Water Reuse Project of Tossa de Mar Consorci of Costa Brava

Costa Brava

Costa Brava is the geographical designation for the coastal strip extending along the northeastern coast of Spain, in the Catalonian province of Girona. Its rugged coastline and its beautiful secluded beaches have helped to make it one of the most attractive tourist areas in the world. It enjoys a Mediterranean climate, with hot and dry summers, mild winters and usually wet autumns and springs; its average rainfall is 650 mm/year, but with episodic and recurring drought periods that raise considerable concerns among those responsible for providing water supply to resident and seasonal populations as well as to agriculture and aquatic ecosystems.

The Costa Brava coastal strip includes 27 municipalities, distributed along 200 km of coastline. A permanent population of 240,000 people becomes a seasonal population of more than 1 million people during the peak tourist summer season (June to August). Most visitors come from Spain and numerous European countries.

Consorci of Costa Brava

Consorci of Costa Brava (CCB) is the water agency, founded in 1971, to provide integrated management of water resources to the 27 municipalities of Costa Brava. Since 2006, operation and maintenance tasks are implemented through a public-private company named Aigües de la Costa Brava. CCB is responsible for:

1) Provision of water supply, as a wholesale drinking water purveyor, to 16 cities (5 of them external to CCB). The water supplied during 2010 was 17.1 hm^3.
2) Operation of 18 wastewater treatment plants (WWTP) where wastewater flows from 31 cities (4 of them external to CCB) are treated using biological processes. The annual volume of wastewater treated during 2010 was 34.1 hm^3.
3) Since 1989, operation of an increasing number of water reclamation and reuse projects for non-potable uses; the total flow of reclaimed water produced by the 14 water reclamation plants (WRP) during 2010 was 6.4 hm^3, which represents 19% of the secondary effluent produced.
4) Design, construction, operation and maintenance of several water treatment facilities, funded by the Catalan Water Agency, the regional water authority responsible for collecting and distributing regional water taxes.

Tossa de Mar Water Resources

Tossa de Mar is a small coastal resort town located in southern Costa Brava, in relative geographical isolation, but harboring beautiful landscapes and valuable historical monuments. Although its permanent population is close to 6,000 people, its summer population may reach up to 60,000 people. Drinking water use is 1 hm^3/year, with about

20% coming from local sources, while the other 80% is provided from external sources: 52% is groundwater from the Tordera river aquifer and 28% is desalinated water from Blanes desalination plant, both located some 15 km southwest.

Under conventional water management strategies, this costly imported water was used by the community, turned into wastewater, treated in a biological wastewater treatment plant and, as in other coastal areas, discharged into the sea. In Costa Brava, Tossa de Mar was one of the leading municipalities to understand that a reasonable additional investment could turn wastewater into reclaimed water, a new municipal water resource for supply to non-potable uses, with lower production and conveyance energy requirements than conventional sources. In Tossa de Mar, those favorable conditions are further intensified by the maximum availability of reclaimed water that takes place during the summer season, when demand for non-potable uses is the highest and local resources are more affected by the Mediterranean dry season.

The urban development of Tossa de Mar, in a geographical area exposed to such seasonal water shortages, inevitably implies higher investments to satisfy water consumption, higher energy costs to cover water production and transfer, and higher costs for domestic water supply and for other urban uses, such as irrigation and street cleansing. Non-potable uses are severely restricted during seasonal droughts.

This water resources situation brought the need of developing new, alternative, additional water resources capable of satisfying very specific requirements: 1) to provide a sufficient water volume, 2) to satisfy non-potable uses quality while ensuring public health protection, 3) to require a low energy use for its production, 4) to provide a high supply reliability, particularly during drought periods and 5) to avert any further environmental impact, by preventing additional abstractions from surface or groundwater.

Although reclaimed water does satisfy all those requirements, its beneficial use poses new requirements: the availability of either a groundwater system with enough recharge capacity to absorb reclaimed water and provide the environmental buffer zone required for indirect potable reuse or, alternatively, a distribution system to supply reclaimed water according to demand. The distribution system had to include preferably 3 new water storage tanks: 1) a secondary effluent equalization tank, to ensure reclamation process reliability, 2) a reclaimed water storage tank, provided with chlorination devices and a recirculation process and 3) a water tank for gravity feed to the urban distribution network. In summary, development of a new, alternative or additional water resource, of whatever type it may be, involves provision of the additional necessary infrastructures with its corresponding investment.

History of Water Reuse in Tossa de Mar

Water reuse in Tossa de Mar began in 1997, when the City Council's Urban Planning Commission approved the conversion of a 4-ha uncontrolled landfill into a public park: the Park of Sa Riera (See Fig. 1). The proximity to the City's WWTP prompted the idea of using reclaimed water as a water source for landscape irrigation. The initial funding limitations constrained the reclamation process to adopt a simple set up: secondary effluent was filtered using out-of-service sludge drying beds, to further remove SS, and then disinfected with sodium hypochlorite. The landscape design adopted a subsurface irrigation method; after percolating through the soil, water was effectively nitrified and then collected and

used to supply an ornamental pond. Some of the percolated water even emerged at a nearby creek that had been dry for years. Reclaimed water supply for park irrigation reaches 150 m^3/day during peak-demand periods.

Figure 1 Landscape irrigation with reclaimed water at Park of Sa Riera, Tossa de Mar (May 2007). A former uncontrolled landfill turned into a public park thanks to the availability of this new water resource.

The serious drought period affecting the area during the late 1990's brought the groundwater levels at the Tordera river's aquifer, the main source of drinking water for Tossa de Mar, to record low levels and promoted intensive seawater intrusion; the resulting salinity increase deteriorated the water source serving several municipalities. In 2001, the Catalan Water Agency declared the Tordera river's aquifer as overexploited and began construction of the Blanes desalination plant (10 hm^3/year in its first phase) in order to reduce well water pumping and help recover groundwater quality. Preliminary discussions between CCB and ACA were established to build a WRP at Tossa de Mar with three main goals: 1) to diminish urban use of drinking water, by replacing it with reclaimed water for non-potable uses, 2) to improve the reliability of the reclamation process, particularly through improved SS and turbidity removal and effective disinfection and 3) to expand reclaimed water use in the city, beyond irrigation at the nearby Park of Sa Riera.

In late 2002, a new WRP had been completed, with an overall investment from ACA of 548,000 €, and reclaimed water began its course to new non-potable urban uses.

Tossa de Mar Water Reclamation Process

The WRP of Tossa de Mar has a capacity of 35 m^3/h (840 m^3/day), upgradable to a maximum of 140 m^3/h, and includes: coagulation-flocculation, lamella settling, rapid sand filtration and a combined disinfection process using sodium hypochlorite and UV light, at a maximum dose of 48 mJ/cm^2 (See Fig. 2). Reclaimed water is stored in a 700 m^3 tank, where reclaimed water is further chlorinated and mixed, and then pumped to the reclaimed water distribution network.

Figure 2 Partial view of the water reclamation plant of Tossa de Mar in April 2008.

Reclaimed water quality control is performed using: 1) an online turbidity sensor at the WWTP effluent point, 2) an online redox potential sensor at the effluent of the rapid sand filter and 3) an online free residual chlorine sensor located at the water storage tank. Reclaimed water produced by the WRP of Tossa de Mar during recent years has ranged from 60,000 m^3/year to 120,000 m^3/year, with monthly flows ranging from 2,000 m^3/month to 12,000 m^3/month.

Tossa de Mar Reclaimed Water Distribution System

Reclaimed water use from the WRP of Tossa de Mar began in 2003 by means of water tanks loading at a hydrant located at the doorstep of the WRP. Initially, water was mostly used for street cleansing, public gardens irrigation and other non-potable urban uses, but with an evident limitation of flows and convenience. It soon became evident that promotion of reclaimed water use required the provision of additional loading points closer to the city center. A design project was prepared and funding was sought at municipal level.

To minimize urban disturbances, piping installation was conducted simultaneously to that of gas distribution network (See Fig. 3). Public spaces of new residential areas were offered connection to the reclaimed water distribution system for non-potable uses, mainly for landscaping irrigation. A demonstration project is being conducted since mid 2007 to assess the reliability of using reclaimed water for private garden irrigation in the near future, in close collaboration with the Catalonia Public Health Service.

Figure 3. Construction of Tossa de Mar reclaimed water distribution network in 2007.

In early 2011, the reclaimed water distribution network at Tossa de Mar had a main line of 5.7 km length and 160 mm diameter polyetheline pipe (See Fig. 4). The total capital investment so far amounts to 365,000 euros. Construction of a gravity storage tank is still pending, with an estimated budget of 226,000 euros. The water distribution network includes irrigation valves, 6 hydrants, several drip irrigation systems, several spray irrigation systems.

The reclaimed water network was designed to maximize its benefits by servicing municipal areas with the highest non-potable water uses. Since 2007, the network has gradually expanded and is currently (mid 2011) providing reclaimed water to the main municipally-owned landscaped areas and municipal services, fire hydrants and other publicly-owned facilities such as the county's dog shelter. In addition, landscape irrigation with reclaimed water at the Parc de Sa Riera is indirectly supplying recharge water flows to the local stream, thus avoiding its total summer desiccation and effectively protecting its fragile aquatic ecosystems.

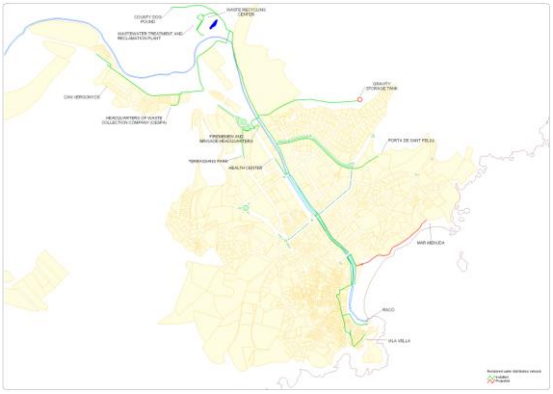

Figure 4. Reclaimed water distribution system of Tossa de Mar in early 2011. Green lines are existing pipeline and red lines are pending infrastructures.

Sampling for water quality monitoring is conducted at the effluent of the WWTP, at the reclaimed water storage tank and currently (2011) at 2 strategically located distribution points in the urban environment, to ensure that water quality limits are met at all the reuse sites (See Fig. 5). A detailed survey had been conducted in previous years, using additional sampling points, to better understand the potential changes taking place in reclaimed water quality along the distribution system.

The operational strategy for reclaimed water distribution has been: 1) to define an operational protocol among all the interested parties (water producers and water users) and 2) to install automatic online safety features, to ensure the reliability of reclaimed water quality and the immediate service interruption when a critical water quality parameter goes outside its specified interval.

Spanish Water Reuse Regulations

Water reclamation and reuse regulations are established by Royal Decree (RD) 1620/2007. In summary, reclaimed water quality is defined by four main parameters: parasitic helminth eggs, *E. coli,* suspended solids and turbidity. Other microbiological parameters, like *Legionella* sp. and physico-chemical parameters are applicable to specific uses of reclaimed water.

Figure 5. Water sampling at Tossa de Mar reclaimed water distribution network (August 2007).

Reclaimed water uses are classified according to the expected exposure of workers, the public at large and the irrigated crops to reclaimed water. Quality requirements become increasingly restrictive as the likelihood of human exposure becomes possible, to ensure both public health and environmental protection. Compliance is established according to the 90 percentile (P90) of the series of water quality parameters recorded during the water reuse period.

Applicable limits for current reclaimed water uses in Tossa de Mar are those corresponding to unrestricted urban use (Quality Use 1.2) with SS, turbidity, parasitic helminths and *E. coli* P90 concentration limits below 20 mg/L, 10 NTU, 1 egg/10L and 200 cfu/100mL. Future mid-term plans include the supply of reclaimed water for irrigation of private gardens, which involves compliance with quality limits for unrestricted residential use (Quality Use 1.1): P90 values below 10 mg/L for SS, 2 NTU for turbidity, 1 egg/10L for parasitic helminths and 1 cfu/100 mL for *E. coli*.

Reclaimed Water Quality

Seasonal samples of reclaimed water collected in Tossa de Mar during 2009 had 90% values for SS concentration of 4.2 mg/L (144 samples), turbidity of 2.5 NTU (180 samples) and absence of *E. coli* in all the 86 samples analyzed. This turbidity value was slightly above the 2 NTU limit required by Spanish regulations for unrestricted irrigation by residential users. Corresponding values for 2010 were 3.2 mg/L for SS (105 samples), 1.9 NTU for turbidity (105 samples) and absence of *E. coli* in all the 99 samples analyzed.

Reclaimed water quality satisfied the microbiological limits for Quality Use 1.2 during 2009 and 2010. The limits for SS and *E. coli* of Quality Use 1.1 were consistently met during 2009 and 2010; the efforts made during 2010 resulted in full compliance of the 2 NTU turbidity limit. Since 2003, reclaimed water is regularly analyzed for parasitic helminth eggs once a year; no eggs have been detected in either the 25L or 50L water samples analyzed so far.

Residual chorine concentration in the Tossa de Mar distribution network markedly decreases from 10% (P10) concentrations of 0.5-0.6 mg/L at the beginning of the distribution pipe, down to equal or less than 0.01 mg/L in the sampling points further located from the WRP, pointing the need for either increasing the initial chlorine dose or adopting some rechlorination strategy within the network, if presence of residual chlorine is desired. However, despite this situation, *E. coli* colonies are very seldom detected in these points. The P10 value for dissolved oxygen concentration decreases from around

8 mg/L at the network entrance to 3-5 mg/L at the furthest point from the entrance, thus ensuring a lack of undesirable odors during landscape irrigation.

Risk Assessment for Legionella Infection

Since 2007, Consorci of Costa Brava and its operating agencies are conducting an extensive assessment of the overall *Legionella* infection risk posed by the use of reclaimed water for irrigation of urban and home garden, following the Technical Guidelines established by the Spanish Ministry of Public Health and Consumer Affairs.

The follow-up studies conducted during 2007 indicate that:

1) Total aerobic bacteria show a regrowth process as water flows away from the point where sodium hypochlorite is applied at the WRP.
2) This regrowth process can be managed and maintained within the safety limits required by the Technical Guidelines for the Prevention and Control of Legionellosis, to prevent proliferation of *Leginonella* in facilities considered as of "low infection risk".
3) The overall infection risk resulting for spray irrigation in urban environments, considering the most unfavorable points of use (sprinklers) and under the most unfavorable microbiological conditions recorded, is about 60 units, a numerical limit corresponding to a "low infection risk" condition, according to the Technical Guidelines.

The main recommendations applicable to the reclaimed water distribution system are:

1) The water distribution system should have a systematic analytical control and maintenance program, to ensure that total aerobic bacteria concentration satisfies the specified limits and to determine if rechlorination points may become necessary.
2) Water storage tanks have to be further evaluated to determine the convenience of adopting elevated tanks (to provide regular pressure throughout the system), the need to keep them covered and equipped with a chlorination system, the need to ensure a regular cleaning and maintenance program, and the possibility of periodically emptying their content into the sewer system.

Apart from these specific evaluations on the safety of reclaimed water, the municipality of Tossa de Mar complies with the requirements of Royal Decree 865/2003 relative to the prevention and control of Legionellosis, by cleaning and disinfecting all the sprinklers under its responsibility, whether they use drinking or reclaimed water, thus ensuring the required level of public health protection.

Capital Investment and O&M Costs

Table 1 shows the capital investments of the water reclamation and reuse project of Tossa de Mar.

Table 1. Capital investments of the water reclamation and reuse project of Tossa de Mar, up to 2009.

Project component	Dimensions	Cost, in euros
Water reclamation plant	840 m^3/day	472,000
Distribution network	5.7 km, 160 mm	365,000
Storage tank (pending)		226,000 (planned)
Total investment		837,000

Until now, reclaimed water has been supplied to different end users under a case by case technical and economic arrangement. CCB is currently completing the official permitting process established by Spanish regulations (RD 1620/2007), to obtain the official category of wholesale reclaimed water producer and supplier from the Catalan Water Agency, the water authority in Catalonia. Once that official designation is obtained, CCB will be able to establish the appropriate wholesale reclaimed water supply contracts with municipalities, which will be responsible for managing the technical and economic aspects of reclaimed water distribution to end users.

Further Information

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Technical References

The CCCB's webpage section on water reclamation and reuse provides extensive information on the current activities and future plans concerning the water reclamation and reuse projects conducted at the 27 municipalities of CCB.

(http://www.ccbgi.org/reutilitzacio.php)

For specific information on Tossa de Mar: (http://www.tossademar.com).

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