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Life cycle analysis of urban water cycle in two Spanish areas: Inland city and island area

J. Uche[a,*], A. Martínez[a], C. Castellano[b], V. Subiela[c]

[a]*Natural Resources Area, CIRCE Research Institute, University of Zaragoza, María de Luna s/n, Zaragoza 50018, Spain*
Tel. +34 976 25 84; Fax: +34 976 73 20 78; email: javiuche@unizar.es
[b]*Campus Tafira Baja s/n, University of Las Palmas de Gran Canaria, Las Palmas, Spain*
[c]*Water Department, Canary Islands Institute of Technology (ITC), Playa de Pozo Izquierdo s/n. Sta. Lucía, Las Palmas, Spain*

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ABSTRACT

In this paper, the results of the complete life-cycle assessment (LCA) analysis of the water cycle in two Spanish urban areas are presented. First case study was Zaragoza city (700,000 inhabitants), with enough surface water resources for drinking purpose. Second case was the Mancomunidad del Sureste, a highly populated and touristic area in a water-scarce island (Gran Canaria). Main objective of the paper was to show, from an environmental global perspective, which was the relative pollutant weights of the diverse water cycle stages in an urban area, in order to put the efforts in reducing the environmental penalties associated to the water cycle. Results showed that environmental load associated to energy consumed in dwelling uses (to produce hot sanitary water) exceeded by far the environmental impact provoked by water cycle infrastructures (water treatment plants, water supply and drainage networks, and wastewater treatment plants). Additionally, it is very important to remark that new water supply alternatives (seawater desalination plant as well as reclaimed wastewater) studied here were energy intensive solutions, and the environmental charge during its life cycle was also very significant.

Keywords: Life cycle assessment; Urban water cycle; Water environmental issues; Water treatment; Water cycle infrastructures.

1. Introduction

There exist some relevant aspects to bearing in mind regarding energy involved in the water cycle, which supposes around the 7% of the consumed electricity in Spain [1], being seawater desalination an important fraction of that value. Transport of water also involves important energy costs. Through the whole water cycle, water is consumed and its quality is degraded as well. Thus, corrective actions must be implemented by means of diverse water technologies which consume, among others, some additional energy. However, water and energy nexus should be managed not only considering the energy consumption of a process or product (and its possible improvements), but also some other impacts related to the

*Corresponding author.

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construction of the technologies, land use, or associated impacts derived from further water uses.

Life-cycle assessment (LCA) is a well-known methodology to assess the environmental penalties associated to any product or process. Main advantage of LCA is its comprehensive scope: it considers "*from the cradle to the grave*" the whole life cycle of a product or processes since it accounts for the environmental charges associated to the assembly, operation and dismantle phases of that product or process. Nevertheless, major drawback consists of the huge amount of information required to carry out the inventory list of incoming materials and/or processes, especially if the problem to attack is quite complex (as a water treatment plant is), or the required information is not available (or confidential).

Within water sector, LCA is becoming more and more significant to evaluate the additional environmental loads at different stages of the water cycle which are not only directly related to the energy consumption. This analysis is crucial when several alternatives for the same purpose could be selected. For instance, if diverse collecting water supply alternatives are feasible within a city, it is very interesting to allocate their different environmental load to discern the best option. On the other hand, when the complete analysis of all stages in the integral water cycle of a city is compiled, the interest is then focused on the comparison among the different water cycle stages and especially in the assessment of the environmental load associated to civil works performed in water supply and drainage networks (apart from their corresponding pumping stations). The environmental penalties related to construction and also the operation of water treatment and wastewater treatment plants can also be compared if a LCA analysis is made. Anyway, they should also be compared with environmental penalties associated to water uses in a city, in order to decide if the efforts should be really focused on reducing the environmental impact on water cycle stages, or alternatively, promoting the reduction of human water and energy consumption patterns.

Traditionally, LCA analysis of water cycle was only partly analyzed and focused into a single stage. For instance, current technologies applied to a water treatment plant (WTP) were analyzed in [2,3]. The LCA of a water supply system in a small urban area and the pipe-replacement period was studied in [4]. Wastewater treatment plants (WWTPs) were also deeply studied [5–9], even considering further water reuses [10]. Additionally, diverse water supply alternatives were analyzed and compared within a LCA perspective [11–13], especially when regional conflicts arose for opting between both solutions. Thus, the LCA of the complete water cycle of a town like Zaragoza (Spain) or a council (Mancomunidad del Sureste) presented here was really a challenge, since it allowed the global environmental comparison of the diverse water cycle stages, as well as the contrast among the different water treatment and supply typologies in a city.

2. Case studies

2.1. Zaragoza city

Zaragoza is a medium-size city located at the northeast of Spain (see Fig. 1). It is placed in the middle of the Ebro River main course (910 km), whose valley (85,000 km^2) is characterized by a wet period (spring and autumn) and a dry one (winter and summer). Annual natural water availability is about 14,000 hm^3 for an average year [14]. Upstream dams usually guarantee the water supply (is the biggest urban area of the Ebro Valley). However, irrigation is by far the highest consumer in the Ebro Valley; Raw water collected to Zaragoza is affected by nonpoint pollution as well by a high sulfate concentration coming from gypsum soils drainage along the upstream tributaries.

Nowadays, there are three alternatives to supply raw water to Zaragoza: the Ebro river, the Imperial Canal (water from the Ebro is delivered 80 km upstream to Zaragoza), and the Yesa reservoir (connected to Zaragoza WTP by a 150 km-length pipe and the intermediate La Loteta reservoir) which collects spring waters from the Pyrenees. Those three water supply alternatives feed Casablanca WTP, which is based on a conventional treatment based on coagulation–flocculation, filtration (sand and carbon), and further chlorination. Main potable water tank is very close to Casablanca WTP, but some additional small water tanks and pumping stations are required to provide potable water to upper town areas. Regarding household uses, it is very typical to find out small water tanks in buildings to maintain a minimum pressure in upper floors; natural pressure coming from the water supply network is then lost and additional pumping energy is required. After domestic, industrial, and gardening purposes, polluted water is collected (pumping is only required to cross waste water from the left bank urban area) and transported to the two existing WWTPs: La Almozara (with a capacity of 100,000 equivalent inhabitants) and La Cartuja (1,000,000 equivalent inhabitants). The first one reduces its net power consumption, thanks to biogas produced in the anaerobic sludge treatment; on the contrary in La Cartuja

Fig. 1. Zaragoza's location in the Ebro Valley (Spain) and water collection from Yesa.

WWTP, sludge is dried and further combusted in a fluidized bed at 850˚C.

To start with the LCA of the water cycle of any city, a preliminary water balance is required. Surprisingly, this water balance is not usually calculated by water managers since, in general, each water cycle stage is managed by a different organism or subcontracted company. Moreover, groundwater use in case of Zaragoza is not well characterized, although it is really important for industrial and irrigation purposes. This water balance is necessary to precisely define a unique functional unit to perform the complete LCA analysis of the water cycle. Fig. 2 shows the water cycle scheme of Zaragoza, including the water balance of the year 2010.

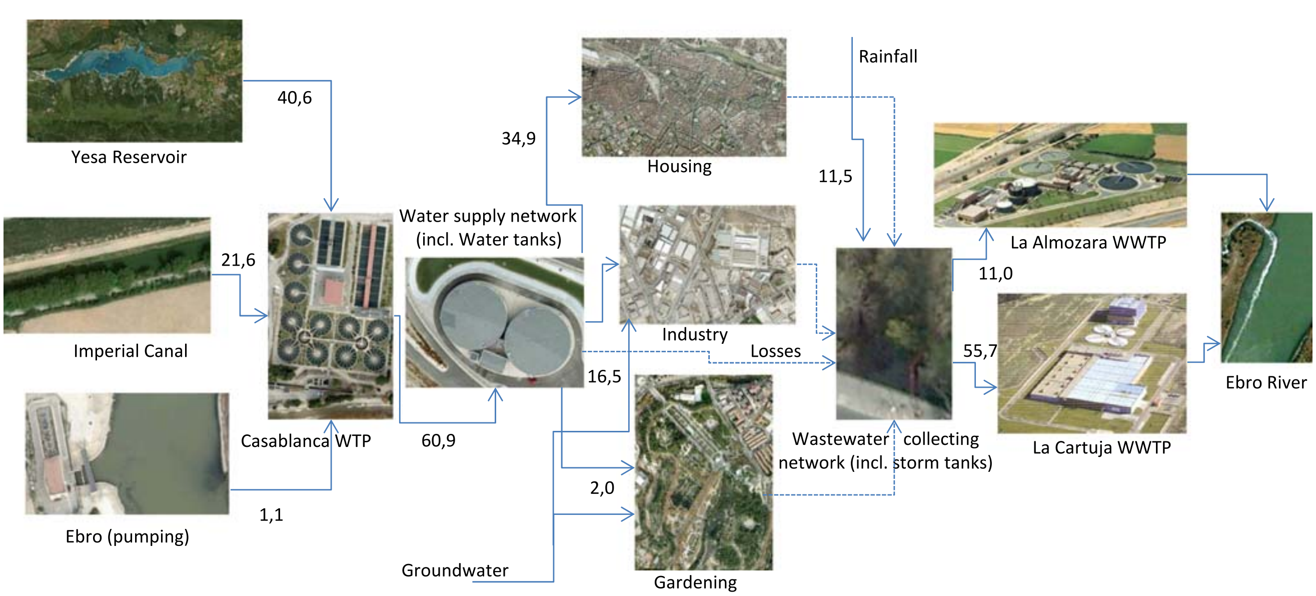

Fig. 2. Water cycle in Zaragoza. Water balance in 2010 (in hm^3/y).

2.2. Mancomunidad del Sureste

The Mancomunidad del Sureste is located at the southeast of the Gran Canary Island. It has a SWRO 2-stage unit of 33,000 m^3/d (Recovery ratio = 55%)—a conventional WWTP with an average capacity of 12,000 m^3/d, equivalent to 100,000 inhabitants and its associated tertiary treatment in a wastewater reuse plant (WWRP, 6,000 m^3/d) for irrigation purposes which includes a RO treatment, as well a complete water supply system for its three municipalities (Agüimes, Ingenio, and Santa Lucía). The sketch of the water cycle infrastructures as well as the water balance in the area are shown in Fig. 3.

3. Methodology

In order to perform any LCA and following the two ISO standards (ISO 14040 and ISO 14044), three fundamental steps are required: definition of goal and scope, life cycle inventory, and evaluation. In fact, the fourth one (interpretation phase) is optional and only performed once the third one is totally finished. Next, they are briefly described.

3.1. Goal and scope (system limits)

First LCA step is to define the goal and scope of the LCA. In this sense, it is necessary to define the limits to the system which is going to be analyzed, as well as to select the functional unit to deal with. Within the present study, the system was composed by all the stages of the water cycle in a city or a council, as previously described. The unit to input the environmental penalties was 1 m^3 of potable water before its use (domestic, industrial, or irrigation) in the case of Zaragoza. Note the network losses, as well as water physically consumed in uses were computed through the cycle, in order to deal with an only functional unit for the complete LCA analysis, following the LCA guidelines. In general, previous LCA studies only attended to a water cycle stage, and 1 m^3 of treated water was usually the functional unit of that analyzed stage, as it is the case of Sureste. It is worth to point out that energy consumptions are usually related to one cubic meter of water (product) leaving a water cycle stage, which do not correspond to the functional unit of Zaragoza; a careful analysis was made in order to fairly compare the two case studies.

3.2. Life-cycle inventory

Second step consisted of performing the complete life-cycle inventory (LCI) of resources consumed to construct and operate the water cycle installations and utilities. To do that, a huge amount of information was gradually obtained from the city council of Zaragoza (Infrastructures Department): numerous

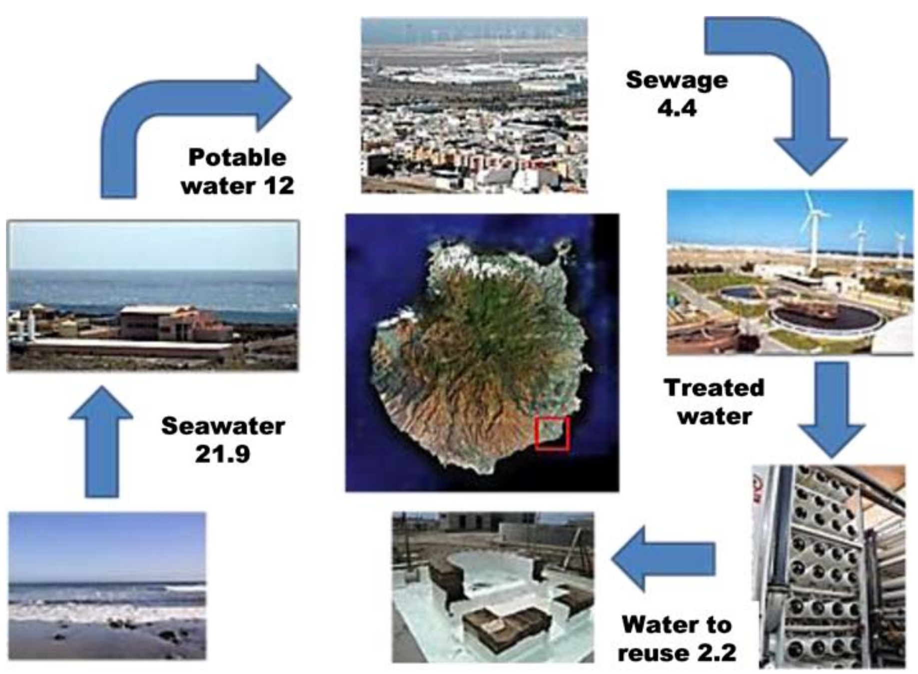

Fig. 3. Main scheme of the water cycle in the Mancomunidad del Sureste (Gran Canaria Island), and water balance in a typical year (hm^3/y).

plans (WTP and WWTPs, as well as potable and storm water tanks, pumping stations, water supply, and sanitary piping systems), and diverse data sheets contained, among others, the remaining and basic information required to implement the LCI of the water cycle of Zaragoza. In the case of Mancomunidad del Sureste, only the information related to water treatment plants could be recuperated.

Apart from infrastructures, of course chemical dosing in WTPs, SWDP (Sea Water Desalination Plant), WWRP, and WWTPs was included in operation phase of the LCA. Specific energy consumption (SEC, kWh/m^3) of those plants and pumping stations were also computed, in order to thereafter perform the LCA of all the water cycles.

Finally, water uses were also introduced in the LCA analysis of Zaragoza in order to completely close the water cycle. Unfortunately, the uncertainty included in this sector was much higher than the one included in infrastructures (Zaragoza has about 312,000 housings). However, domestic and industrial uses consume by far more energy and chemicals (detergents) than municipal water cycle stages, and its study is then compulsory required in a global environmental vision of the water cycle of a city. Additional efforts are currently being carried out to fulfil a detailed study of water uses in Zaragoza. Next table shows some selected materials from a long list performing the complete LCI of the water cycle in Zaragoza (Tables 1a and 1b) and the Mancomunidad del Sureste (Table 2).

3.3. LCA methods

Third step is the evaluation phase of the LCA, and several life-cycle impact assessment (LCIA) methods have been developed in recent years. In general, all methods include a characterization phase, in which the LCI substances that contribute to an impact category are multiplied with a characterization factor that expresses the relative contribution of the substance. Many methods also normalize those values, in the sense that they are compared with a reference (or normal) value, for instance the average yearly environmental load in a country or continent. Finally, some methods (classified as end-point ones) allow weighting across impact categories, in order to add the (normalized) impact of diverse categories into a total or single score.

In this part of the analysis is strongly recommended the use of LCA software to perform the environmental assessment. Here, maybe the most widely used one (SimaPro, v7.2.2) was taken to develop both LCA case studies. Three LCA methods were selected from SimaPro because of the following reasons:

- IPCC GWP 2007a (Global Warming Potential at 100 years, from the International Panel of Climate Change): it provides a unique and well-known value (kg CO_2 equivalent). Thus, LCA scores could be compared with other environmental methodologies.
- Ecoindicator 99 EP H/E (endpoint, hierarchical, European vision): it is a widely used end-point method which allows easy comparisons. It provides a single end score that concentrates the overall assessment of diverse environmental impact categories.
- ReciPe MP H/E (midpoint, hierarchical, European vision): it is a new method composed by a two widely used LCA methods (CML 2 baseline 2000 and Eco-indicator 99). It includes a specific impact category (water depletion), which accounts for the impact of water physically consumed (not returned) which was extracted from diverse raw water sources. However, as it is a midpoint-oriented/damage approach, it does not provide any unique result (normalization and weighting were not applied), but a set of categories.

4. Results and discussion

First, LCA results included urban water uses. In a second step, as the environmental penalty of water uses was by far the highest pollutant stage of the water cycle, only the water cycle infrastructures were studied. As the environmental impacts associated to the dismantle phase (via recycling, landfill, and incineration) of the life cycle were not representative at all with respect to the assembly phase (infrastructures, phase I) or operation phase (energy consumption and chemical dosing, phase II), they were not presented in Zaragoza. Alternatively, this phase was included in Sureste water treatment plants (phase III), as well an additional phase related to membranes replacement (phase IV), but again they were not as impacting as the assembly and operation phases of the LCA.

4.1. Zaragoza water cycle (including human uses)

As expected, the first LCA result was that environmental load of water users in Zaragoza were really high (almost the 88%). This is due to the huge energy consumption destined to produce hot sanitary water (HSW) from cold potable water, throughout natural gas

Table 1a
Summary of the LCI of Zaragoza water cycle infrastructure

Water cycle stage	Steel (ton)	Sand (ton)	Gravel (ton)	Concrete (ton)	Clay (ton)	PVC (ton)	Cast iron (ton)	PRFV (ton)
Collecting								
Yesa	6,852	2,747,512	1,822,115	50,205	1,950,000	236	62	3,568
Imperial Canal	31			1,604	9,639			
Ebro		16,192	86,020	2,926				
Casablanca WTP	1,457	1,290		21,608	862	289		
Water supply								
Network	5,273	503,123	5,241,871	32,374		130	40,048	3,343
Tanks	2,200			576,491				
Water uses								
Domestic	39,946					1,125	71,552	22,789
Irrigation		5,847		11,824		14	680	
Industry	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Drainage								
Network		1,921,957	5,223,417	1,332,389	876	3,343	6,487	
Storm tanks	1			11,666				
WWTPs								
La Almozara	303	150	2,319	12,957	1,040	4		765
La Cartuja	1,783	19	4,838	107,176	4,757			3

Table 1b
Main operating data of Zaragoza water cycle (year 2010)

Water cycle stage	SEC (kWh/m^3)	Land use (ha)	$HClO_2$ (kg/m^3)	Polyelect. (kg/m^3)	Cl_3Fe (kg/m^3)	Input (hm^3/y)
Collecting						
Yesa	0.08	1,105				40.58
Imperial Canal	0	216				21.64
Ebro	0.22	0.88				1.09
Casablanca WTP	0.029	6.37	0.0161	0.0622		60.96
Water supply						60.90
Network	0.087	126.56				
Tanks	0	14.38				
Water uses						
Domestic	17.19	0				34.91
Irrigation	0.15	1,636.7				3.9
Industry	n.d.	n.d.				16.5
Drainage						71.61
Network	0.012	154.49				
Storm tanks	0.002	0.21				
WWTPs						
La Almozara	0.062	2		0.0014	0.019	11.05
La Cartuja	0.47	11.26		0.005	0.081	55.76

boilers or electric heaters (operation phase of the LCA). Furthermore, infrastructures associated to dwellings are not negligible (assembly phase, see Table 3); for instance, the use of copper (piping) and cast iron (radiators) is around the 4% of the total impact in the whole water cycle. Table 3 shows the main results for the IPCC GWP 2007a method, where the strong relevance of water uses (in kg of equivalent CO_2 per m^3 of drinking water before its uses, note that this was the functional unit adopted here) can be observed.

Similar results were obtained when the ReciPe method was applied (see Fig. 4); for the vast majority of the impact categories included, water uses ranged from 80 to 90% of the total impact in the overall water cycle. Some exceptions were found: land use impact category (agricultural land occupation and natural land transformation bars) was quite important if spring water was collected from the Pyrenees (La Loteta reservoir flooded 1,086 hectares); fresh water eco-toxicity was mainly affected by chlorination in Casablanca WTP (freshwater ecotoxicity bar); and finally water depletion (the third bar from the right) impact category appeared when water losses were considered as an additional stage in the LCA of the overall water cycle.

At this point, it is interesting to note that with a single-score method (Eco-indicator 99), the score obtained for human uses (mainly HSW in dwelling) had again the highest environmental impact, both in the characterization phase (see Fig. 5 for a detailed analysis of 11 impact categories) and in a single-score form, once impact categories were normalized and weighted: the impact of water uses reached up to the 91% of the total environmental impact, see Table 4.

Therefore, it is clear that efforts should be mainly devoted in reducing domestic water consumption and its embodied energy. Anyway, as the LCA analysis of

Table 2
Mancomunidad del Sureste water cycle infrastructure: LCI report

WTP	Steel (ton)	Sand (ton)	Concrete (ton)	Cast iron (ton)	Copper (ton)	Polyamide (ton)	PRFV (ton)
RO SWDP	1,029	1,000	5,626	92.57	12.12	152.99	7.21
WWTP	80.60	–	9,583	12.48	1.67	–	0.25
WWRP	9.43	–	915	17.18	2.25	31.18	1.67

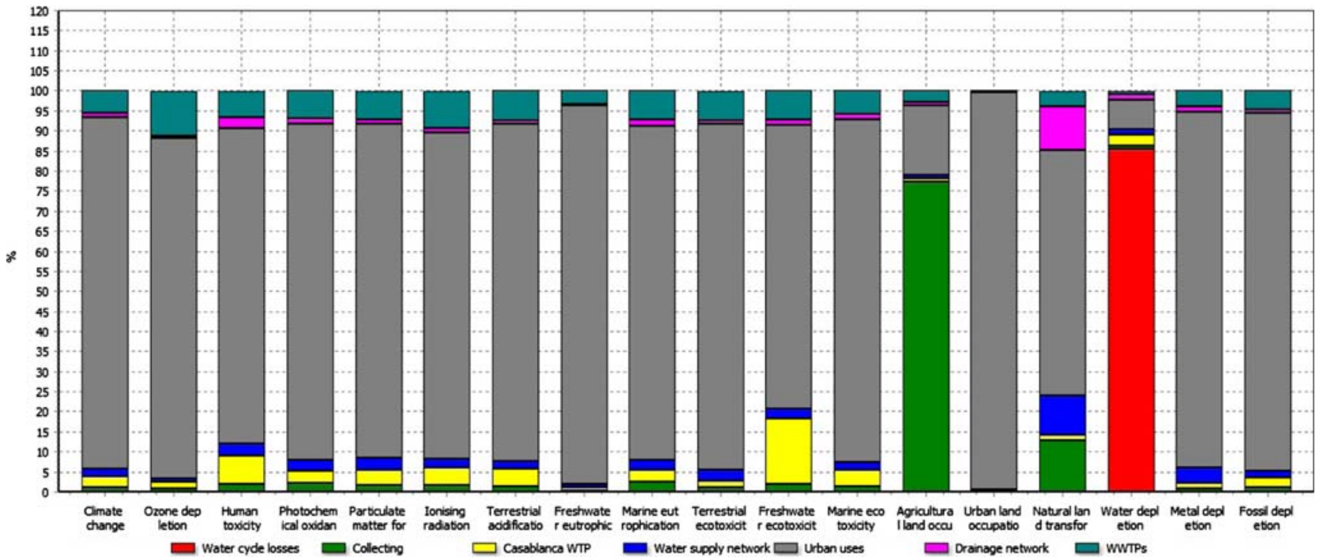

Fig. 4. Results obtained with ReciPe (MP H/E) method.

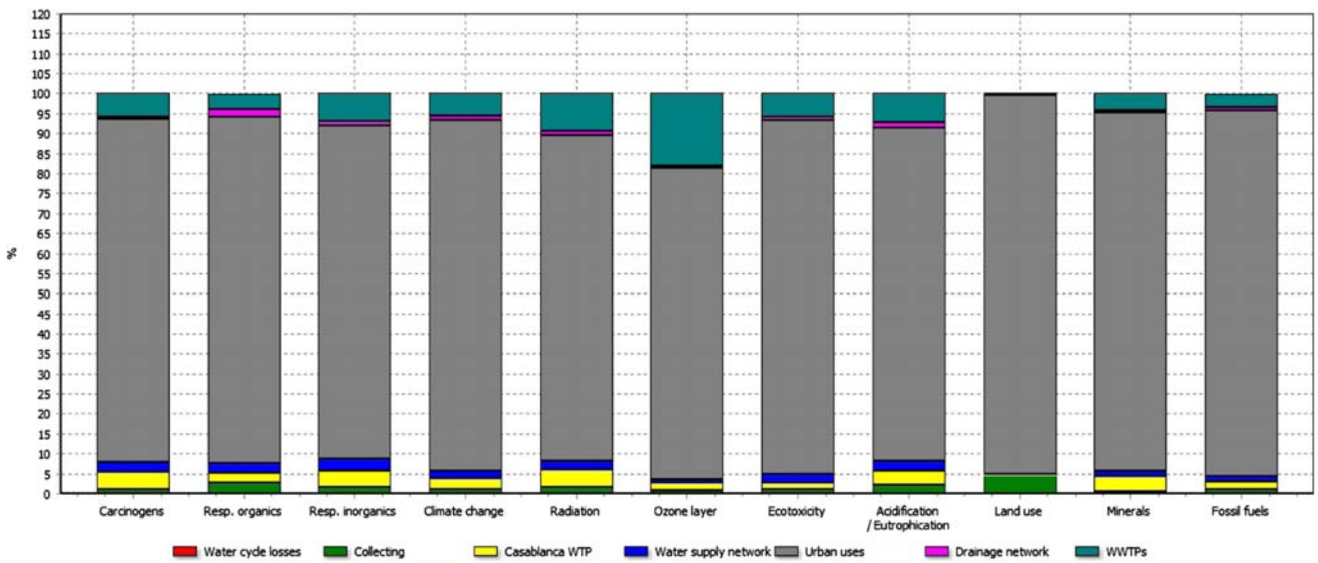

Fig. 5. Results obtained with Eco-indicator 99 method (characterization phase).

the complete water cycle was being shadowed by that use, further analysis was presented with respect only to water cycle infrastructures, that is, the water cycle without water uses.

4.2. *Water cycle infrastructures of Zaragoza*

Once water uses were discarded from the LCA analysis, depuration (WWTP) provoked the highest impact since it had the highest energy consumption and chemical dosing (see Fig. 6 for the IPCC GWP 2007a method). Note that very large amortization periods of infrastructures gave low-associated impact figures, despite of the huge amount of materials involved in water supply and drainage networks.

The ReciPe method also incorporated some interesting results (see Fig. 7) regarding the impact categories that it managed: land use impact category in urban areas was representative for water supply and drainage networks (gray bars, as expected) and ozone depletion damage was intensified in the case of the WWTP (the upper fraction of all bars, sludge treatment).

Table 3
LCA results with IPCC GWP 2007a method (kg of equiv. CO_2 per m^3 of water before the use)

Phase	Total water cycle stage	Collecting	WTP	W. supply	Human uses	Drainage	WWTPs	
Total	7.440		0.089	0.189	0.143	6.530	0.086	0.404
Assembly (I)	0.549		0.051	0.007	0.084	0.317	0.075	0.015
Operation (II)	6.893		0.038	0.182	0.059	6.211	0.011	0.389

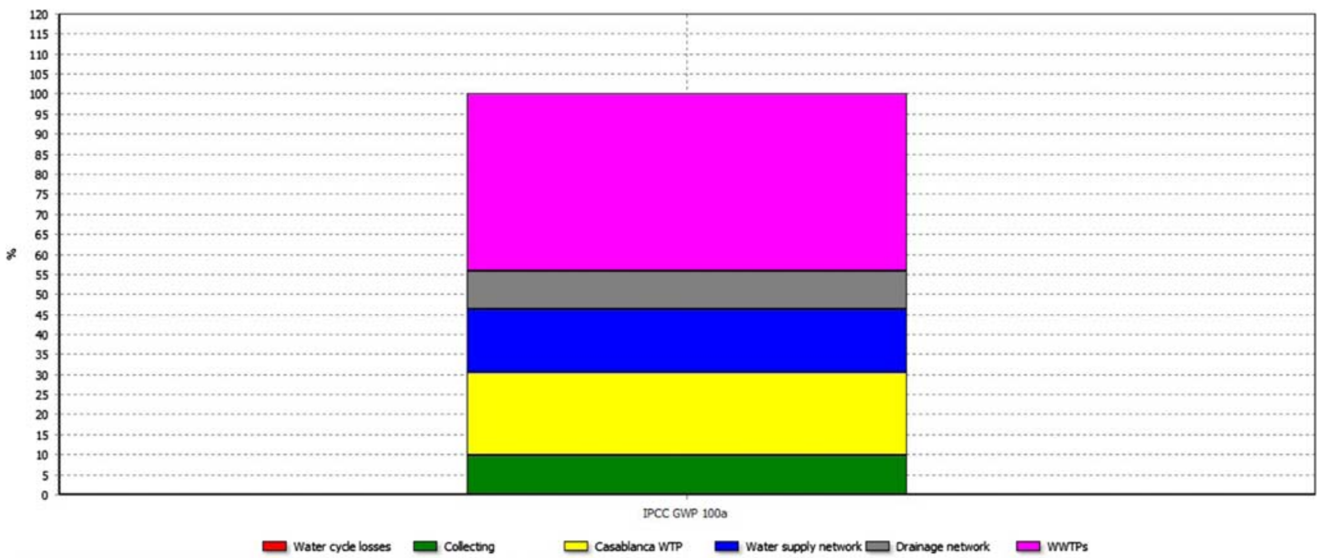

Fig. 6. Environmental LCIA (IPCC GWP2007a method) of water cycle phases in Zaragoza.

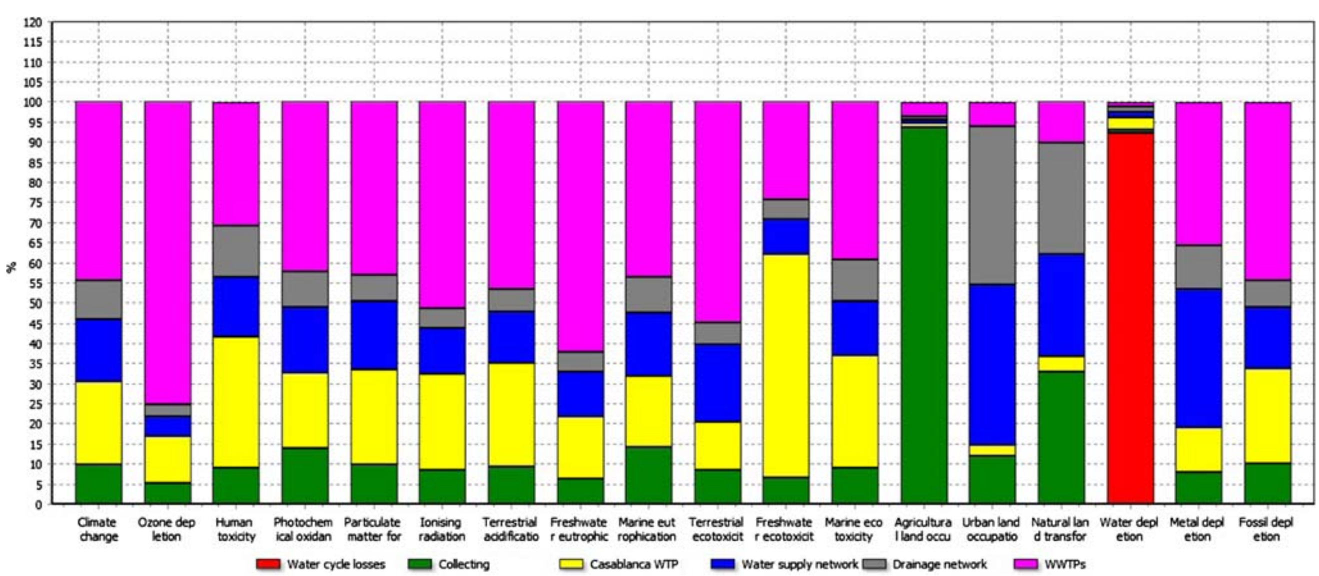

Fig. 7. Detailed LCA analysis with ReciPe (MP H/E) method of Zaragoza water cycle stages. Water uses were intentionally excluded.

Finally, Eco-indicator 99 method could give a unique number to compare diverse water cycle phases. If characterization phase was firstly studied, results were quite similar than those obtained in ReciPe. Nevertheless, once the method normalized and weighted those categories in order to find out that score, the collecting alternative from Yesa reservoir obtained the highest figures, as can be seen in Fig. 8, coming from the land use impact, which is really an important category in this LCA method.

The environmental load of any of the three existing water supply alternatives for Zaragoza was also very interesting to analyze. It is clear that water from the Pyrenees (Yesa reservoir) has better quality than water collected in the medium Ebro, and lower chemical dosing is required in the WTP. But it provokes a nonnegligible environmental impact associated to their huge associated civil works, as well as the pumping required when water is previously stored in La Loteta reservoir. Table 5 shows which were the environmental impacts associated to collecting alternatives in Zaragoza for the last three consecutive hydrologic years (from 2008 to 2010). As that infrastructure was only partially used, its environmental penalty obviously increased. However, as raw water is almost freely delivered from the Canal Imperial, and pumping directly from the Ebro River is not significant (in terms of volume), the environmental impact associated to its highest energy consumption does not compensate the load use of the infrastructure. That is, Yesa is always the worst option to supply water to Zaragoza from the LCA approach.

Finally, as already described, Zaragoza has two WWTP with different sludge treatment systems. The LCA performed here was also valid to compare them from the environmental point of view. Despite wastewater origins and plant construction, better results (that is, lower environmental impact) were found for a WWTP that consumed biogas from their sludge. As it can be seen in Table 6 with the IPCC GWP 2007a method, although La Cartuja WWTP (sludge incineration) operated with the 80% of the Zaragoza wastewater volume, the environmental impact of its operation phase (energy and chemical dosing consumptions) was around the 96% of the total impact in the depuration stage. Those results met with the specific energy consumption and chemical dosing of both alternatives. Furthermore, the detailed LCI of civil works related to the two WWTPs showed that La Cartuja provoked higher relative environmental loads associated to its construction (it is an indoor WWTP).

4.3. Water treatment plants in Mancomunidad del Sureste

As expected, the LCA analysis of those water treatment plants showed that highest scores were

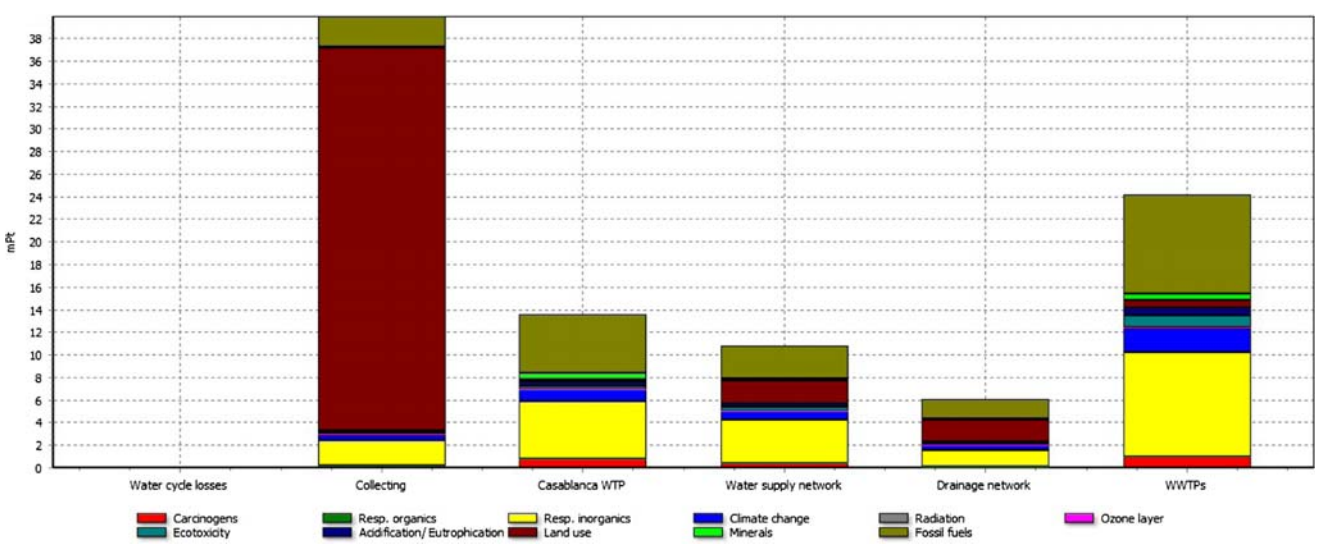

Fig. 8. LCA results with Eco-indicator 99 MP H/E method.

Table 4
LCA results with Eco-indicator 99 (EP H/E) method (Pts./m^3)

Total	Water cycle stage	Collecting	WTP	Water supply	Water uses	Drainage	WWTPs
1.21		0.0399	0.0136	0.0108	1.110	0.006	0.0241

Table 5
LCA analysis of water collecting alternatives to Zaragoza depending on raw water source. IPCC GWP 2007a method (kg of equiv. CO_2/m^3)

Phase/year	Yesa Reservoir	Imperial Canal	Ebro River	Total
hm^3/y (2008)	1.49	54.72	4.87	61.08
Total	0.0518	$5.74{\cdot}10^{-6}$	0.0123	0.064
Assembly	0.0505	$5.74{\cdot}10^{-6}$	0.0003	0.051
Operation	0.0013	0	0.0120	0.013
hm^3/y (2009)	13.65	44.61	1.63	59.90
Total	0.0626	$574{\cdot}10^{-6}$	0.0043	0.067
Assembly	0.0505	$574{\cdot}10^{-6}$	0.0003	0.051
Operation	0.0121	0	0.0040	0.016
hm^3/y (2010)	40.58	21.64	1.09	60.94
Total	0.0865	$5.74{\cdot}10^{-5}$	0.003	0.089
Assembly	0.0505	$5.74{\cdot}10^{-5}$	0.0003	0.051
Operation	0.0361	0	0.0027	0.039

found for the SWDP, because of its elevated energy consumption. Nevertheless, as WWRP incorporates an additional RO treatment, its environmental impact was the second one in the area. The WWTP provokes the lowest impact beside of their energy and chemical dosing consumption. Table 7 shows the main results of the area obtained by the Eco-indicator 99 method, and Table 8 included the environmental penalties of the water treatment plants of the Mancomunidad del Sureste, including the four LCA stages (assembly, operation, dismantle, and membrane replacement), following the IPCC GWP 2007a method.

With respect to establish any kind of comparison with respect to the LCA results of Zaragoza city, only similar water treatment plants could be really compared. In this case, three analyzed WWTP presented similar figures in different LCA methods, as could be checked in Tables 6 and 8. Note that different mix of technologies was used for the Spanish Peninsula and Gran Canary Island to generate power, which was taken into account in the LCA analysis.

Table 6
LCA analysis of two existing Zaragoza WWTP, year 2010. IPCC GWP 2007a method (kg of equiv. CO_2/m^3)

Phase	La Almozara	La Cartuja
hm^3/y	11.05	55.76
Total	0.0121	0.392
Assembly (I)	0.0012	0.014
Operation (II)	0.0108	0.378
Sludge treatment	Biogas	Dry incineration

Table 7
LCA results of Sureste WTPs with Eco-indicator 99 (EP H/A) method (Pts./m^3)

Total (WTPs)	SWDP	WWTP	WWRP
0.276	0.18	0.062	0.034

Table 8
LCA results of Sureste WTPs with the IPCC GWP 2007a method (kg of equiv. CO_2/m^3)

Phase	SWDP	WWTP	WWRP
hm^3/y	12	4.38	2.19
Total	4.69	0.873	1.64
Assembly (I)	0.041	0.018	0.005
Operation (II)	4.62	0.854	1.61
Dismantle (III)	0.003	0.0002	0.0002
Membrane Replacement (IV)	0.019	–	0.021

5. Conclusions

Thanks to the support of Zaragoza city council technicians and the Mancomunidad del Sureste managers, it was possible to perform, for the first time, a complete LCA analysis of the water cycle of a medium-size city and a island council, by using the real data of existing infrastructures and consumables (energy and chemical dosing) of each water cycle stage. That is, the environmental impact of the assembly (and dismantle) phase of the infrastructures associated to any cubic meter of water along its complete life cycle could be assessed.

Results were quite convincing: water cycle infrastructures do not supposed an important weight in the total environmental impact of the water cycle. The reasons were the high-energy rates of some water treatment plants (SWDP, WWRP, WWTP, and WTP in this order) and especially the energy consumed in water uses. Thus, the cornerstone of the sustainability in the water cycle of a town or a council will pass on the adequate water and energy use of consumers. Civil works were found to be harmful to the environment in case of large infrastructures collecting raw surface waters not working at full capacity: alternative systems guarantying water supply in a city increase the environmental impact of further water uses.

Different impact categories appeared at different water cycles stages, mainly provoked by diverse damages to the environment. As an example, attending to the water losses along the water cycle is a key issue in the framework of water depletion. Lighter materials to build, for example, water supply networks would mean also a reduction in the impact categories related to natural resources depletion, including minerals. impact Selecting the appropriate LCA method could help to perform specific studies on a unique category.

The work presented in this paper summarizes an intensive period of data collection, interpretation, and analysis. With all the reserves, it gives some guidelines to promote the sustainability of new or already existing water supply and collecting alternatives, as well as the design and management of new water cycle infrastructures (water networks, water treatment, and reuse plants) based on low LCA scores.

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Nomenclature

E	—	European level
EP	—	End-point (oriented impact category)
GWP	—	Global Warming Potential
H	—	Hierarchical
HSW	—	Hot Sanitary Water
IPCC	—	Intergovernmental Panel for Climate Change
LC	—	Life Cycle
LCA	—	Life-Cycle Assessment
LCI	—	Life-Cycle Inventory
LCIA	—	Life-Cycle Impact Assessment
MP	—	Mid-point (oriented impact category)
SEC	—	Specific Energy Consumption
SWDP	—	Sea Water Desalination Plant
WTP	—	Water Treatment Plant
WWRP	—	Waste Water Reuse Plant
WWTP	—	Waste Water Treatment Plant

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