

Water Reclamation and Reuse in Costa Brava (1989-2009): Lessons learned and practical contributions

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In 1989, the Consorci de la Costa Brava (Costa Brava Water Agency, CCB) started the supply of reclaimed water for the irrigation of the Mas Nou golf course (nowadays Golf d'Aro). This happened after the request of the Castell-Platja d'Aro municipality and as a consequence of the lack of water, not only for the irrigation of their facilities but also for the supply of drinking water to the municipalities of the Vall d'Aro. Back then, the water transfer from the Montfullà drinking plant in Girona to the central Costa Brava (1993) still did not exist and the region was also in the midst of a severe drought, which prompted the development of alternative and unexplored resources as the treated wastewaters.

In 1985, four years earlier, the CCB had organized the first workshop on wastewater reclamation and reuse at a Spanish level. The two most prominent speakers came from California and were the professor Takashi Asano, awarded in 2001 with the Stockholm Water Prize, and James Crook, the father of the world renowned California regulations for water reuse. The main ideas from that workshop that stuck in the minds of the local water managers were that the beneficial use of treated wastewaters was feasible –it was already common practice in California and other parts of the US- and that disinfection was the main process within the reclamation treatment.

Despite those impressions and certainties, and also despite the abundant technical and scientific literature, the true challenge was to transform these ideas into reality in a place like the Costa Brava in the late 80's, in a field in which we had to start from scratch. During these 20 years, the improvement on the performance of the reclamation treatments and on the quality of the reclaimed waters being produced has been gradual and progressive. Over time we have developed a better understanding of the processes that produce a safe reclaimed water and we have been able to put them into practice, thanks to the rigorous and disciplined work of the people in charge of the operation and maintenance of the water reclamation facilities and also to the collaboration with people coming from the academic and research environments. The arrival of a new generation of technical staff at the operation and maintenance companies has been another important factor, thanks to the passion, strength and work capacity they have shown in the recent years.

During these 20 years of development of water reclamation and reuse in the Costa Brava there have been some key moments in which the situation after was radically different than the situation before, on issues like the technical capabilities, the understanding of the processes and/or the divulgation of what was being done. In a more or less chronological order, the key developments and/or achievements of these years are commented below.

Development of practical criteria for the use of reclaimed water in golf course irrigation (1989-1997). In these first years, the almost exclusive use of reclaimed water was the irrigation of golf courses, which prompted the development of a set of recommendations and practical criteria for the adequate management of reclaimed water, in order to get maximise its advantages (i.e., fertilizer savings) and minimise the potential problems (i.e., salinity, management of storage ponds). This period ended with the publication of the book "*Aspectos básicos de la reutilización de las aguas residuales regeneradas para el riego de campos de golf*" ("Basic aspects of the reuse of reclaimed water for golf course irrigation"), where all these issues were compiled and presented.

Energy balances in the municipal water cycle (2001-2003). Worried by the sustainability of the reclamation processes as we were, in the CCB we worked in the development of indicators that could be used to evaluate whether the reclamation step made sense in a global sustainability framework or it meant instead a new environmental burden. In this sense, we proposed and made the calculations of the energy balances in the water cycle for each of the 27 municipalities of the CCB and we identified in which of them the reclamation and the subsequent reuse produced simultaneous savings of both water and energy. The comparison of the energy consumption related to the volume of water produced (kWh/m³) among the different portions of the water cycle has resulted an interesting parameter in order to ascertain whether a water reuse project leads to a greater sustainability or not. In this sense, it is better than calculations related to monetary prices or costs and has four main advantages: i) allows a totally objective evaluation; ii) is independent of prices, taxes and subsidies; iii) is applicable to any given technology; and iv) is universal.

Publication of the paper "Towards sustainability in water recycling" (2004). This paper was originally presented at the IWA 4th International Symposium on Wastewater Reclamation, Recycling and Reuse held in Mexico DF in November 2003. Afterwards, it was highlighted as the introducing paper in the volume of *Water Science and Technology* devoted to this conference. The text proposes criteria in order to assess the sustainability of the water reuse projects and the five issues to be evaluated are the following: i) water reuse as a tool for efficient allocation of water resources; ii) ecological analysis of the cycle of the main pollutants (carbon, nitrogen and phosphorus); iii) public health protection; iv) energy balances in the municipal water cycle; and v) determination of the positive externalities.

Combination of disinfectant agents for a wide-range disinfection (2005-2006). In collaboration with scientists from the University of Barcelona (UB) and the Politechnical University of Catalonia (UPC), and the technical staff with the Empresa Mixta d'Aigües de la Costa Brava SA (Costa Brava Water), two full-scale experiments were carried out in the Castell-Platja d'Aro and Blanes reclamation facilities in order to assess the efectivity of UV and chlorine, alone and in combination, in the inactivation of different indicator and pathogenic microorganisms. In both cases the results showed that disinfection strategies that included both UV and chlorine produced a reclaimed water of a better and more reliable quality from the point of view of the public health protection, as

compared with the results obtained with only a disinfectant agent, even if applied at higher doses.

Improvement of the disinfection capacity and reliability. These experiments on the combination of disinfectant agents allowed CCB's reclamation plants to achieve a better performance and a greater reliability in the quality of the reclaimed water produced. In some water reclamation plants (i.e., Tossa de Mar) the absence of colony forming units of *E. coli* in 100 mL is consistently achieved in almost 100% of the samples analyzed, a level of quality similar to that required for the drinking water. In this sense, the use of reclaimed water of this quality to cope with non-potable demands becomes a safe practice.

Control of the risk of legionellosis in the reclaimed water distribution facilities. Evaluations performed according to the requirements of the Spanish Ministry of Health (Chapter 10 of the "*Guía técnica para la Prevención y Control de la Legionelosis*" – "Technical guide for the prevention and control of Legionellosis") have proved that the risk posed by a reclaimed water adequately disinfected and monitored is minimum and of the same range than that related to the use of drinking water, even though water is applied through sprinklers.

Use of the online monitoring of redox potential for the control of the chemical disinfection (2007-). This recent investigation being performed in collaboration with the University of Barcelona and the Empresa Mixta d'Aigües de la Costa Brava SA (Costa Brava Water) has allowed us to conclude that there is a relationship between the increase in the redox potential values after the addition of a chemical disinfectant and a certain degree of inactivation of the different indicator and pathogenic microorganisms. This discovery will again increase the reliability of the disinfection processes.

Participation on the pioneer studies on the Waterharmonica systems in collaboration with research teams from The Netherlands (see www.waterharmonica.nl). Despite that the discharge of a given treated wastewater may comply with the regulations, an impact downstream of the discharge point can still be detected. Logically, the smaller the impact, the lesser the length of the river (or of the receiving water body, whatever it may be) which is impaired. Metaphorically expressed, this is as if the effluent "speaks" a language that the river does not "understand". Whereas effluents contain particles, flocs, suspended bacteria, nutrients and low concentrations of dissolved oxygen, healthy ecosystems show the opposite characteristics and because of this the water body where the discharge is done requires time and space to turn these contributions into something which can be considered similar to what is found on the natural ecosystem. Ruud Kampf and Theo Claassen in The Netherlands proposed the creation of natural treatment systems that would do this "translation job" offstream of the receiving water bodies (the Waterharmonica systems), so what would be discharged in them would be something closer to what they have in terms of biodiversity and water quality. This simple but effective idea can help comply with the EU Water Framework Directive, which requires the good ecological status of the receiving water bodies.

Collaboration in the pioneer studies on the biological filtration with cladocera cultures as a natural water reclamation technique. Also in collaboration with the same research team from the The Netherlands, in the Costa Brava there is one of the three existing pilot plants that are providing the initial information on the capacity of the cladocera cultures to improve effluent quality. The results up to now show a clear reduction in the concentration of indicator microorganisms, as well as an improvement in other physico-chemical parameters, such as suspended solids, turbidity or nutrients, the latter removed by the filamentous algae that also grow in the mesocosmos used for the experimentation. This type of systems can be of great interest in the production of reclaimed water aimed at coping with environmental demands.

Municipal reclaimed water networks. In May 2007, the municipalities of Tossa de Mar and Lloret de Mar put in service their respective municipal reclaimed water networks. Up to now, these pipelines are delivering reclaimed water for municipal non-potable uses but the intention of these two municipalities is that they could also supply reclaimed water for the irrigation of private gardens on the mid term. The detailed monitoring performed up to now has shown no quality deterioration and that this kind of water is safe and suitable to cope with non-potable demands. It is interesting to note that these networks appear in two municipalities that are partially supplied with desalinated water, which has turned some urban uses such as street cleaning or garden irrigation into an expensive activity because of the greater cost of the desalinated water. In this sense, the development of a local resource such as the reclaimed water produces clear savings, both in the fields of water and energy.

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