Jornades Tècniques: La integració de l'aigua regenerada en la gestió dels recursos
Jornadas Técnicas: La integración del agua regenerada en la gestión de los recursos
Technical Workshop: The integration of reclaimed water in water resource management
Lloret de Mar, Costa Brava, Girona, Octubre 2005

BALANCE OF THE EXPERIENCE ON THE USE OF RECLAIMED WATER IN PORTAVENTURA

Vicenç Veses

Industrial Engineer, Universidad de Navarra
Master in Business Management EADA
Director of Technical Services at Port Aventura, SA
E-mail: vicenc.veses@portaventura.es

SUMMARY

Under the code 2, 1989[1], the Generalitat (regional government) of Catalonia announced the launching of Tourist & Recreational Centres in their territory, and established the urban uses and the building density of the centres, with the result of that could be considered as a landscaping project. That very same year, Decree 152[2] approved the CRT "Tourist & Recreational Centre" of Vila-seca/Salou and had into account for its construction the necessity of non potable water supply.

PortAventura at that moment had very clear what law asked for, in this kind of resort, located at Tarragona coast areas would need hydraulic resources not available in the area.

The addition of a tertiary in the water residual treatment plant under construction was a first step for PortAventura gardens would be a reality, as well as it will be for the pending development works.

The experience of watering so many and different species during the last 10 years, has resulted very positive and a benchmarking process is considered in here as an idea to be followed, showing its advantages and disadvantages.

Palabras Clave: Tourist and Recreation Center (CRT), leisure, entertainment activities, landscape, gardening, ornamental plants, reclaimed water, chloride effects, SAR effects, ET_0.

THE TOURIST & RECREATIONAL CENTRE (CRT) IN VILA-SECA/SALOU

The creation of big ludic spaces were foreseen in Catalonia to help the tourism, the Government idea came up at the end of the 80´s, following the multinational Disney example, who had decided to build a resort in Marne-la Vallée near Paris.

At that time tourism had slowly decreased in Costa Daurada. Few or none alternates presented to the visitors; sun and beach were not sufficient to choose that destination.

Local and Catalan administration started to work together to bring investors who wanted to stay; not only in a lucrative finance operation, but a company involved with the country and helped to rise what already was a worrying situation in tourism needs.

An space nice enough to recuperate what Costa Daurada used to be and much more, motivate quality investments, bring tour operators, make the brand bigger, contribute to the economic area rising, employment increasing, etc.

The solution was to build a Recreational and Tourist Centre (CRT) with private capital that could make all that, so water was needed for this idea.

PortAventura project covered 826 ha on which a big Theme Park would be built during the first years as a promotion of a brand. Afterwards will follow hotels, sport areas, golf courses, convention centres, etc. Some of them still are pending.

Due to the low rates of land occupation and construction, the project had to be necessarily a landscape project, environmental respectfully and aligned with the sustainable development. To keep the landscape in perfect conditions foresees water needs, so planning how to get it was needed.

At the first conversations, it was talked about investment and infrastructures, as electric connection, highway connection and of course sewage treatment and regenerating of residual water.

In this brief document we try to explain how that thought was correct and how our experience has been.

THE CATCHMENT AREA AT VILA-SECA Y SALOU

Vilaseca and Salou had and still have a seasonal population as a consequence of those visitors attracted by the nice beaches. Sewage is urban, because industry represents a small part of the area. In the 80's they had no water treatment plant, the water was thrown direct into the sea, causing sometimes worse water quality in the beaches

Theme Park installation, which would bring more seasonal population, and would throw lots of cubic meters into the sea, that would make things even worse.

It was necessary to give the cities of Vila-seca and Salou a sewage water treatment (EDAR) which was capable of treat also the CRT residual waters. EDAR would have a physic treatment as well as biologic previous of sending water into the sea, but a tertiary physical-chemical which would treat a part of the secondary, transforming it into water for irrigation. That decision was taken between the Generalitat and PortAventura and it was the key for the CRT landscape project.

THE WORKS

Theme Park works started in June 1992, following a conceptual project of great quality previously developed. The executive project got more in detail as the works went on.

The EDAR works began in 1993.

Soft Opening of the park was in April 1995 and in May it opened in regular operation, at the same time EDAR started to treat the residual water, the tertiary began as well to produce irrigation water.

The Catalan Water Agency (ACA) financed the tertiary, but PortAventura agreed to pay monthly the pay back of it and also production costs.

CONCESSION AND AGREEMENT, ADMINISTRATION COMMITMENT

PortAventura got a concession by the ACA of 1.8 Hm3 per year, to use regenerated water coming from the EDAR of Vilaseca /Salou. Although bureaucracy got long in time, water could be used from the very beginning.

The concession ruled in terms of administration of the water use, but for technical features there was a separate agreement that defined the water quality and the acquired commitments by the ACA and PortAventura, as a CRT promoter.

The Catalan Health Authorities imposed conditions to use regenerated water as follows;

- Separate the net from freshwater one, to ensure there is no possible error in connections.
- Different socked from the potable water.
- Never use regenerated water for spraying systems
- Periodic Bacteriologic Analyses
- Use and time of regenerated water not to have contact with public as well as be careful with aerosols that can be produced
- Never install exterior taps in contact with public connected with regenerated water net.
- Warranty that near the use and storage of regenerated water is not accessible to public, on the contrary signs must be readable and seen saying no potable water, and its exclusive irrigation use.

Having those restrictions, the use of regenerated water was decided to be only used for landscape irrigation.

We needed to know what was the real quality of the water, and the irrigation experience with it.

PREVIOUS QUALITY EXPERIENCES

As the water comes from non industrial villages, the salt concentration and micro organisms were, and are the parameters to be controlled.

Regenerated water has more salt than the original potable water, as this salt varies on time; in our case seasonality matters in the content of salt, it is convenient to know and control it with analyses.

As a parameter, the electrical conductivity is used, because it has a lineal relationship with salt content. We measure it in micro siemens per centimetre.

As an expert in reusing water, the ACA and PortAventura counted with Dr. Rafael Mujeriego, who marked the minimum quality parameters, based on his works as researcher in California[3].

Those parameters are shown in Table 1. Those works were based on species used in agriculture, not in gardens.

The great amount of salt found in regenerated water was a problem. That concentration of salt in the water came from its own sodium chloride, a regular problem in water treatment plants in the coast.

Summarizing, high quantity of sodium chloride in regenerate water for watering the landscape has a negative effect on plants growing and on the ornamental value as well as for the soil conditions. The first effect described, is due to chloride presence on it, and the second one, is due to the sodium presence.

To avoid EDAR brings salted water to the gardens, a conductivity cell, measuring in continuum at the tertiary exit, controlled by the same EDAR and another in the entrance of PortAventura irrigation reservoir and controlled by PortAventura where installed. Both give real time info, and an alarm rings when reach the maximum level, 3000 µS/cm although in lower levels control systems detects pre-alarms.

Table 1. Quality criteria of reclaimed water (adapted from Mujeriego, 1990).

Agreed parameters to be controlled

	Units	*Limits*	*Periodicity*
Faecal coliforms	In 100 ml	Absence	Daily
Faecal streptococci	In 100 ml	Absence	Daily
pH	pH units	6-9	Continuous
Turbidity	NTU	<2-3	Continuous
Suspended solids	mg/l	<10	Daily
Residual chlorine	mg/l	>1	Continuous
BOD_5	mg/O_2	<10	Daily

Recommended parameters to be controled

Chloride	mg/l Cl^-	<350	Weekly
Conductivity	µS/cm a 20º	<3000	Continuous
Total nitrogen	mg/l	<30	Weekly / Daily
Soluble phosphorus	mg/l	<15	Weekly
Sodium	mg/l	<600	Monthly
Potassium	mg/l	<30	Monthly
Calcium	mg/l	<400	Monthly
Magnesium	mg/l	<60	Monthly
Total iron	mg/l	<5	Monthly
Manganese	mg/l	<0.2	Monthly
Cadmium	mg/l	<0.01	Monthly
Chromium	mg/l	<0.1	Monthly
Copper	mg/l	<0.2	Monthly
Nickel	mg/l	<0.2	Monthly
Lead	mg/l	<5	Monthly
Zinc	mg/l	<2	Monthly
Mercury	mg/l	<0.001	Monthly
Molibdenum	mg/l	<0.01	Monthly
Selenium	mg/l	<0.02	Monthly
Boron	mg/l	<1	Monthly

To avoid micro organisms presence, water is chlorinated when having passed the tertiary treatment, an equipment measuring the chlorine level in water and another one measuring de

pH, in continuum, also doubled at the exit and entrance would detect any error if out of the allowed concentration: 1 ppm for the chloride and for pH 6.8-7.8, but a 6-9 would be admissible.

OWN EXPERIENCES AFTER 10 YEARS

In general terms, the global experience has been positive, water has acceptable quality and only those parameters that accidentally or long term could cause human being, plants or soil damages must be controlled.

Very complete analyses are done monthly. We will focus on the parameters mentioned above, the ones that could cause such damages.

Chlorination

The 1 ppm level is enough, although at the beginning of the pumping to Port Aventura reservoir can be over 2 ppm levels, to guarantee the biological cleaning of the outlet pipe. After that, we try to level less than 1ppm. The error on chlorine system is detected by sensor register readings and alarm systems, but being redundant is quite improbable to happen.

In case of not having enough chlorine level in the water, the problem could be the possibility of having Coli-forms or Streptococcus, which are required not to be in water because of their negative effects: caused by the aerosol with their presence and caused by the soil and plants contamination. The first case is controlled because there is no watering by sprinklers (nor other aerosol type) with visitors, and the risk is controlled by automatic irrigation software.

Salinity: Chloride

As it has been said, residual water has more salt than the potable water from which comes from. The EDAR can not treat the salt in the final regenerated water, so we have to take into account the parameters from the original water.

There are especial salted periods caused by;

- Works of excavations near the coast, where sea water could be found in phreatic levels and is pumped to sewage in high quantities, increasing so the salt concentration. This circumstance happens in winter, when there is less residual water flow and so the sea water is an important amount in the total water. On the other hand it is in winter when irrigation is less needed.

- Strong winds from east make that sea water goes into the earth running of to sewage which is not always correctly separated from the residual, as well as penetrates across the cracks in buried sewage pipes. Effects are the same as described above.

In those cases irrigation with regenerated water is cancelled till the salt parameters are correct again, conductivity and analyses tested, ensuring water quality.

The continuous effect of salt and chlorides in plants directly affect the landscape quality, as the ornamental effect on CRT landscape degrades. During the firsts years some species were damaged and PortAventura lead researches on chlorine effects on some species.

First works were in 1998 and 2000, ordered to IRTA, the research was leades by Dr. Joan Girona from Lleida R+D, sponsored also by CESPA and AGBAR foundation. The aim of those investigations were the ornamental plants and the term "ornamental" had to be very well defined first to study its evolution. The selected species were treated with different concentration of chloride in the irrigation water, in order to study osmotic effects and its toxicity. Some important results came from that, as plant growing effect from not affectation, the necrosis of the foliate mass and dry of the branches, to almost death of certain species from ornamental point of view. As a consequence, PortAventura would take out some species from his buying list because of the regenerated water quality that EDAR is providing to Vila-seca / Salou

The second work made in 2003-2004, coordinated by CESPA, leaded by Dr. Miquel Salgot from Pharmacy School in Barcelona University, sponsored also by CESPA, AGBAR foundation and GP Resort. The aim of the investigation was different lawn species than are used in Golf courts. Methodology was similar as different concentration of chloride in the water, and evaluates the ornamental as well as low cost of maintenance. The future golf courts to build in CRT will have into consideration those results to choose the right species to be irrigated with recycled water.

Salinity: Sodium

We must bear in mind that the soil where landscape species are planted, are over other earth that, even very close to the original orography, suffered different alterations by platform construction for buildings, infrastructures, gardens. So we commonly can find the original land, the selected compacted land over it, which has been excavated to add the vegetal soil to plant. We must say that drainage for irrigation is good.

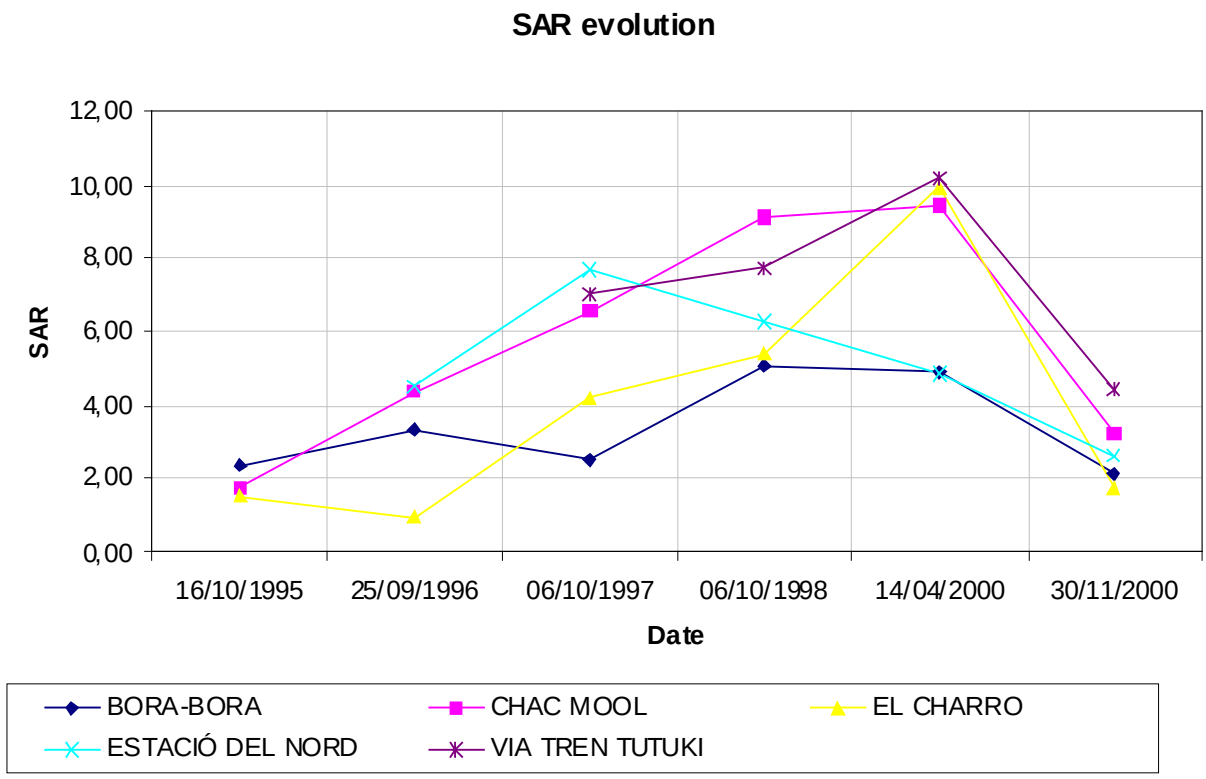

Figure 1. Evolution of SAR in the irrigation water at PortAventura between 1995 and 2000.

The indicator of the land "health" in sodium terms is known as SAR (Sodium Absorption Range) TAS (Tasa de Absorción de Sodio) in Spanish. Not only is the sodium concentration present in the indicator, but also calcium and magnesium.

PortAventura from the very beginning of using recycling irrigation water has taken samples of the soil, measures and register the indicator, being this monitoring of great importance.

SAR is quite sensitive in continued use of salted water, as per cations accumulation, its evolution is always increasing. That provoked an alarm in the first months of the registers. Solution was advised to be irrigation with potable water to take sodium to drainage, by fortune that winter intensive rains cleaned it in natural way, having SAR results adequate for Landscape. Those cleanings have been repeated, but not last year (2005) affected by an important drought, maintaining values under dangerous limits. Figure 1 shows the evolution of this indicator from 1995 to 2000.

Irrigation system

PortAventura has an automatic irrigation system to optimize regenerated water use and minimize risks above.

The information provided by the meteorological station is registered in a PC that calculates potential evapotranspiration (ETo) and monitors the rain daily. That info is the basis for necessary water calculation for next day irrigation.

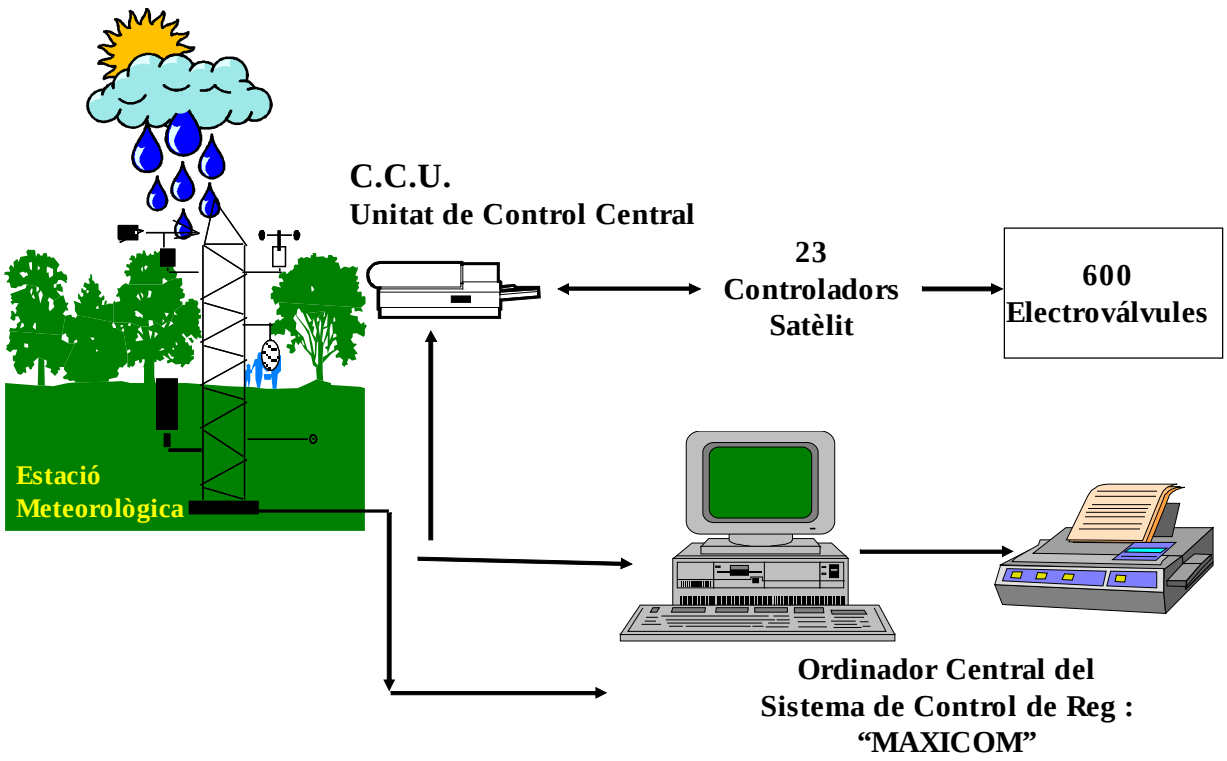

Figure 2. Scheme of the operation of the irrigation system at PortAventura.

As the gardens are divided in areas with independent irrigation, where surface and particularities of the crops are well known, values can be calculated and corrected to best water dosage.

The main program makes the total calculation of irrigation having into account: ETo and rain, composition of soils and kind of plant in each parcel and pumping capacity and total irrigation time. After, the program gives the orders to programmers distributed by the garden, which control the electro valves giving the water needed.

In such way, the use of water is optimum, causing saving in water use and minimizing salt effects in plants and soil. The scheme of the operation system is displayed in Figure 2.

PRICE

It is important to remind the economic conditions on the recycling water irrigation.

As in chapter 3 was said, the construction of EDAR was financied by Generalitat through ACA (Catalan Water Agency), but PortAventura agreed water fees considering one part as tertiary paying-off, and other part as exploitation expenses; energy, maintenance, operation, analyses, consumables, etc.

ACA, in its policy of taxes, applied specific and general taxes to irrigation water (as it did to fresh water for human consumption, but only when the total amount of consumption of irrigation water is less than the 50% of the total water consumed in the activity) PortAventura appealed for consideratio against this decision because it is considered a barrier of random 50%, without any basement, because it do not promote any water save nor even of irrigation water, and finally because water with this tax has been already taxed when it has been used as fresh water in its first consumption.

The appeal is now in hand, but we must say that Decree 47/2005 of March 22[4], ACA has reconsidered the position and the general canon is used no more but exceptional cases of small consumers.

CONCLUSIONS

Recycled water for Irrigation (coming from waste water of Vila-seca, Salou and CRT) has been used in PortAventura for 10 years with the best results; once water quality and methods to control have been defined and built; the water has big reliability and has allowed increasing gardens from the quality they had at the beginning.

The fact that the water is not under general canon makes the cost better than the potable water. The drought that endures Spain and southern Europe this year, and climatic changes in the following years, make us think the use of regenerated water not only to agriculture but also to other applications will be a social demand. Companies and academics should work hard to make it real.

BIBLIOGRAPHY & REFERENCES

1) Ley 2/1989 de 16 de febrero, sobre centros recreativos y turísticos. DOGC 1109 del 20.2.1989

2) Decreto 152/1989 de 23 de junio, por el cual se aprueba la instalación de un centro recreativo y turístico en Vila-seca y Salou. DOGC 1164 del 5.7.1989

3) Riego con Agua Residual Municipal Regenerada. Manual Práctico. Translation and edition by Rafael Mujeriego. Universitat Politècnica de Catalunya. 1990

4) Decret 47/2005, de 22 de març, de modificació del Decret 103/2000, de 6 de març, pel que s'aprova el Reglament dels tributs gestionats per l'Agència Catalana de l'Aigua. DOGC 4350 del 24.3.2005