DELIVERABLE D 3.3:

Water use, reuse and treatment practices in Euro-Mediterranean tourist facilities

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement nº 619116

Deliverable D 3.3: Water use, reuse and treatment practices in Euro-Mediterranean tourist facilities

Project acronym: demEAUmed

Project full title: Demonstrating integrated innovative technologies for an optimal and safe closed water cycle in Mediterranean tourist facilities

Grant agreement no.: 619116

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Dissemination Level		
PU	Public	✓
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including Commission Services)	
CO	Confidential, only for members of the consortium (including Commission Services)	

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List of acronyms and abbreviations

CA: Consortium Agreement

DM: Dissemination Manager

DoW: Description of Work

EC: European Commission

EM: Exploitation Manager

GA: Grant Agreement

IPR: Intellectual property rights

SC: Steering Committee

S&T Manager: Scientific and Technical Manager

WP: Work Package

WPLs: Work Package Leaders

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1. Project Overview

demEAUmed (Demonstrating integrated innovative technologies for an optimal and safe closed water cycle in Mediterranean tourist facilities) is a European project co-funded by the European Union under the 7th Framework Program within ENV-2013-WATER-INNO-DEMO-1 with a budget of 5,831,908 M € over 42 months, and started officially on January 1st, 2014. The aim of demEAUmed project is the involvement of industry representatives, stakeholders, policy-makers and diverse technical and scientific experts in demonstrating and promoting innovative technologies, for an optimal and safe closed water cycle in Euro-Mediterranean tourist facilities, leading to their eventual market uptake.

The demEAUmed consortium is led by LEITAT, scientifically coordinated by ICRA and is composed of 15 members from different fields - business, research, technology, hotel communities and public agencies and organizations - from seven European countries: Spain, Germany, The Netherlands, Austria, Italy, France and Belgium.

DemEAUmed will face two key challenges: the importance of the tourism economy and water scarcity characteristic of the area. It will be a critical platform for promoting the use of sustainable and innovative technologies in other Euro-Mediterranean tourist facilities in light of also the global tourism market. The project will design a dissemination plan analysing critical stakeholders/customers to adequately transfer demEAUmed results. Creation of new market opportunities to European industry and SMEs will also be addressed.

A representative resort placed in Catalonia, Spain, is considered as a DEMO site, where a representative part of all inlet and outlet waters will be characterised, treated with proper innovative technologies, and reused to reduce the carbon footprint of water management in an integrated approach at demonstration level.

2. Document objectives and targeted audience

The objective of this deliverable is to provide a **roadmap for a closed and safe water cycle in Euro-Mediterranean resorts**, based on the work carried out by the demEAUmed consortium in WP3.

This deliverable is public; the target audience is European authorities and hotel/resort owners can use as a guideline toward the implementation of a greener tourism sector.

This document seeks to build on previous deliverables of WP3, namely D3.1, D3.2 and D3.4 and to delineate the way forward for guiding resorts and hotels to apply closed water cycles at their premises, contributing to a greener image and a more sustainable use of resources.

This is a working document and it will be complemented (and eventually modified) by many other open workpackages and tasks (i.e. WP6, WP7 and WP8).

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3. Water Cycle in Euro-Mediterranean hotels and resorts

In order to collect information about the state-of-art of water infrastructure in tourist facilities (hotels, in continuation) of Mediterranean coastal area, an online survey was prepared. For convenience reasons, the original English version was translated into 9 other languages of the Mediterranean countries: Albanian, Arabic, Croatian, French, Greek, Italian, Slovenian, Spanish and Turkish. Simultaneously, a database of hotels that were to be invited to participate in the survey was compiled.

The survey went online in July 2014. By beginning of December 2014, the link to the survey and a request to participate in it was e-mailed to 5269 hotels and the obtained results were presented in Deliverable D.3.2. However, the response was very poor - by the end of January 2015, only 32 responses were collected. In order to increase the number of responses, an outbound call center was hired, that was to contact 400 random hotels out of the original database. Despite additional efforts, total number of responders by the time the survey was taken offline (July 2015) was **73**. The most relevant results are given in continuation and update the deliverable D.3.1.

3.1. Information about the hotels that participated in the survey

In 4 countries none of the hotels agreed to take part in the survey. From the rest, number of positive responses is depicted in Figure 3.1.

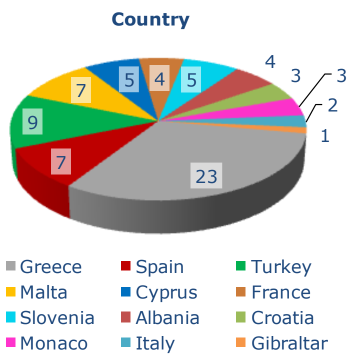

Figure 3.1: *Number of responses per country participating in the survey.*

Figure 3.2 shows some basic characteristics (category, years of construction and bed capacity) about the hotels that participated in the survey (hotels, in continuation). Despite the small final number of participants, the responses covered the entire range of hotels' category, age, size, and pool capacities. It was therefore proposed that the treated sample is representative for the entire Mediterranean area.

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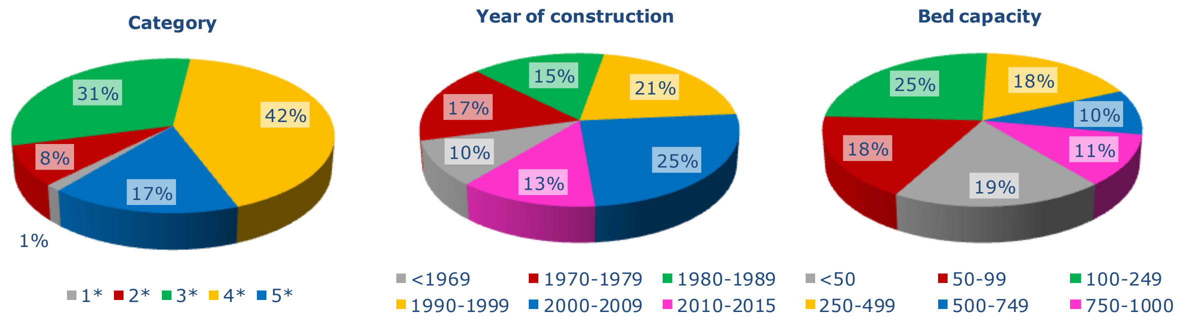

Figure 3.2: *Basic characteristics of hotels participating in the survey*.

3.2. Water sources

The hotels were asked to specify what type of water source they use for different purposes of use. There were 6 water sources offered that they could choose from. The results are shown in Figure 3.3 and Figure 3.4.

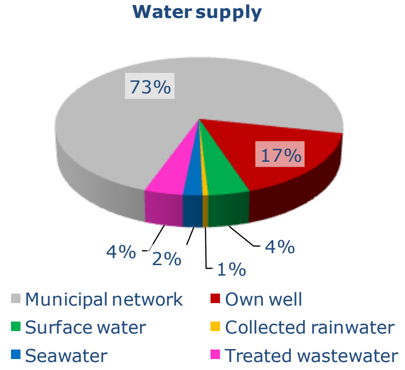

Figure 3.3: *Sources of water supply in hotels participating in the survey*.

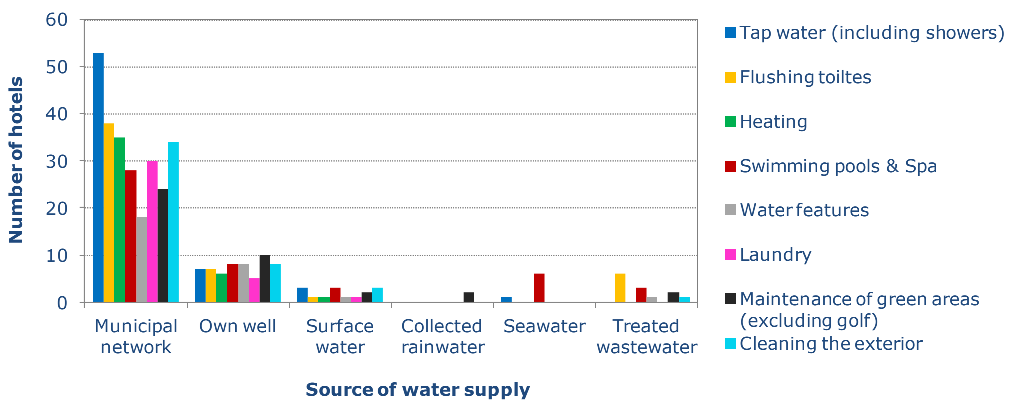

Figure 3.4: *Source of water supply detailed per purpose of use*.

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The major water source in the hotels is municipal network (Figure 3.3), regardless the purpose of the water usage (Figure 3.4). The next most frequent water source is own well. It is encouraging to note that the treated wastewater seem to be an accepted water source, albeit in fairly small extent. Nevertheless, considering that almost half of the hotels treat water only to discharge it into the municipal sewage (Figure 3.5), there is significant room for improvement of the water cycle. It also means that more hotels might be available for installing treatment technologies, like the ones tested in demEAUmed project, in order to promote water reuse and innovative technologies.

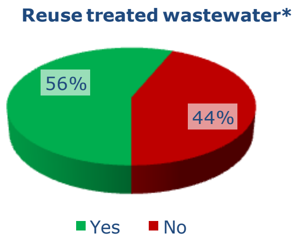

Figure 3.5: *Number of hotels analysing | treating wastewater (left) and the portion of them reusing it (right). (*Includes data for treated grey-, black- and wastewater.)*

3.3. Water consumption

Collecting information about the water uses was mainly focused on needs other than tap | shower water. In particular, the hotels were asked to provide information about presence and capacities of indoors | outdoors pools and spa, as well as other infrastructure consuming large(r) amounts of water. Reponses are presented in continuation.

Regarding recreational waters, about a third of the hotels participating in the survey have neither pool nor spa (Figure 3.6, left). None of the hotels have spa without pools. Hotels that do have pool(s) have it | them outside, in most of the cases (Figure 3.6, middle). As expected, seaside hotels seem to have more pools outside, than inside (Figure 3.6, right).

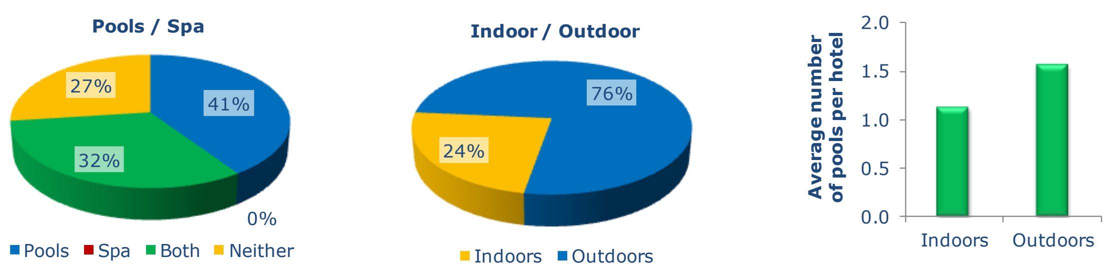

Figure 3.6: *Presence | absence of recreational waters in hotels*.

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From Figure 3.7 (left) it can be seen, that most indoor pools are of small capacity. Such result does not surprise since inside space is usually limited, and it is fair to assume that the majority of seaside hotels have limited indoor pool capacities. As for the capacity of outside pools (Figure 3.7, right), they vary from very small to very large. It should be noted that the capacity is a total one - sum of all outside pools (in the case of hotels that have more than one pool). It should therefore not be concluded that some hotels have very large pools, but rather more of smaller sized ones. Regardless, the capacity per pool does not influence total water requirement for them, and this varies quite substantially.

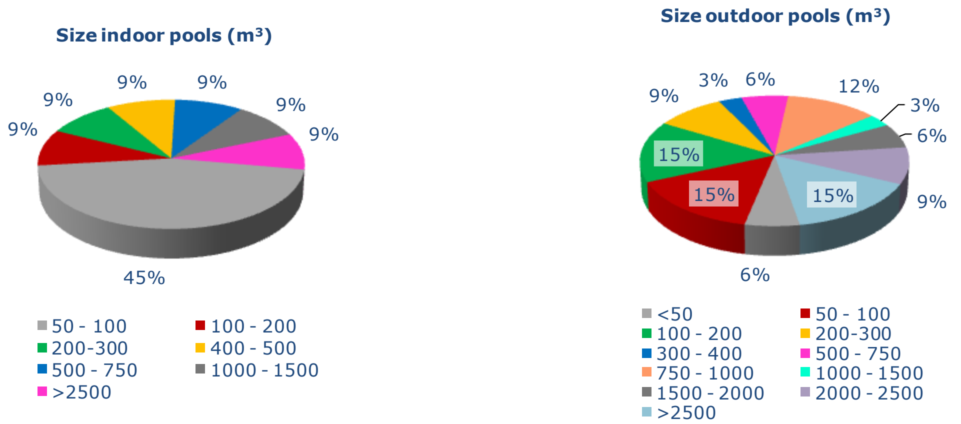

Figure 3.7: *Capacities of indoor | outdoor pools*.

Most frequent type of pool | spa water treatment is rapid sand filtration, with or without prior coagulation (Figure 3.8, left). About one fifth of the hotels apply cartridge filtration. Disinfection is for the most carried out by Cl_2 gas (Figure 3.8, right). Only 2% of hotels use other methods - ozone or UV irradiation. Also these treatment methods could possibly be successfully replaced by the less intrusive technologies researched in demEAUmed project for pool water.

Figure 3.8: *Treatment of pool and spa water applied in hotels*.

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Another large water consumption activity of hotels could be washing their own textiles (bed linen, towels, table cloths, *etc.*). The survey revealed that a little more than half of the hotels are outsourcing washing of these, as seen from Figure 3.9.

Figure 3.9: *Portion of hotels washing own textiles*.

Original survey results (prior to engaging an outbound call centre) implied that textiles are washed on own premises only in smaller hotels. However, increasing the number of responses it became clear that washing textiles on own premises is not a function of hotel capacity (Figure 3.10).

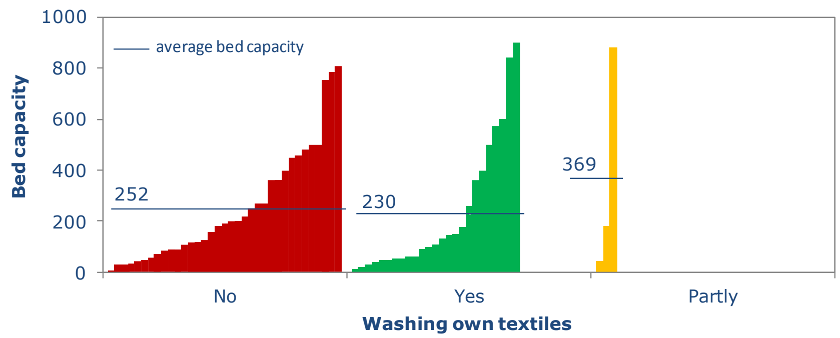

Figure 3.10: *Average bed capacities of hotels that do / don't wash textiles on own premises*.

Figure 3.10 shows hardly any difference between hotel capacities that don't (252 beds average) and do (230 beds average) wash textiles on own premises. Taking into account that nearly half of the hotels do wash their own textiles, care should be taken about greywater treatment. Detergents contain surfactants which are often not only difficult to remove, but can also interfere with conventional treatment techniques.

The maintenance of green areas is another possibly large consumer of water. The survey collected responses about their sizes (Figure 3.11).

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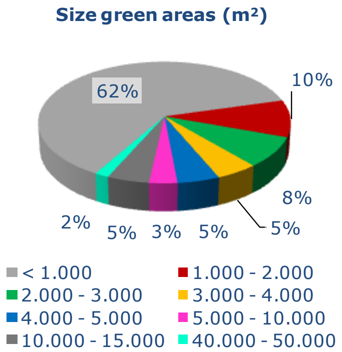

Figure 3.11: *Sizes of green areas that require maintenance*.

As it can be seen from the above Figure 3.11, vast majority of hotels don't have much outside maintenance requiring water. The probable reason is that most of the hotels that responded to the survey are within cities, which offer limited space for green areas around them. Nevertheless, for all of the facilities that do have green areas to maintain, from the environmental point of view it would be beneficial to not 'waste' tap water for it - which, currently, majority of hotels do (Figure 3.4). Treated greywater/wastewater and/or collected rainwater would offer a much more sustainable solution.

Finally, some hotels have additional facilities that consume water, as shown in Figure 3.12. All of these can consume quite large amounts of water; therefore extra effort should be put into using alternative water sources.

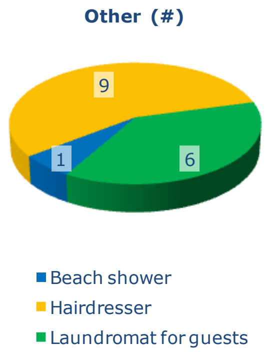

Figure 3.12: *Other facilities consuming water in some hotels*.

3.4. Water saving strategies

The hotels were asked about the extent of water consumption monitoring. The choices given in the survey were between monitoring complete consumption, monitoring separately for indoor and outdoor consumption, and monitoring individually for different water streams. The results are given in Figure 3.13.

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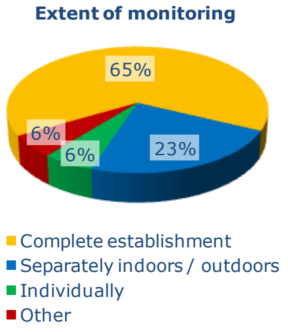

Figure 3.13: *Extent of water consumption monitoring*.

As seen from the results, the majority of the hotels only have an overall monitoring of the water consumption. The respondents of 'individual' monitoring listed:

- separately for each villa;
- separately hot water, pool, spa, garden, air conditioning and carwash; and
- separately for rooms, kitchen and pools.

The responses for 'other' included

- no monitoring;
- only monitoring kitchen; and
- only monitoring pools.

Further on, the survey was to collect information about the type of water saving devices hotels have installed, if any. Respondents were offered a choice between 4 different types of water saving measures, or describe any other that they have in place in order to reduce water consumption. To avoid confusion about the type of water saving device their pictures with names were shown in the survey (Figure 3.14). The respondents could choose any, many, or all. The results are given in Figure 3.15.

Figure 3.14: *The types of water saving device respondents could choose from*.

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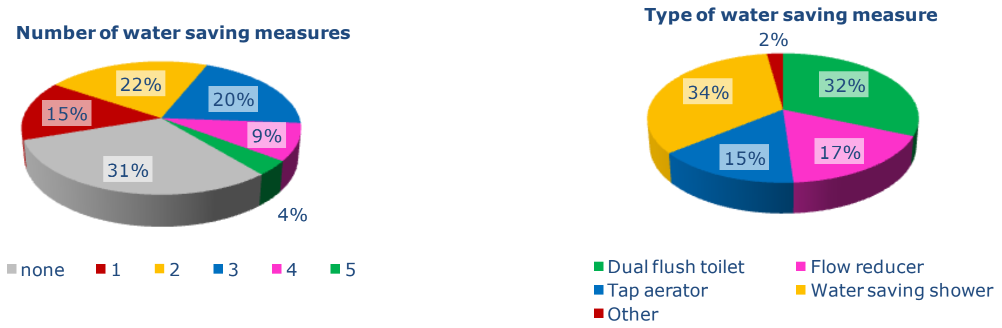

Figure 3.15: *Occurrence (left) and type (right) of different water saving devices installed in the hotels*.

As seen from Figure 3.15 (left), about one third of the hotels have no water saving measures in place in their hotels. Of the hotels that do have them, the most frequent one is water saving shower (Figure 3.15, right). Tap aerator is the least frequently used device, out of the offered choices. The responses under category 'Other' were tank for saving and storing water from air conditioning system and installment of water sensors (the responded did not specify the type or placements of sensors).

Majority of hotels do not separate grey | black water nor do they treat any of the liquid waste (Figure 3.16).

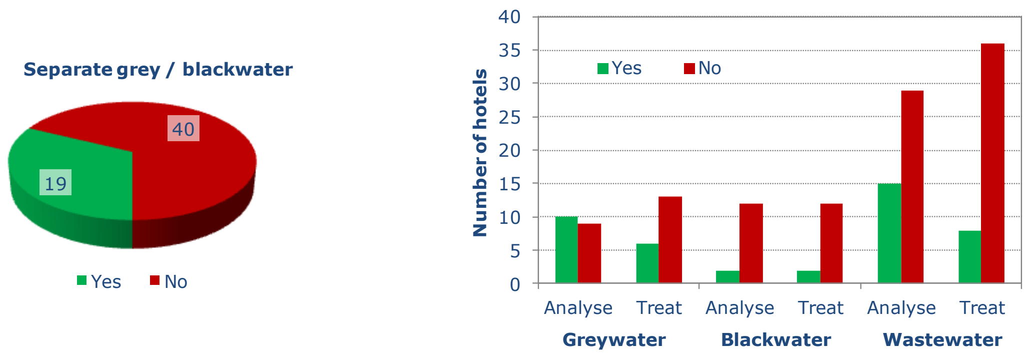

Figure 3.16: *Occurrence of different water saving devices installed in the hotels participating in the survey. Left: number of measures per hotel, right: type of measure*.

Vast majority of the non-treated liquid waste is disposed into the municipal sewage system (Figure 3.17). Based on these survey results, the outcomes of wastewater treatment technologies investigated under demEAUmed project could not only significantly improve the water infrastructure of hotels in the Mediterranean area, but also help diminish water consumption through reuse of treated wastewater.

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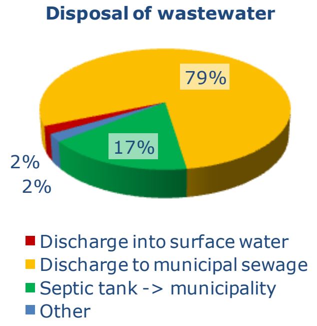
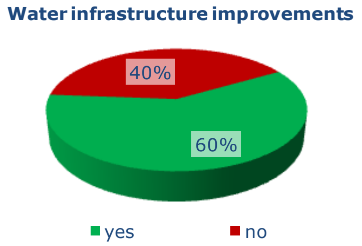


Figure 3.17: *Handling of liquid waste*.

3.5. Maintenance and infrastructural improvements

Of the 73 hotels that participated in the survey, a little over a half had improved at least parts of their water infrastructure, as seen from Figure 3.18, left.



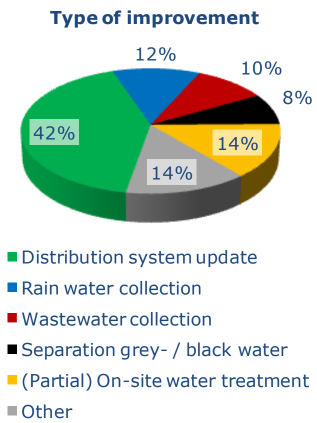


Figure 3.18: *Extent (left) and type (right) of improvements to water infrastructure since the hotels were built*.

The most frequent type of improvement was the update of distribution system (Figure 3.18, right), followed by installation of rain water collecting system. Under the category of 'other', improvements include collection of water from air-conditioning, instalment of decalcification unit, extensions to water cycle units, renovated pool and laundry facilities, and replacement of water tanks.

It should be noted that the 40% hotels that had no improvements carried out since the construction of the hotel approximately corresponds to the portion of the hotels that were built in the last 15 years (Figure 3.19). It was assumed these hotels would have been built with environmental considerations in mind already.

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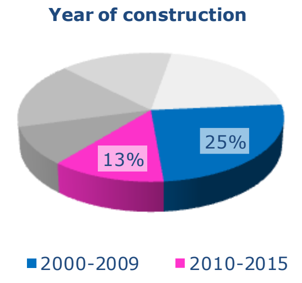

Figure 3.19: *Portion of the hotels built since year 2000*.

The final part of the survey was dedicated to questions about environmental awareness of hotels and their willingness to improve the water infrastructure in the future (Figure 3.20).

Figure 3.20: *Environmental awareness (left) and preparedness for future improvements (right)*. The results are in numbers, not percentages.

The vast majority of hotels are environmentally aware (Figure 3.20, left) and are making their guests aware of it, as well (results are in numbers, not percentages, since not all hotels responded to this question). Also the number of hotels willing to invest in new technologies in order to improve their water cycles is the prevailing choice (Figure 3.20, right). The respondents willing to conditionally improve the state of their water infrastructure were for the most relating to costs involved, and willingness of the owner of the hotel to go along with it (in cases when respondents were managers).

From all of the above responds to the survey it transpires that the greywater and wastewater treatment technologies demonstrated | researched at Samba hotel through demEAUmed project could be the way forward for many of the hotels in the Mediterranean area, even beyond those that participated in the survey. As such, the water cycle could be optimized and the need for municipal water supply greatly reduced.

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4. Water Cycle in the DEMO site - Samba Hotel

4.1. Information about the DEMO site and its water sources

The water cycle characterization in the DEMO site (Hotel Samba) is presented in Deliverable D.3.1. In continuation it is resumed and updated, in order to compare it coherently with the survey presented in Chapter 3.

Samba Hotel is a large three star resort (441 rooms, 882 beds on average) in Lloret de Mar (NE Spain) with green areas and an exterior pool, conference room, bar and restaurant. Consequently the DEMO site is representatives of the largest category of hotels presented in Figure 3.2.

It was built in 1972 and it is certified by EMAS and ISO14001. The water use ranges from 25,000 to 34,000 m^3/year (100 to 135 L/client/day) and greywater is disinfected and reused for water closets since almost twenty years.

The initial location of the water meters in the DEMO site is presented in Figure 4.1. It is remarkable the high level of control that was implemented in the hotel even before the beginning of the demEAUmed project.

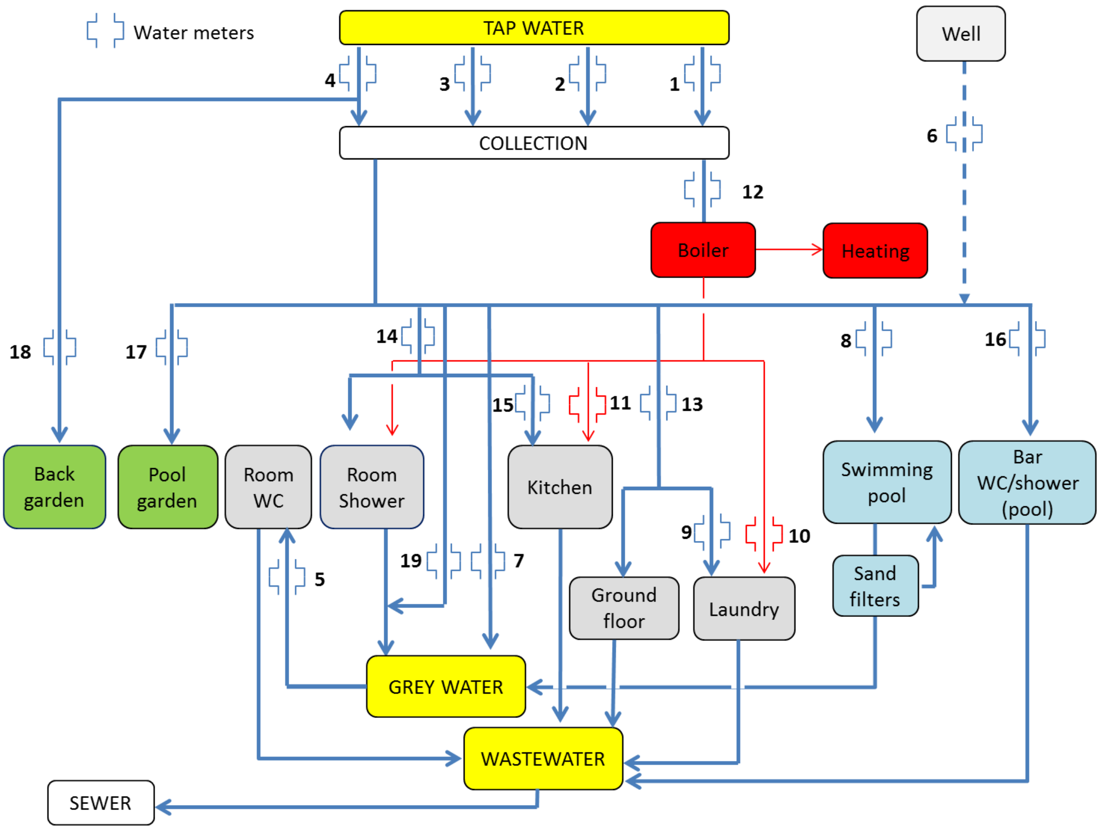

Figure 4.1. *Hotel SAMBA water meters scheme with different water uses indicated. In blue cold water, in red hot water. Dotted line stands for old connection, not in use anymore.*

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In particular, the DEMO site uses water from the municipal network for any purpose but toilet flushing (partially). The greywater system collects water from the hotel rooms' showers together with the backwash water from the swimming pool sand filters. The collected water from the showers is filtered with a grid (to take out the biggest solids) and disinfected before being returned to the water closets. In case the grey water flow from these two sources is not enough, tap water is added to the cycle (water meters n° 7 and 19). The reused water is registered (water meter n°5).

No other wastewater treatment was present at the beginning of the project. Wastewater analyses are performed periodically (once or twice per year).

During the project all the water meters were replaced and a couple more were added (number 20 and 21, Task 5.1 of WP5), as it can be observed in the following Figure.

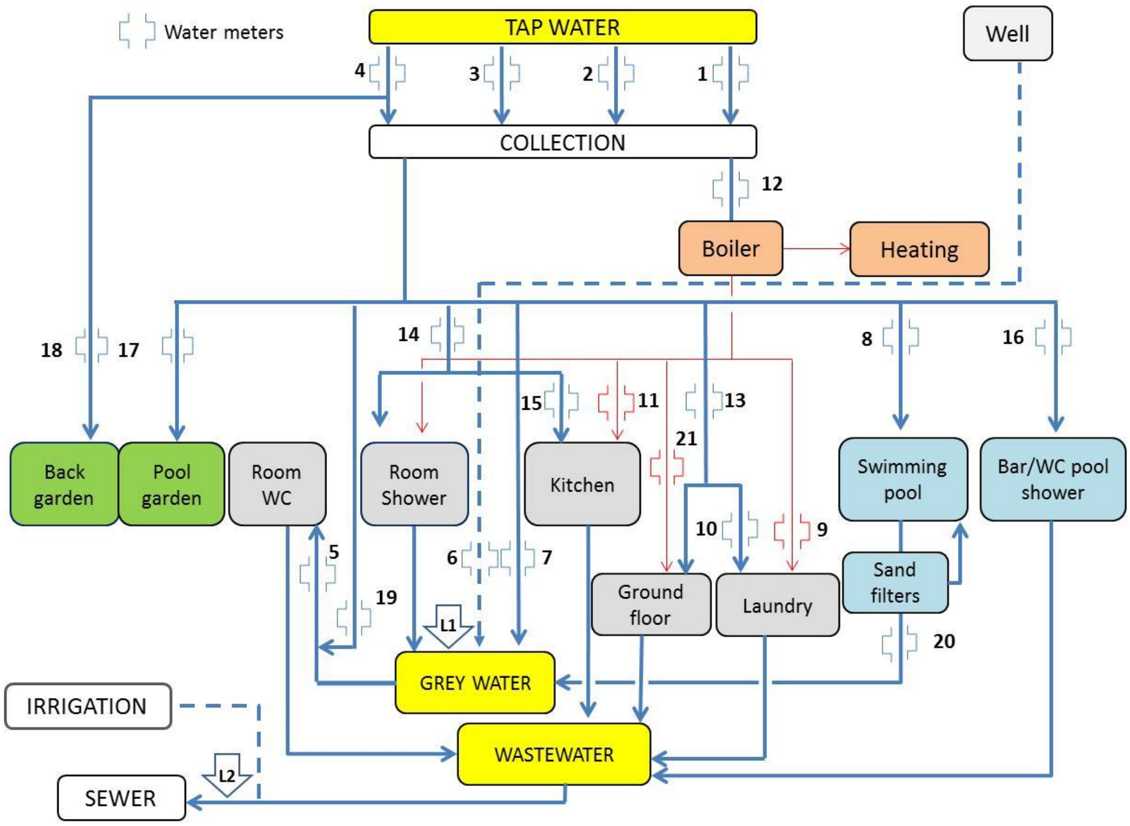

Figure 4.2. *New counter scheme with newly installed water meters (20 and 21) at the DEMO site. To be noted small differences in the position of water meters 6, 9, 10 and 19 compared to Figure 4.1.*

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4.2. Water consumption

The main uses of water from the municipal network in the DEMO site are: tap water (including showers), heating and air conditioning, swimming pool, laundry, irrigation of green areas and cleaning.

The hotel has an exterior pool (Figure 4.3) with a surface in the category 200-300 m^2 (small capacity range of Figure 3.7) and the pool treatment is a standard sand filtration and disinfection with chlorine.

Figure 4.3. *Pool of the DEMO site*

In terms of water consumption for laundry the DEMO site washes partially their own textiles. The DEMO site has green areas between 1000 and 2000 m^2 (small range of Figure 3.11).

The water consumption was evaluated with both historical data of the hotel and two intensive sampling campaigns performed during WP3. Part of the results are presented in D.3.1 and resumed and updated in the following.

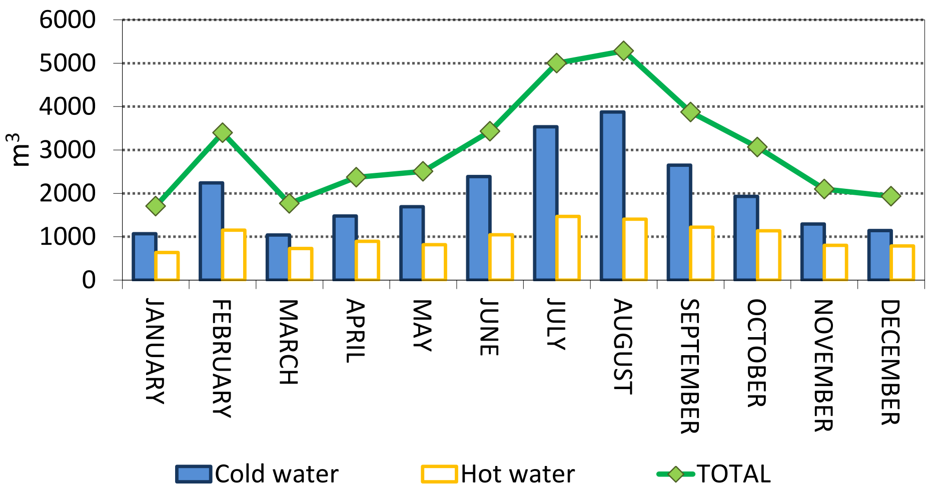

Figure 4.4. *Hotel Samba inlet flows (year 2012).*

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Historical data, facilitated by the resort personnel, have been elaborated throughout the year 2012. Hotel SAMBA inlet flows are presented in Figure 4.4. More water consumption was observed (as expected) in the summer period due to the higher number of tourists in the hotel and hot temperature.

As regards to the different hotel water streams, higher water consumption was observed for the hotel rooms, the kitchen and the greywater system (tap water necessary to fulfil the requirements for the hotel room water closets in case the other two sources are not enough), Figure 4.5, Table 4.1.

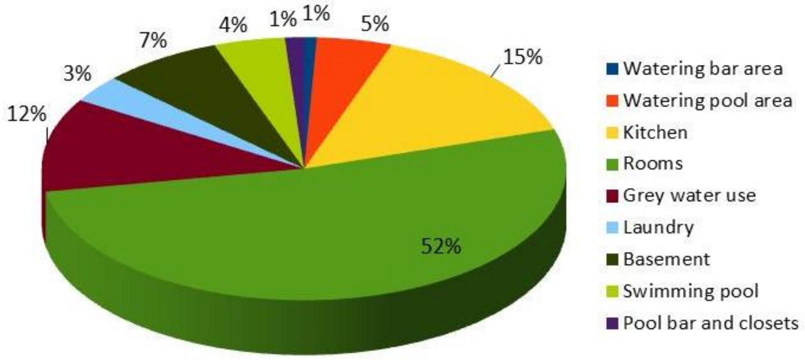

Figure 4.5. *Tap water consumption in SAMBA hotel during 2012, by use.*

Table 4.1. *Hotel SAMBA water use (percentage) for 2012.*

Use	%
Watering bar area	0,8
Watering pool area	4,7
Kitchen	14,7
Rooms	52,0
Grey water use	11,5
Laundry	3,4
Basement	7,4
Swimming pool	4,4
Pool bar and closets	1,2
Total	100,0

In 2014 two intensive sampling campaigns were performed in June (high touristic season) and November (low touristic season) highlighting significant differences in water use distribution.

The hotel rooms occupied in the high touristic season were 398 in the 1st day, 438 in the 2nd and 337 in the 3rd (90%, 99% and 76% of the total rooms respectively). In the low touristic season a significant occupancy of the hotel was recorded: 297 in the 1st day, 202 in the 2nd and 156 in the 3rd (67 %, 46% and 35% of the total rooms respectively).

The total water used, in the three days of each sampling campaign, was 384 m^3 and 200 m^3 in the high and low touristic season, respectively, with a reduction of 48% in total tap water use during the low season.

Nonetheless it was observed that not only the total amount but also the distribution by use was extremely different during the year.

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The water consumption, by use, is presented in the following Table for the high touristic season in terms of volumes and in Figure 4.6 in terms of percentages for both the sampling campaigns.

Table 4.2. *Consumption of water based on the water meters during June 2014 DEMO site sampling campaign.*

		m^3			L/person			L/room		
Water meters	**Zone**	**Day 1**	**Day 2**	**Day 3**	**Day 1**	**Day 2**	**Day 3**	**Day1**	**Day 2**	**Day 3**
1+2+3+4	**Total tap water**	161.2	131.2	92	168.8	129.8	130.1	405.0	299.5	273.0
14-15	**Room shower**	53.3	42	33	55.8	41.5	46.7	133.9	95.9	97.9
5	**WC**	39.4	56.9	54.4	41.3	56.3	76.9	99.0	129.9	161.4
12	**hot water**	4.3	4.1	3.9	4.5	4.1	5.5	10.8	9.4	11.6
8	**swimming pool**	26.9	9.4	6.7	28.2	9.3	9.5	67.6	21.5	19.9
9	**laundry cold**	0.5	0.7	0.7	0.5	0.7	1.0	1.3	1.6	2.1
10	**laundry hot**	2	2	2	2.1	2.0	2.8	5.0	4.6	5.9
11	**kitchen hot**	0.7	0.9	0.9	0.7	0.9	1.3	1.8	2.1	2.7
13	**groundfloor + laundry**	10	11	11	10.5	10.9	15.6	25.1	25.1	32.6
14	**hotel room + kitchen**	61.3	49	38	64.2	48.5	53.7	154.0	111.9	112.8
15	**kitchen cold**	8	7	5	8.4	6.9	7.1	20.1	16.0	14.8
16	**garden swimming pool**	0	2	0	0	2.0	0	0	4.6	0
17	**garden bar**	13	17	0	13.6	16.8	0	32.7	38.8	0
18	**back garden**	3	2	2	3.1	2.0	2.8	7.5	4.6	5.9

It can be observed that reusing greywater water for toilet flushing (water meter 5) represents a significant level of water saving (between 40 and 80 L/person, around 30-35% of total water consumption during the sampling campaign) in the high touristic season.

On the other hand, it can be observed that the greatest amount of tap water used in the low touristic season was for toilet flushing (Figure 4.6 on the right), with the greywater reuse system temporarily not functioning (and the exterior pool empty).

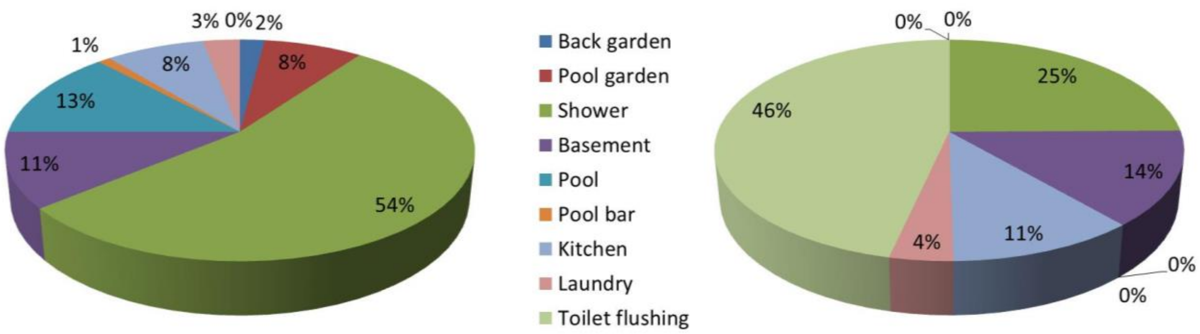

Figure 4.6. *Tap water consumption in SAMBA hotel during 2014, by use: on the left high touristic season (June 2014), on the right, low touristic season (November 2014).*

The observed differences between the two seasons are extremely relevant. The obtained valuable information needs to be considered in advance when applying treatment technologies in the DEMO site and in general to be investigated in any touristic installation.

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In this context to be reminded that data on water uses (by means of the sensors installed in task 5.1) are being evaluated since spring 2015 for around a year. This activity will lead to more detailed information on daily, weekly and seasonal variability in the DEMO site and will completed the results presented in this paragraph.

Moreover WP8 (Decision Support Systems) is considering different kind of scenarios obtaining useful information to be applied in any other touristic facilities of the Euro-Mediterranean area exploring different treatment possibilities (business as usual, greywater treatment and/or wastewater treatment, application of one technologies and/or of series of technologies, etc.).

4.3. Water quality

The main used/generated water fluxes in the DEMO site were characterized also in terms of quality, as presented as resumed in the following.

Different chemical (including a broad spectrum of micropollutants), physical and microbiological parameters were analyzed in the sampled (waste)water. The list of chemical parameters included alkalinity, pH, conductivity, TSS, VSS, BOD, COD, TOC, TKN, Ammonia, Nitrate, Nitrite, Phosphates, Sulphates, Chlorite, free and total Chlorine, Bromide, Fluoride, Sodium, Potassium, Magnesium, Calcium, an extensive screening of metals, THM, HAAs, temporary hardness, etc. With regard to micropollutants, a broad number of pharmaceutical, endocrine and UV filter compounds were measured in all the water fluxes. Finally as to microbiological parameters Total Count, Total Coliforms, *Escherichia Coli*, *Legionella spp*., Intestinal Enterococci, *Giardia*, *Cryptosporidium*, Nematodes and *Clostridium perfringens* were measured in several points of the Hotel water cycle.

The main characterized water samples were from tap water, pool, kitchen effluent, laundry effluent, greywater and wastewater. Based on the roadmap for demEAUmed treatment technologies (D.3.1 and task 4.3) only the main conclusions on greywater and wastewater are here presented.

<u>Greywater</u>:

- generally limited daily and weekly variation even if some peaks were observed in some cases;
- smaller variability in the greywater tank due to its size and the homogenization of the water in it (even though there is no mechanical mixing in the tank);
- limited-medium organic content in terms of COD (around 440 and 200 mg/L for shower and greywater tank respectively) and of BOD (around 160 and 130 mg/L for shower and greywater tank respectively);
- higher conductivity than tap water (also taking into account that the tank receives the backwash water from the sand filters of the swimming pool);
- limited solid content;
- presence of several micropollutants with extreme seasonal variability;
- microbiological contamination in the shower water but never in the greywater tank (due to the disinfection with Chlorine).

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Wastewater was characterized with an extensive sampling campaign (with a refrigerated automatic sampler and 3-hours composite samples during each of the sampling campaign). It was observed:

- a significant daily, weekly and seasonal variability;
- standard values for wastewater in terms of chemical contamination for several parameters;
- presence of several pharmaceutical, EDCs, UV filters;
- microbial contamination.

WP6 activities, which are on-going, will produce results for demEAUmed innovative technologies of treatment of greywater (and pool disinfection) and wastewater and will complement WP7 and WP8 activities on environmental and socio-economic assessment and decision support tool respectively.

4.4. Water saving strategies and maintenance

The DEMO site already implemented a thorough control of water uses (as presented in 4.1 and 4.2) and several water saving strategies and maintenance activities before the project started.
The water saving devices present in the hotel are dual flush toilets, flow reducers, tap aerators and water saving showers and the hotel itself is extremely environmental aware and willing to install new technologies in future, if cheap and easy enough to be operated.
Moreover, as presented before, Hotel Samba already separates greywater from wastewater, with a conventional treatment of greywater, to be applied for toilet flushing.
For all these reasons it is confirmed that the DEMO site is a suitable touristic facility for demEAUmed project because it is both a large touristic facility in the Mediterranean area, significant in terms of produced volumes, and an advanced installation in terms of water saving and control. Both the characteristics are leading to interesting results potentially applicable at a larger scale to many other resorts with similar high water necessity in water scarcity areas.

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5. Closed water cycle in hotels

5.1. Decision making process

When dealing with closed water cycle in touristic areas, the understanding of the levels of action and the drivers for its implementation is crucial to select the goal(s) to be pursued.

As detailed in Deliverable 3.4, the levels dictating different drivers and goals can be categorized as economic, social or political (Figure 1).

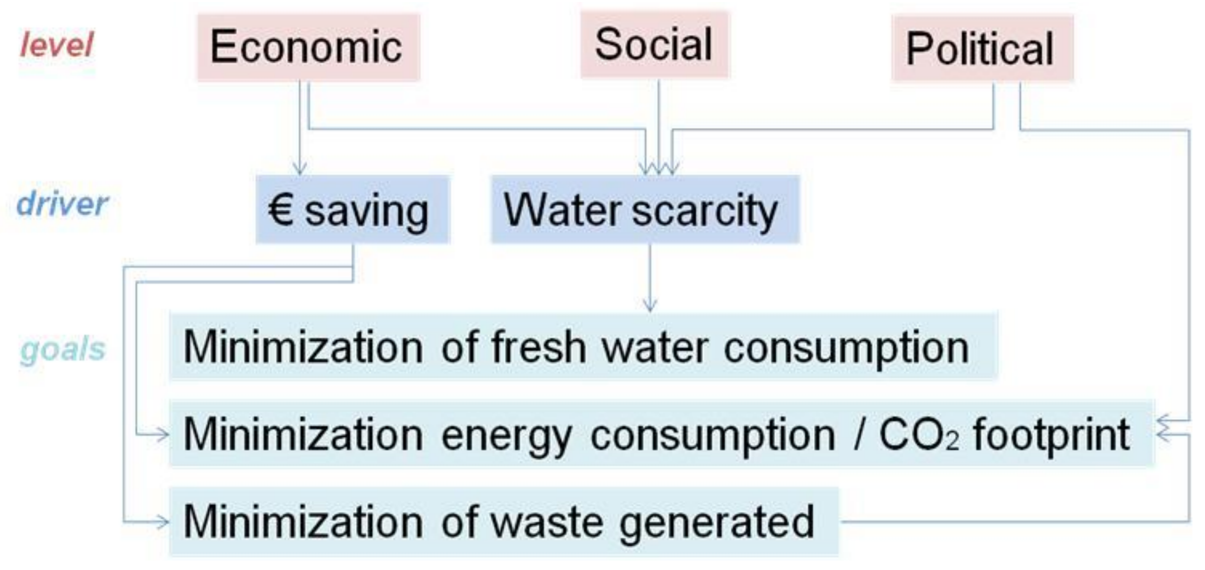

Figure 5.1. *Conceptual scheme of the criteria for closed water cycle implementation.*

When focusing on the **economic aspect**, the main driver for the implementation of closed water cycle in hotels is simply decreasing the expenditure linked to water. The most prominent goal can be identified with the minimization of energy consumption but can also be linked to a cost benefit analyses that involves the investment costs for the treatment technologies, as well as the costs associated to their operation and maintenance. The questions linked to the economic level that can be asked during the decision making process can be simplified as follows:

- **Energy** used by technologies: what is the energy consumption of the technologies proposed? Is the energy bill due to closed water cycle in hotels more advantageous than traditional centralized treatment systems? Can energy be supplied by alternative energy sources?
- **Cost benefit analyses**: which is the most economically advantageous treatment train? Which is the return on investment (including purchase/installation, operational costs, maintenance costs, waste treatment costs)?
- **Maintenance and space:** is the degree and complexity of maintenance considered acceptable? What is the saved and/or required time for both operation and maintenance? Are the selected technologies saving space compared to other ones?

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- **Skills of users:** does the technology require to be operated by highly skilled professionals? What is its level of automation? Does the technology require a complex installation and start up?

The **social aspects** linked to closed water cycle in touristic areas are mainly acceptance and social impact. Nowadays, increasing awareness of clients and business owners alike is driven by more frequents episodes of water scarcity across the Mediterranean region. Hence, the social pressure of minimizing fresh water consumption. The questions that shall be asked during the decision making process as follows:

- **Acceptability**: is the closed water cycle considered acceptable by users in terms of aesthetics, odours generated, etc.?
- **Social impact**: is environmental awareness in hotels a criterion for choosing one hotel over another? Does water consumption minimization at hotel level have an impact on the community surrounding the hotel and on the region at large? Can a closed water cycle located in hotels be used to inform guests on the importance of water treatment, reuse and water safety?

Lastly, the **political** level is mainly driven by public health and water scarcity; it resulted in directives and regulations for water treatment and reuse across the Euro-Mediterranean countries for minimization of energy consumption and waste generation. The questions that can help in the decision making process as follows:

- **Safety**: is the technology safe to use? Does it require any chemicals (so additional safety measures are needed)? Are there technologies reducing the chemicals usage compared to existing treatments (e.g. chlorine) and improving safety and health issues? Is the technology reliable? Will there be any public health related implication?
- **Waste** generated by technologies: how shall the waste generated by the treatment technologies be handled? Which would be the cost for disposing it? Which would be the impact?
- **Carbon foot print:** are green-house gases generated in the life cycle of the technologies used for safe water cycle in hotels lower than the ones generated in centralized treatment systems?

5.2. Water re-use according to existing legislation

Since currently there is no regulation at EU level for water reuse practices, water quality parameters and their corresponding limits that are required for the different uses by National legislations are being summarized and compared under Task 7.3. In this deliverable only the national Spanish regulations (RD 140/2003, RD 742/2013, RD 1620/2007) and the European directives (for drinking water (98/83/EC) and for urban wastewater treatment and discharge (91/271/EC) were considered, even though it should be stressed that none of the latter refers to water reuse quality limits.

The uses have been categorized in seven types based on water quality requirements:

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- Type 1: Potable water used for human consumption, kitchens and showers/tubs
- Type 2: Swimming pool
- Type 3: Aquifer recharge through direct injection
- Type 4: Irrigation of private gardens
- Type 5: toilet flushing
- Type 6: Irrigation of golf courses
- Type 7: Aquifer recharge through localized percolation

In Table 5.1 the parameters and the threshold values or ranges established in the aforementioned legislations are summarized.

The parameters in blue in Table 5.1 are proposed by demEAUmed consortium to be taken into account: although they do not appear in the Spanish reuse regulation, the values reported are the limits of discharge for treated wastewater in the Spanish regulation (RD 509/1996).

The consortium is aware that a European legislation for water reuse is under evaluation at European level for water reuse in agricultural irrigation and aquifer recharge. Nonetheless at the present day no homogenised legislation for water reuse is present. In any case the Deliverable D.7.2 "Policy brief on water quality legislation and possible recommendations for existing and future regulation" will consider these aspects more in detail.

In order to take into account the existing legislation, while deciding to move towards a closed water cycle in hotels, the basic decision tree presented in Figure 5.2. The grey water treatment decision tree and wastewater treatment decision tree are currently being developed and will be integrated with the information produced by WP8.

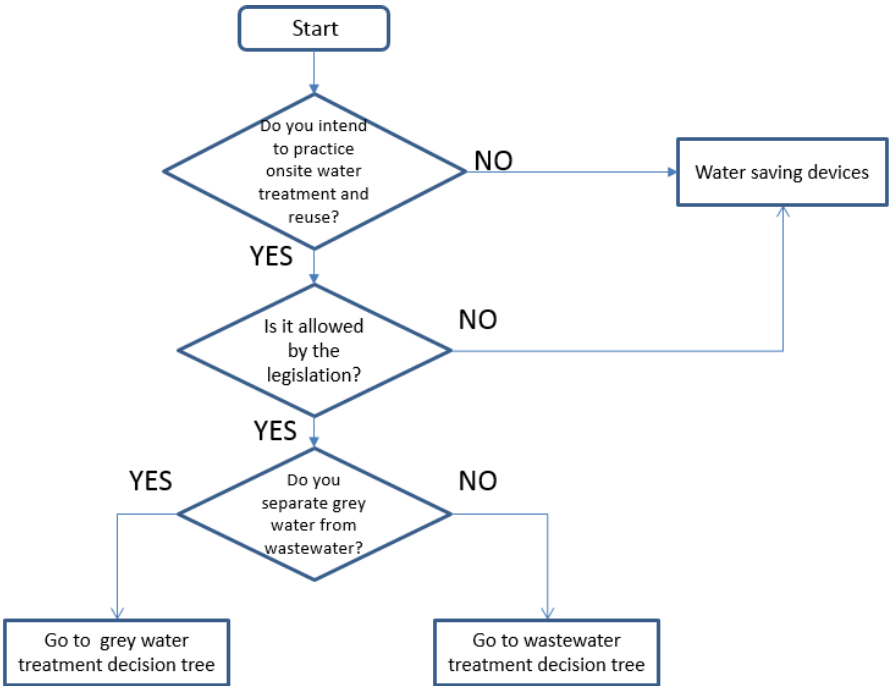

Figure 5.2. *Decision tree for selecting the type of closed water cycle.*

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Table 5.1. *Key parameters according to Spanish and EU legislation.*

INCREASE IN WATER QUALITY REQUIREMENTS TO BE ACCOMPLISHED ←

	Type	1	2	3	4	5	6	7
	USES	**Drinking Kitchen Shower**	**Swimming pool**	**Aquifer recharge Direct injection**	**Irrigation Private garden irrigation**	**Toilet flushing‡**	**Irrigation Golf course irrigation**	**Aquifer recharge Localized percolation**
	European Legislation	**98/83/EC**		**91/271/EC**	**91/271/EC**	**91/271/EC**	**91/271/EC**	**91/271/EC**
	Spanish Legislation	**RD 140/2003**	**RD 742/2013**	**RD 1620/2007**	**RD 1620/2007**	**RD 1620/2007**	**RD 1620/2007**	**RD 1620/2007**
Key Parameters	*Escherichia coli* (CFU/100 mL)	0	0	0	0†	0†	200	1000
	Enterococci (CFU/100 mL)	0						
	*Clostridium perfringens** (CFU/100 mL)	0						
	Intestinal nematodes (egg/10 L)			1	1	1	1	No set limits
	Pseudomonas (CFU/100 mL)		0					
	*Legionella spp.*** (CFU/L)		< 100		100	100	100	
	COD (mg/L)				**125**	**125**	**125**	**125**
	BOD_5 (mg/L)				**25**	**25**	**25**	**25**
	TSS (mg/L)			10	10	10	20	35
	pH	6.5-9.5	7.2-8.0					
	Residual combined chlorine (mg/L)	2	≤ 0.6					
	Residual free chlorine (mg/L)	1	0.5-2.0					
	Chloride(mg/L)	250						

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	Type	1	2	3	4	5	6	7
	Conductivity (µs/cm)	2500					3000	
	Aluminium (µg/L)	200						
	Iron (µg/L)	200						
	Fluoride (mg/L)	1.5						
	Sulphate (mg/L)	250						
	Sodium (mg/L)		200					
	Total Nitrogen (mg/L)			10				10
	Nitrate (mg/L)	50		25				25
	Hardness							
	Turbidity (NTU)	5	≤ 5	2	2	2	10	No set limits
	Transparency		bottom or Secchi disk well visible					
	Redox potential*** (mV)		250-900					
	Temperature		24-30°C					
	Total bromine (mg/L)		2-5					
	Isocyanuric acid**** (mg/L)		≤ 75					

*including spores

**Only measured if there is risk of aerosolization.

***Only measured when disinfectants are others than chlorine, bromine or their derivatives

****Only has to be analyzed if derivated from acid thriclo isocyanuric acid are used

†Authorization only if there is a marked dual circuit.

‡Toilet flushing and private garden irrigation have the same water quality according to the RD 1620/2007, therefore there is no increase in water quality.

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6. References

- COUNCIL DIRECTIVE 91/271/EC of 21 May 1991 concerning urban waste water treatment.
- COUNCIL DIRECTIVE 98/83/EC of 3 November 1998 on the quality of water intended for human consumption.
- Deliverable D.3.1 Roadmap for a closed and safe water cycle in Samba DEMO site.
- Deliverable D.3.2 Database of Euro-Mediterranean sites data with identified (dis)-similarities.
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- EPA/600/R-12/618, Guidelines for Water Reuse.
- RD 140/2003, Real Decreto 140/2003, de 7 de febrero, por el que se establecen los criterios sanitarios de la calidad del agua de consumo humano.
- RD 1620/2007, Real Decreto 1620/2007, de 7 de diciembre, por el que se establece el régimen jurídico de la reutilización de las aguas depuradas.
- RD 509/1996, Real Decreto 509/1996, de 15 de marzo, de desarrollo del Real Decreto-ley 11/1995, de 28 de diciembre, por el que se establecen las normas aplicables al tratamiento de las aguas residuales urbanas.
- RD 742/2013, Real Decreto 742/2013, de 27 de septiembre por el que se establecen los criterios técnico-sanitarios de las piscinas.

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