Jornades Tècniques: La integració de l'aigua regenerada en la gestió dels recursos
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PUTTING A PUZZLE TOGETHER: THE INTEGRATION OF RECLAIMED WATER IN WATER RESOURCE MANAGEMENT

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INTRODUCTION

"*Practice makes perfect*" as the English popular saying goes. In water recycling, the suitability, the treatments and practices also improve with everyday experience, with having to achieve a certain quality under variable and often unpredictable conditions, and above all, in having to satisfy a certain user. This is the attitude with which the Consorci de la Costa Brava (CCB, the Costa Brava Water Agency) has confronted water recycling since its origins, an attitude based on gradual improvement and on learning that has arisen from effort and having had to face reality on a daily basis, and directly opposed to that which demands the "perfect solution" right from the start. The first attitude enables us to advance because all trips require steps to be taken in a consecutive way, while the second is paralysing because it needs to know what the arrival at the destination will be like without taking into account the fact that on the trip there may be multiple vicissitudes and unexpected happenings. Since 1989, when the supply of reclaimed water to the Costa Brava started, water recycling has advanced with notable improvements in the treatments provided and in the services offered to users, based on the production of information, its evaluation and on the corrections that have often been derived from these analyses. What we are going to present in this speech is nothing more than the certainties, uncertainties, proven ideas, doubts and suggestions that have come about from the practice of water recycling on the Costa Brava for 16 years.

WATER RECLYING, A POLYHEDRAL ACTIVITY

Water recycling is a clearly polyhedral activity, with many sides. It means creating a new resource, particularly in coastal areas, but it also produces an estimable reduction in discharges, such that one way of defining reuse could be "the meeting point between supply and wastewater treatment".

However, water recycling is really a tool with multiple applications. Many of them, in fact, happen simultaneously, but the reason for going ahead with a water recycling project in a given area will always have a main motive, which is the factor that tips the scales. In any case, this polyhedral reality requires important mental flexibility and a good dose of imagination when seeking the suitability of recycling in resource management.

It might seem obvious, however in the face of a given water recycling project, the first question to ask is "will the situation of the resources, of the environment, be better in a future situation with reuse than the current situation without reuse?" If the answer is affirmative, then you need to look for the way to make the project become reality, with mental flexibility and the imagination we mentioned previously. Therefore, you need to make what is desirable possible and avoid converting it into something impossible due to formal or structural rigidity, or an excess of misunderstood zeal. However, inversely you must also have this flexibility and this realist vision present: if a water recycling project does not provide benefits or if at certain moments there are doubts about the quality of a certain water, the project should be abandoned, or the water supply should be interrupted to prevent problems of a magnitude greater than those you are trying to solve from being created. In short, water recycling should be a solution, not a new problem added to the many that already exist. And for this activity to be a success, you must envisage how to fit together the multiple pieces of which this complex, and at the same time interesting puzzle is made up.

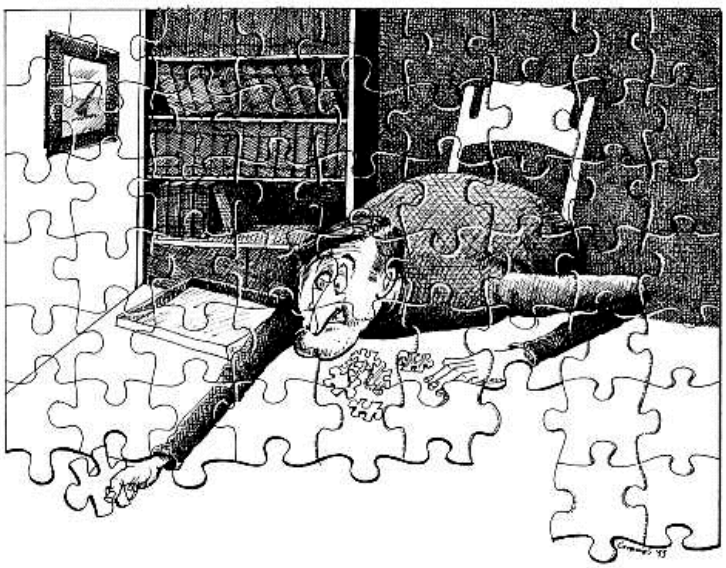

Figure 1. The suitability of water recycling is metaphorically equivalent to doing a puzzle. © Andrzej Graniak (www.dc.slupsk.pl/graniak/GALERIA/puzzle.htm)

THE ECONOMIC AND ADMINISTRATIVE SUITABILITY OF WATER RECYCLING

Although in the great majority of cases a water recycling project serves to create a new resource, this activity must be resolved economically and administratively in a different way to how wastewater treatment is dealt with up to a secondary level. There are many voices in the various administrations that opt for tertiary treatments funded, projected, carried out and managed by their direct beneficiaries. The application of the benefit principle is clear - that

those who benefit should pay - however, this principle can be applied in different ways, and the best one is not usually that which only transfers the responsibility or the obligation to carry out certain actions to the beneficiary, as a way of avoiding any responsibility that could be had as a water administration. On the other hand, often the beneficiaries are diverse, disperse and intangible at first sight. The case of environmental benefits is paradigmatic. Who should be responsible for the reuse when the beneficiary is the environment or the ecological state of a river or stream?

Only through precise studies, in which general criteria are applied case by case, objectifying beneficiaries and environmental benefits, will we be able to obtain guidelines to follow for the fair distribution of the costs of additional treatments to secondary ones, to be charged to the various beneficiaries (directly benefiting private users, diffuse collective users and environmental benefits). Universal maxims are not usually useful, because not all cases are the same and the best solution is not to treat different users and situations in the same way. We are not vindicating arbitrariness and discretion, but fairness for each different situation. The contextual reality is always more complex than well-meaning manual instructions.

SUITABILITY IN MANAGING WASTEWATER TREATMENT PLANTS

Although it seems interesting that economically and administratively tertiary treatments should not have to be tied to the rest of the wastewater treatment plant (WWTP), at an operation and maintenance (O&M) level it is a good idea to have that unity with the rest of the WWTP installations. If, for a proper water recycling, it is essential that the WWTPs offer maximum performance, it is obvious that we should not conform to achieving the routine standards of 25 mg/l BOD and 35 mg/l SS, and that all these efforts to improve the quality would mean an increase in the O&M costs. Then, if the operator of the tertiary treatment is different from the one that operates the treatment until secondary level, what incentive could the latter have to make this additional expense if later the benefit derived from the operation of the tertiary treatment is given to a third party? The most likely thing is that in a situation like this one the operation of the secondary treatment will offer treated water of a quality close to those 25-35 - which will be the quality limits that are in the contract, and which we must not forget, is based on averages-. Meanwhile, the operator of the tertiary treatment will have to make a supplementary expense with regard to chemicals and energy with an overall treatment that is much more complex and with greater difficulty in achieving the desired results in the reclaimed water - which we should not forget are not based on averages, but on the 90th percentile of the annual set of data-. Therefore, the operation by a single subject of all the installations of a WWTP, from the pre-treatment to the tertiary treatment itself, is the simplest way of guaranteeing harmonious, coherent decision making, at minimum expense, and destined to achieve the high quality requirements demanded.

The additional effort in the secondary treatment required by that later reclamation has a beneficial effect on the overall function of the WWTP: on the one hand, all the decisions are made to obtain an improvement in the quality; and on the other hand, the reduction of BOD and SS that can be made for the better operation of the tertiary treatment are also reflected as a reduction of the discharges with the non supplied reclaimed water. Therefore, the benefit on the environment comes from a double reduction of discharges: that of the recycled water which is not discharged and that of the organic load not discharged thanks to the better quality fostered by the need to divert a portion of the flow through tertiary treatment. The diagram in Figure 2 tries to reflect this situation.

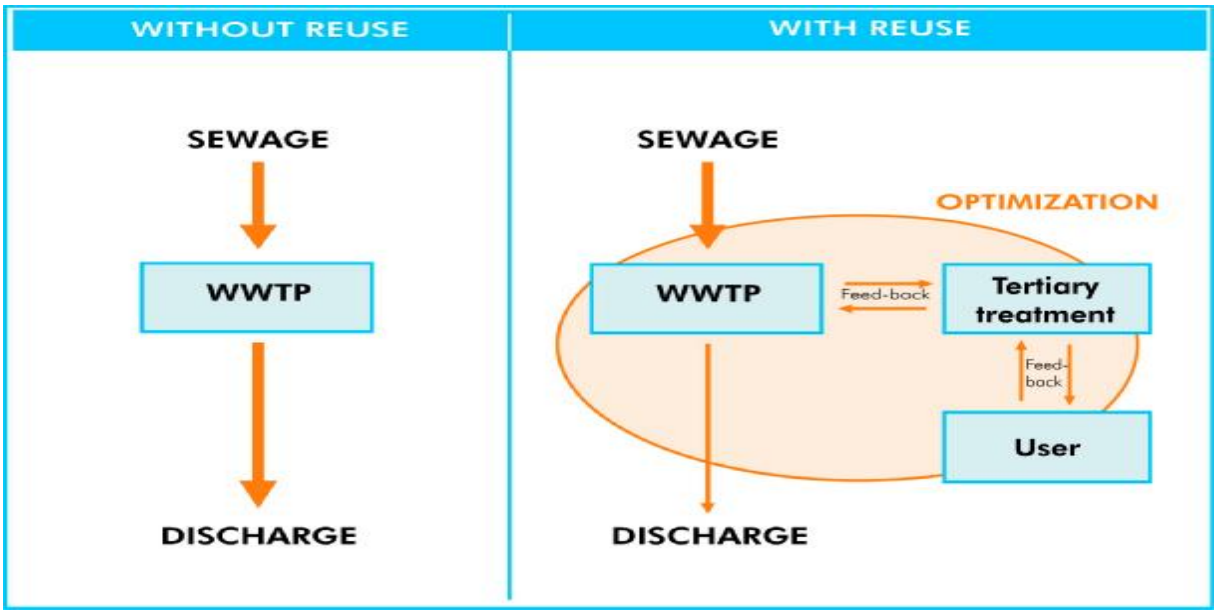

Figure 2. Diagram that shows the improvement in the exploitation and the reduction of spilling caused by reusing.

SUITABILITY IN PUBLIC HEALTH

The main premise in water recycling projects is that they should not pose any appreciable risk for public health. Collecting wastewater through sewages and collectors and its later transfer to wastewater treatment plants has historically been one of the factors that has most increased human life expectancy. Therefore, and given the concentrations of microorganisms, both indicators and pathogens, that still exist in treated wastewater, we must avoid wasting the effort made to isolate these microorganisms that the reuse of secondary effluents without any kind of additional treatment would mean. Tertiary treatments, therefore, seek to offer this public health protection before water is recycled, both through disinfection and/or through those preliminary treatments that may be required (coagulation, flocculation, sedimentation, filtration or membrane treatments).

The most commonly used indicator for assessing the result of disinfection is based on the count of the concentrations of faecal coliforms (or more recently of *Escherichia coli*, not without significant problems when doing the counts), which can testify to whether the disinfection process has been efficient or not on the bacterial pathogens . However, on the one hand, we know that this group of microorganisms is relatively not very resistant to disinfection agents, and on the other hand, that there is not a good correlation with the elimination of others kinds of pathogens, such as certain viruses (enteroviruses) or protozoans (*Cryptosporidium* and *Giardia*). For this reason, recognised experts in the field of environmental microbiology recommend the routine monitoring of more than one indicator microorganism, and if possible that represents more than one kind of pathogen (Jofre and Lucena, personal communication). Therefore, apart from the faecal coliforms, other indicator microorganisms that could be used are enterococci, that would serve to assess bacterian disinfection more carefully, as they are more resistant than faecal coliforms; bacteriophages (bacterial viruses), as indicators of the disinfection achieved with regard to enteroviruses, which are human pathogens; and clostridium spores, which despite being bacterial spores, their behaviour in disinfection shows an interesting parallelism with the removal of pathogen protozoans such as *Cryptosporidium* and *Giardia*.

It is also known that some microorganisms have high levels of resistance to certain disinfectants (i.e., *Cryptosporidium* and *Giardia* to chlorine) and a high sensitivity to others (protozoans to UV light), which maks a hard desision to make if having to choose a single disinfectant. This is one of the several reasons why the trend in the CCB area is that of combining two disinfectants such as UV light and chlorine, in order to cover a wider range of disinfection than either of the two on their own, even if higher doses of each were to be applied. In this way, a wider range of disinfection is obtained, as well as additional advantages such as:

i) the final chlorination enables having an alternative treatment to disinfection in the case of failure or maintenance of the UV light equipment
ii) it provides a residual element that maintains the quality of the water during transport, at the same time that its detection enables the efficiency of the disinfection to be validated
iii) the key feature of the tertiary treatment (disinfection) is duplicated without doubling the cost, being able to obtain practically the microbiological quality level desired
iv) obviously it enables the dose of chlorine to be reduced which, otherwise, would be applied if there were no disinfection with UV light equipment.

Figure 3. Images of different reclaimed waters produced on the Costa Brava. Left: UV disinfection equipment at the WWTP in Torroella de Montgrí, 22nd July 2005. Centre: Reclaimed water produced at the WWTP in Colera, 17th August 2005. Right: Reclaimed water produced by the WWTP in Blanes, 9th August 2005.

Another question that is usually mentioned with regard to public health in water recycling projects is the one that refers to the possible generation of trihalomethanes during the disinfection of the water when chlorine is used as a disinfectant, as the reaction that can occur with the organic matter present in treated wastewater is usually a cause for concern. However, the results available so far show, on most occasions, a practically non-existent formation of these compounds, which is explained by the common presence of ammonia in secondary effluents, which reacts with the chlorine faster than the organic matter, producing the formation of chloramines (innocuous) rather than trihalomethanes. In this sense, and precisely to prevent the formation of these substances, it would be sensible not to achieve complete nitrification of the effluents that are to be disinfected with chlorine compounds, so that there is always a small concentration of ammonia available to react with the chlorine and thus protect from the formation of these dangerous substances.

ENVIRONMENTAL SUITABILITY

As we mentioned earlier, water recycling involves the reduction of discharges into the environment, which translates into an ecological improvement at the point where the discharges are reduced. If, in addition, reclaimed water is used for irrigation, then there is a simultaneous recycling of nutrients, which represents a saving in mineral fertilisers and therefore in the energy that is needed to produce and transport them. On the other hand, in areas in which drinking water requires a great expenditure of energy, whether because it comes from facilities with a high energy consumption (desalination plants) and/or because it has to travel long distances, the reclamation and later reuse ***in situ*** for non-drinking purposes can represent a double saving, of water and of energy. These questions of environmental suitability are dealt with in more depth taking the example of the WWTP in Castell-Platja d'Aro in the speech "Maximising the environmental benefit in the operation of a WWTP in a coastal tourist area", also presented in the framework of these workshops by Josep Maria Caus and Jordi Muñoz.

THE SITUATION OF WATER RECYCLING ON THE COSTA BRAVA

Water recycling on the Costa Brava is an activity that has increased over the years, until reaching a probable 7 hm^3/year for 2005, of a total of between 30 and 35 hm^3/year of treated wastewater. The drought in the first half of the year, as well as the increase in the number of users means that we can expect an increase of 1.5 hm^3 on the 5.5 hm^3/year treated in 2004. The main uses, by volume, are the following:

- Aquifer recharge: this use alone has meant the reclamation of 3.0 hm^3/year since 2003, all at the WWTP in Blanes, that are discharged into the river bed of the River Tordera for the recharge of its aquifer. This action has been promoted by the Catalan Water Agency (CWA) and is integrated in the plan for the recovery of the aquifer in the lower part of the Tordera, together with the construction and setting up of the desalination plant in Blanes. On the waiting list for aquifer recharges, there is the project in the Port de la Selva stream, whose aquifer is the only source of drinking water for the municipal supply and which has clear limitations in years of low rainfall, in which natural recharging is insufficient.

Figure 4. Two images of the reclaimed water discharged into the river bed of the Tordera for aquifer recharge. 7th July 2005.

- Environmental uses and discharge improvement: in this group of uses the main one, as far as volume in concerned, is the one of the WWTP in Empuriabrava, in which the water is reclaimed by means of a constructed wetland system and then transported the Natural Park of Els Aiguamolls de l'Empordà (NPAE), where it is used for environmental purposes.

Although initially the object of the managers of the NPAE was to maintain flood conditions in El Cortalet Pond during the summer months, it has now been observed that this water provides more significant environmental improvements if it is used for the creation and/or restoration of the pastures (damp meadows) typical of the area, which are currently in serious regression. Another environmental use is that linked to the creation and maintenance of the Park of Sa Riera, in Tossa de Mar, which has meant the transformation of an old uncontrolled dumping place of construction debris into an urban park, as well as an indirect recharge for the final stretch of the stream, which, in this way, prevents it from completely drying up in the summer. Finally, in this group of uses we should also include the improvement of the discharges that has occurred with reclaimed water produced, but which, because of the typical variations in consumption throughout the different times of the day (production is usually kept at a constant flow) have not been supplied to any user and thus are discharged with a better quality than if it was secondary effluent.

Figure 5. Two images of the constructed wetland system in Empuriabrava. Left: flock of flamingos, 6th May 2005. Right: detail of the treatment cells, 31st August 2005.

- Golf course irrigation: reclaimed water is currently being supplied to 5 golf courses and one Pitch & Putt facility, which corresponds to all but one of the facilities of this kind that exist on the Costa Brava. We should also mention that the golf course that does not yet uses reclaimed water is currently applying for the permits to use water of this kind at the Catalan Water Agency. Much of the experience gathered about water recycling on the Costa Brava, especially during the first years, has been thanks to the supply to golf courses.

Figure 6. Two images of golf courses on the Costa Brava watered with reclaimed water. Left: Golf Empordà, May 2005. Right: Golf Costa Brava, 15th June 2005.

- Agricultural irrigation: despite its enormous potential demand, this is still a limited use in the Costa Brava area, where until not long ago irrigation water was only supplied for relatively small exploitations, ranging from sweet corn to vines, and including vegetable garden products. In the middle of the summer of 2005, the supply of reclaimed water was started for agricultural irrigation to a large irrigation district, and therefore it is to be hoped that in the future this will be the kind of use with the highest growth, thanks to the dissemination that comes from existing projects and to this new supply.

Figure 7. Two images of fields of crops on the Costa Brava being watered with reclaimed water. Left: Sweet corn at Solius, 15th June 2005. Right: Vine plantation in Garbet, summer 2001.

- Non-potable urban uses: despite still being modest uses, as far as volume is concerned, it is also to be hoped that there will be a significant growth in the medium-term future, as some municipalities (Lloret de Mar, Tossa de Mar) have inarguably opted for the installation of networks for the supply of reclaimed water, as a way of reducing the demands on drinking water and also the consumption of energy associated with its production and transport. Other municipalities that have shown an interest in the installation of larger or smaller networks of distribution of reclaimed water, medium- and long-term, as a way of saving drinking water which is usually in short supply in dry years, are Portbou, Colera, Port de la Selva, Cadaqués, Roses, Palafrugell, Palamós, Castell-Platja d'Aro, Santa Cristina d'Aro and Blanes.

Figure 8. Two images of non-potable uses in municipalities on the northern Costa Brava. Left: Firemen charging at the hydrant of the WWTP in Port de la Selva, summer 2003. Right: Cistern loading reclaimed water from the storage tank of the WWTP in Portbou, for use on the construction of the new road, 30th June 2005.

CONCLUSIONS

The integration of a new resource such as reclaimed water which is, in addition, a controversial resource, is like trying to put a puzzle together, in which each piece must fit in suitably with the others so that the end result is coherent. This suitability must occur at different levels: economic, administrative, linked to the management of the WWTPs or concerning public health and the environment. Water recycling projects that comply with these criteria are those that will be solid enough to last over time and to represent a genuine step towards sustainability and environmental improvement.