection settings: UV dose approx. 80 mJ/cm² + 1ppm Cl₂ (210 mg Cl₂.min/L)
- Current uses: aquifer recharge and agricultural irrigation



N/DN secondary effluent and flocculation tanks



Flocculation tanks & lamella clarifiers (left) and pulsed-bed filters

UV disinfection system (Berson) and reclaimed water used for surface aquifer recharge



Why reuse in Blanes?

- Aquifer of the lower Tordera river overdrafted due to the increasing demand (urban, industrial and agricultural) and due to severe drought (1998-2002). Decline in the water table and loss of quality due to seawater intrusion.
- Measures undertaken by the Catalan Water Agency (ACA) to reverse the situation:
 - Establishment of a plan for the regulation of aquifer extractions
 - Construction of a 10 million m³/year desalination plant
 - Construction of a water reclamation facility at the Blanes WWTP to recharge the aquifer instead of discharging secondary effluent into the sea (average 3 million m³/year)
 - Promotion of internal recycling in local industries

Water produced by the Blanes reclamation plant (N/DN + Title-22) and used for the recharge of the lower river Tordera aquifer by percolation, 7 July 2005



Summary of quality 2007 (Percentile 90 of the annual set of samples):

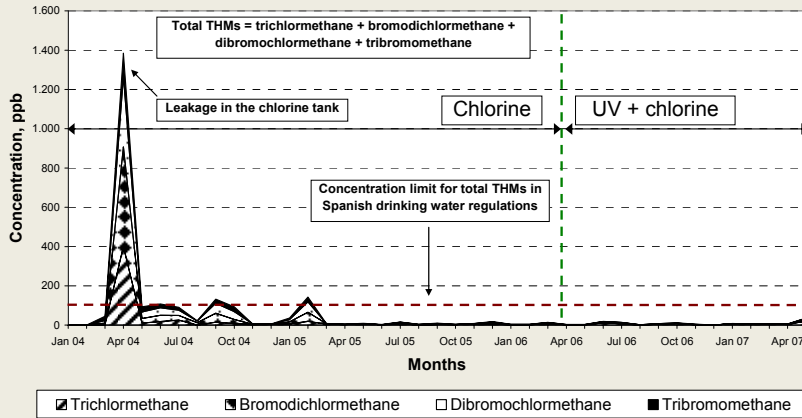
SS = 2.4 mg/L (319 samples)
Turbidity = 2.2 NTU (324 samples)
Total nitrogen = 9.2 mg N/L (140 samples)
Total phosphorus = 1.8 mg P/L (141 samples)
E. coli < 1 cfu/100 mL (116 samples)

The reclamation treatment

- Disinfection is the essential process - aimed at reducing at safe levels the microbiological risk:
 - Wide range disinfection: UV + Cl₂
 - Inactivation capacity similar than concentration of indicators (= greater than the concentration of pathogens)
- Preparation processes, ahead of disinfection may be needed (coagulation, flocculation, sedimentation, filtration)
- Combination of disinfectants reduces chlorine doses = lower risk of THM formation
- On-line probes for the measurement of turbidity and residual chlorine or redox potential – great reliability to the supply

Control of THM formation

EVOLUTION OF THE TRIHALOMETHANE CONCENTRATION IN THE WATER PRODUCED BY THE BLANES RECLAMATION PLANT

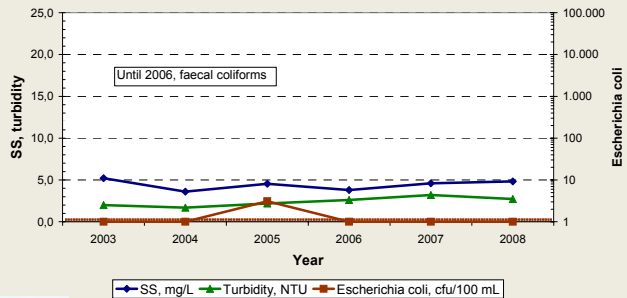


Tossa de Mar reclaimed water quality

Physico-chemical treatment prior to disinfection

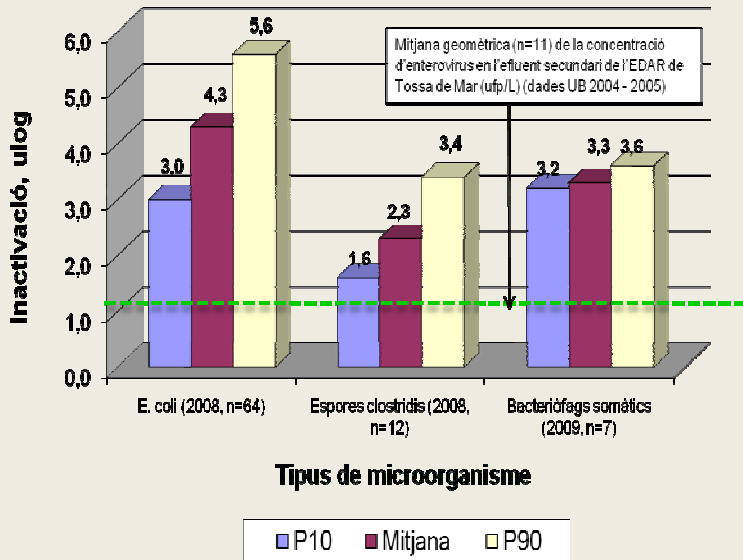


EVOLUTION OF THE RECLAIMED WATER QUALITY IN TOSSA DE MAR. PERCENTILE 90 OF THE ANNUAL SET OF DATA.



Berson UV disinfection

Tossa de Mar: inactivation capacity



Environmental enhancement at Tossa de Mar

- Former uncontrolled landfill of construction materials turned into a park (Parc de Sa Riera) thanks to the availability of reclaimed water.
- New urban non-potable uses (irrigation, cleaning, improvement of ecological status of local stream) that wouldn't be possible without it.

Pictures by courtesy of Jordi Couso, municipality of Tossa de Mar



Surroundings of WWTP, 1997



Surroundings of WWTP, 2002











Improvements at the Tossa de Mar Creek

- Small mediterranean temporary stream
- Increased use of external sources – decrease on the pressure on the small local aquifer
- Active use of reclaimed water:
 - Streamflow augmentation in the local Tossa Creek through percolation in the park’s wetland. Avoids total dessication in summer and provides minimal but highly valuable flows that sustain the ecological function.
 - New projects for the improvement of the ecological condition of the stream also based on the use of reclaimed water – planting local riparian vegetation

Period	Example year	Tossa aquifer, %	Tordera aquifer, %	Blanes desalination plant, %
Until 1980	1975	100	0	0
1980-2003	1990	20	80	0
From 2003	2004	20	52	28



Comparsion of streamwater quality

Sampling point	Parameter	Winter	Spring	Summer	Autumn
Before urban park (no influence of reclaimed wastewater)	Conductivity, mS/cm	0,408	0,358		0,435
	Dissolved oxygen, mg/L	10,4	8,4		8,8
	Total nitrogen, mg/L	<3,2	<3,9		<4,2
	Ammonia, mg/L	<1,0	<1,2		<2,1
	Nitrate, mg/L	1,6	1,8	Dry	1,9
	Total phosphorous, mg/L	0,7	<0,5		0,8
	IBMWP	97	114		31
	Category IBMWP	II	I		IV
	ASPT	4,7	5,2		3,1
	Number of taxa	21	23		10
After urban park (infiltrated reclaimed wastewater)	Conductivity, mS/cm	0,426	0,398	0,581	0,507
	Dissolved oxygen, mg/L	10,6	9,0	5,3	10,8
	Total nitrogen, mg/L	<3,2	<4,2	<4,2	<3,7
	Ammonia, mg/L	<1,2	<1,3	<0,8	<1,7
	Nitrate, mg/L	1,6	1,5	2,0	1,8
	Total phosphorous, mg/L	0,9	<0,5	0,7	0,7
	IBMWP	108	121	85	55
	Category IBMWP	I	I	II	III
	ASPT	5,1	5,2	3,5	4,4
	Number of taxa	21	24	24	13

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Lower than usual due to the wash-out effect of heavy rains

Monthly averages of seasonal sampling since 2003 (N=3 for each season except autumn - 2005 not yet sampled at the time of preparing the table)

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Tossa de Mar Creek

- Visited by celebrities!



Prof. Takashi Asano visiting the Park de Sa Riera and Tossa Creek in June 12, 2007. Flows due to artificial recharge from the pond of the park.

Reclaimed water distribution networks

- New development in several municipalities of the Costa Brava – where drinking water is scarce and/or expensive
- Initially, only for municipal non-potable uses. Will to extend the supply to private non-potable uses
- In operation in Tossa de Mar and Lloret de Mar (both since May 2007) and in construction in Port de la Selva
- In Tossa de Mar and Lloret de Mar produce water and energy savings
- Detailed monitoring has shown no quality problems



Summarizing....

Water reclamation and reuse in the Costa Brava is the result of an **enthusiastic, persistent and dedicated task**, based on **common sense** and **open to technological and scientific improvements**, of a group of people willing to leave their mark in the water resources management in the area.

Newest task: Applied research

- Cooperation with universities to:
 - Promote applied works of Master's students (i.e., Alba Balés with the Empuriabrava mesocosmos for biological filtration)
 - Help with ongoing studies (i.e., MODELKEY project, "*Models for assessing and forecasting the impact of environmental key pollutants on marine and freshwater ecosystems and biodiversity*")
 - Answer practical questions, i.e. "Do faecal microorganisms inactivated during disinfection regrow on reclaimed water storage facilities or the ones found are from external contributions?"
 - Build or host pilot plants and learn from experience:
 - Biological filtration at Empuriabrava
 - MF + RO at Torroella de Montgrí – coupled to the MODELKEY project
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External contributors!

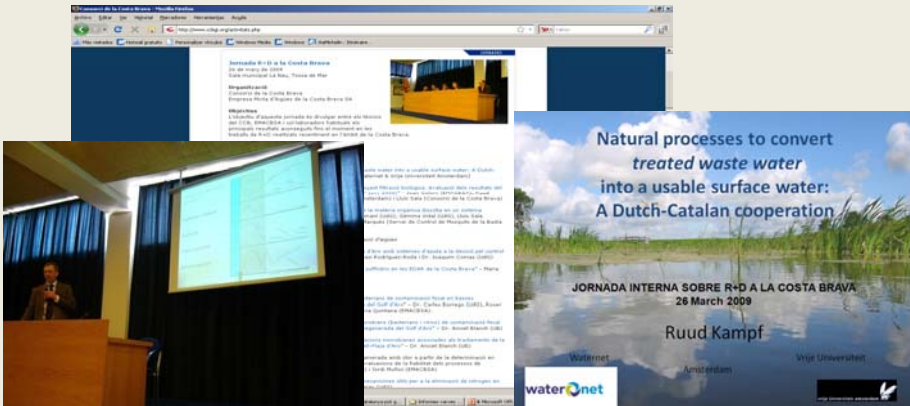
First harvest

- Workshop in Tossa de Mar, 26 March 2009
- Pdf of presentations already on CCB's website



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Significant past achievements - individual

- Secretary and Newsletter Editor of IWA's Water Reuse Specialist Group (1995-2003)
- Task leader within the Mediterranean Network on Wastewater Reclamation and Reuse – MedReunet (2003-2005)
- Papers presented at several international conferences
- Co-author of a chapter within "Water reuse for irrigation" by Valentina Lazarova & Akissa Bahri (eds.)
- Co-author of a chapter within "Water Reuse: An International Survey of current practice, issues and needs" by Blanca Jimenez & Takashi Asano (eds.)

Chances for the future

- International collaboration at water agency level?
We're open!



Cooperation always produces fruitful results



RO water produced from
Torroella de Montgrí's
secondary effluent and used
for the MODELKEY project



**Thanks for your invitation
and your attention!**

Questions?