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Environmental and economic aspects of water kiosks: Case study of a medium-sized Italian town

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ABSTRACT

The consumption of bottled water in Italy began in the 1970s. Since then, this usage has grown considerably, also as a result of changes in habits. The environmental impact as a result of the water production chain is very significant; it would be considered, for example, the use of plastic bottles, the consumption of oil in the production of the bottles, the emission of air from the vehicles that transport the bottles, non-recycled plastic packaging, etc.

In this study, considering the comparison between two situations, use of bottled water and use of water kiosk (WK), an environmental and economic impact evaluation has been done. The study considered the production of a WK in a town with 9000 inhabitants, which supplies controlled, still and sparkling water, with an organoleptic quality higher than tap water coming from the aqueduct. In particular, taking into consideration the environmental aspects, specific attention was paid both to CO_2 emissions and PET bottle waste reduction. The economic impact evaluation was carried out from the consumer's point of view. In order to provide a supply service that was economically sustainable, a calculation was done with the aim of determining a specific fee for the supplied water. Moreover, a comparison has been made between quality parameters achieved with the analysis of water from aqueducts with the limits established in the Italian legislation and the parameters of several Italian water brands.

The study has the aim at considering the opportunity to follow a different people's habits, closer to the concept of sustainability, reducing the environmental charge related to the realization, transport and consumption of plastic water bottles without significant reduction of the quality of the service and with convenient and interesting economic implications. In fact the results of the study show that the alternative of WKs is more efficient in economic and environmental terms respect to the use of bottled water.

1. Introduction

The consumption of bottled water in Italy began in the 1970s. Since then, the consumer has had an increasing stimulus, often associated with social phenomena: over the years, drinking bottled water first became a symbol of status, and then a practice, combined with massive, growing investments on advertising campaign by multinationals which, as well as for other products, transformed the perception of water from an essential and basic drink to a source of health and even beauty. In 2010, the specific consumption of bottled water (BW) in Italy has been the highest in the world, with 200 L per capita (Legambiente, 2010) and is steadily increasing, considering that this value has tripled in just over 20 years.

Such phenomenon has had a positive economic impacts in terms of (a) number of employees as well as (b) turnover for beverage, logistics and retail marketing companies. Considering environmental aspect, Polyethylene Terephthalate (PET) water bottles life (production, transportation and disposal) and mineral water industry impacts are negative; in particular:

- during 2008 in Italy, 350,000 t of PET was used to produce the plastic bottles necessary to contain, approximately, 1.2×10^{10} L of mineral water (COREPLA, 2012), with a consumption of 665,000 t of oil; the related greenhouse gases emission was approximately 910,000 t CO_2 eq, calculated using the emission factor suggested by the US-EPA (2012);
- in Italy, the transportation of mineral water has a considerable effect on air pollution, because (a) the bottles travel many kilometers before arriving to consumers (Table 1) and (b) only 18% of the total amount of bottle freight travels by rail, one of the less pollutant means of transport (Torretta, 2009);
- in Europe, only about one third of the used plastic bottles are collected separately and forwarded for recycling (PlasticsEurope, 2012).

Regarding the management of plastic bottle waste (WPET), the disposal problem has different aspects that need to be considered.

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Table 1
Distance between springs and main Italian cities for the most diffused BW brands.

Brand	Spring-to-city distance (km)					
	Milan	Turin	Florence	Rome	Naples	Genoa
Levissima	193	323	424	696	894	342
Vera	251	411	244	516	715	373
Uliveto	264	423	266	538	736	401
Rocchetta	302	349	81	353	551	182
Lilia	491	609	196	191	390	432
Sant'Anna	250	134	420	695	695	185
Lete	252	102	390	662	860	184
Ferrarelle	720	838	419	173	65	656
Panna	288	406	36	324	523	263
Sant'Antonio	38	154	344	615	814	173
San Pellegrino	72	201	356	627	826	218
Vitasnella	124	313	335	607	806	278
Mean	270	355	293	500	656	307

First of all, as PET is a non-biodegradable plastic (Shah et al., 2008), the disposal of post-consumer PET has huge environmental impacts (Gironi and Piemonte, 2010; Krueger et al., 2009).

PET is widely recycled as a material, making a large contribution to the recycling targets required for plastics by the EU directive 2004/12/EC. Nevertheless, a vast amount of WPET still remains unused (COREPLA, 2012). Indeed, PET is reported to be of the most abundant plastic in solid urban waste (de Mello et al., 2009).

The PET bottles obtained from household sorting are usually collected, compressed and packed by councils for transportation to recycling plants, which are operated by recycling companies. After the selection, the remaining PET bottles are shredded, cleaned, and finally turned into flakes and pellets for recycling (Al-Salem et al., 2009).The materials obtained from conventional recycling processes are PET materials customary used for non-foods, fibers and core of multi-layer applications. Currently, the main outlet for recycled PET is the fiber market (e.g. polar fleece). Other applications include strapping, sheet and even building materials (for example, as an additive to concrete). High quality sorting and washing allows bottles to be made back into bottles for beverages and non-foods (Petcore, 2012).

For a long time, bottle-to-bottle post-consumer PET packaging materials recycling was not possible, because of the lack of knowledge about packaging polymers contamination during first use or collection. Furthermore, the decontamination efficiencies of recycling processes were in most cases unknown. Today, sophisticated decontamination processes, the so-called super-clean recycling processes, are able to decontaminate post-consumer contaminants to the concentration levels of virgin PET materials (Welle, 2011; Petcore, 2012). The output material can be used for packaging applications in which PET bottles come into direct contact to foodstuffs.

Such technologic effort brought bottle-to-bottle PET recycling to be a sound alternative to the conventional PET recycling.

Since its high calorific value (Al-Salem et al., 2009), non-recyclable PET may be used for energy recovery, which implies burning waste to produce energy in the form of heat, steam and electricity.

However, it is clear that there will be always a non-recyclable and non-recoverable WPET, maybe simply because it was not collected separately; this waste may be destined for the landfill. PBs will be crushed flat without fragmenting, occupying less space than the more rigid glass ones. In this case, the plastic residue will remain inert because it is not biodegradable (one of the reasons it is such a good choice for packaging foods is its resistance to attack by micro-organisms) and it is resistant to chemicals found in landfills. Moreover, it will not give rise to any harmful leachates (Petcore, 2012).

In order to reduce the environmental pressure of drinking water consumption, a solution could be to drink water supplied by the public aqueduct, with considerable technical, environmental and economic advantages for both the individual consumer and the whole community. With the aim of both promoting the use of drinking tap water and spreading eco-sustainable behaviors by reducing waste production at source, some Italian parish and city councils are moving towards promoting “water kiosks” or “water houses”. Water kiosks (WKs) are facilities that usually have a rectangular layout, covering an area of 7–12 m^2, with a height not exceeding 3 m, that are often designed to fit into the urban landscape, with architecturally well-planned solutions. These structures are located in strategic positions and provide the public with withdrawal points of drinking water, in particular:

- water with improved organoleptic characteristics compared to tap water coming from the public aqueduct;
- still (or natural) and carbonated (or sparkling) water, either chilled or at ambient temperature.

Currently in Italy there are almost 250 WKs (about 70% in Lombardy Region), placed in small and medium sized towns, with the exception of Milan (3 WKs) (Casa dell'Acqua, 2012).

The objective of this paper is a preliminary environmental and economic comparison between two alternative situations: the use of BW and WKs in a medium sized Italian town. After a description of the technical characteristics of the case study WK, the methodological approach is introduced. The environmental comparison is based on CO_2 emissions due to the production and consumption of the same volume of drinking water, while the economic one is done on the basis of the costs for the consumer. The paper also includes a comparison between quality parameters of various aqueduct waters and BWs, also considering Italian law limits.

2. Materials and methods

2.1. Case study

The case study considers a WK situated in a town of about 9000 inhabitants in Northern Italy and its results performed during 2011 (Lura Ambiente Spa, 2012). The supplied water volume and the costs for the consumer are listed in Table 6.

The WK has a rectangular layout (3.30 × 3.00), height 2.50 m, and has three external walls equipped with dispensers for drinking water: two for sparkling water and one for still; the fourth wall contains the access door for WK equipment check and maintenance. Water kiosk water (WKW) is supplied by the public aqueduct.The system diagram of the WK is shown in Fig. 1 (Ciuta et al., 2012).

The sampling line from the aqueduct consists of a pressure regulator, which has a pressure valve, whose function is to maintain a constant, low water pressure within the system. Aqueduct water flows through two types of filters in order to improve its quality. The activated carbon filters remove the suspended substances and chlorine, reducing the presence of any by-products (resulting from the chlorination) and other types of micro-pollutants (up to 0.5 μm); they are changed every 5 m^3 of treated water;

A battery of UV filters provide a quick, safe and economic method for disinfecting water. UV lamps are replaced whenever they stop working (max estimation, twice a year for the 3 lines).

Each water line is equipped with a flow meter in order to quantify the amount of drained water.

The outgoing still water is sent to the dispenser for the distribution of “normal water”, and the water allocated for “cold sparkling water” undergoes a process of chilling and carbonation. A pump, located within the chiller, draws the water from the tank of the ice bank and pumps it into the recirculation pipe. The continuous flow of water allows maintaining a low temperature in the line that connects the cooler to the delivery points. The unit is connected to a CO_2 cylinder (which adds a dose of 5–7 g CO_2 L^{-1} water to produce sparkling water). WK has five cylinders (30 kg CO_2 each), three installed in line 1 and two in line 2. At this point, also the carbonated water reaches the line for distribution to the delivery points, passing through a flow meter and the UV filter.

Every night, the pipes undergo a cycle of sanitization to prevent bacterial regrowth with a stabilized solution based both on hydrogen and silver peroxides (H_2O_2 and Ag_2O) and repeated washings using aqueduct water until the cleaning solution is no longer detected by the test strips. The WK is equipped with a remote control system which communicates failures, sudden problems and data useful to replace filters and gas cylinders.

2.2. Methodological approach

The methodological approach entails both a simplified environmental and economic assessment.

The comparison was made between two situations: the consumption of BW and the direct supply of water at the WK. Considering a drinking water consumption of 1.5 L d^{-1} per capita, the water supplied by the WK satisfies the demand of about 3390 inhabitants. Therefore, assuming that an average Northern-Italy family is statistically composed of 2.29 persons (ISTAT, 2011), the number of families that uses WKW is about 1480.

Before the above mentioned assessments, a short discussion about water quality of WKS and BW has been carried out comparing the same water quality parameters of both aqueduct and spring (bottled) waters, also considering respective limits established in the Italian legislation (Ministerial Decree 31/2001 and Ordinance 29/12/2003 of the Minister of health, which is the implementation of 2003/40/EC Directive regarding natural mineral waters).

The environmental assessment focuses, above all, on the CO_2 emissions into the atmosphere.

BW assessment considers both PET bottles production and BW transportation. BW CO_2 emissions from spring to market evaluation was done assuming that:

- the whole quantity of packaging for BW is PET (with an average unit weight of 30 g; EFBW, 2012);
- the corresponding quantity of BW is transported by road by the means of Euro IV lorries with a 17.3 t maximum payload (EU–JRC, 2012);
- the number of 1.5 L BW transported per route is about 10,000;
- the estimated average distance between spring and market is about 270 km; it was determined by considering the distance between the most popular Italian brands springs (or production sites) and the considered town, near to Milan (Table 1).

Annual CO_2 emissions due to BW transport from the supermarket to the final user ($E_{\mathrm{CO2\,BW}}$, in kg CO_2 y^{-1}) has been estimated considering the following formula:

$$E_{\mathrm{CO2\,BW}} = (2L_{Mh}\, f_{s\,\mathrm{BW}}\, 365)\, F_{d\,\mathrm{BW}}\, n_f\, P_{\mathrm{CO2}} \qquad (1)$$

where L_{Mh} is the average distance between the market and the final user house (in km), $f_{s\,\mathrm{BW}}$ is the BW supply frequency (in d^{-1}), $F_{d\,\mathrm{BW}}$ is a coefficient, ranging from 0 to 1, which takes into account how the route is specific for the purchase, n_f is the number of equivalent families who use WKW and P_{CO2} is the car CO_2 emissions per km.

The considerable local variability prevents also considering the impacts and the emissions due to the disposal of the bottles.

The evaluation of WKW CO_2 emissions from groundwater to WK was carried out assuming that:

- groundwater is withdrawn from 100 m below the ground level;
- pumping station efficiency is about 0.5;

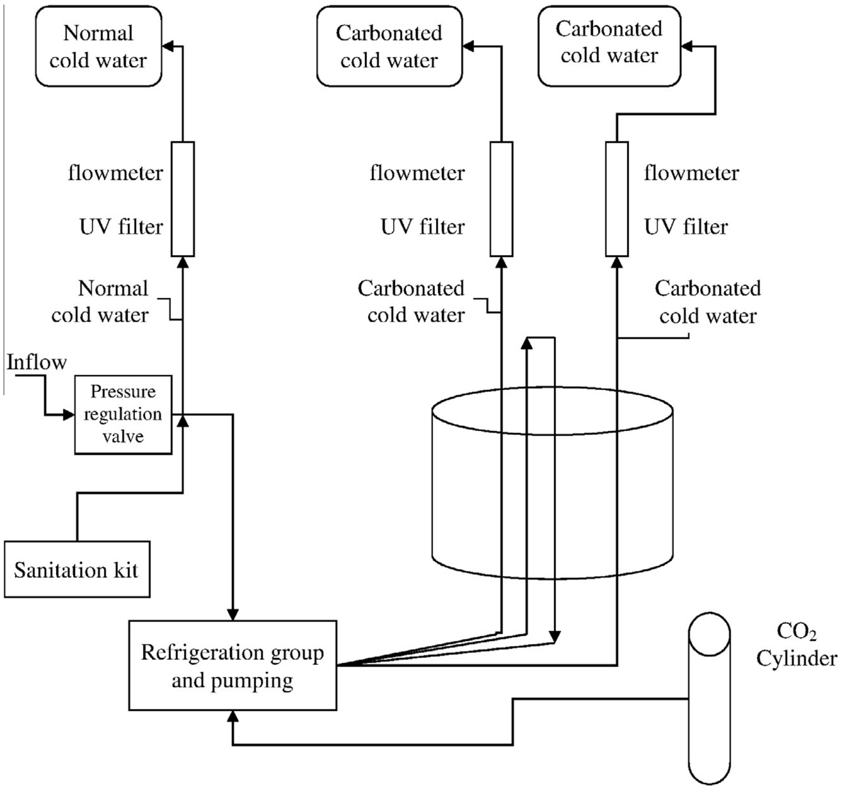

Fig. 1. Scheme of the plant.

- water supply losses are about 30% of the pumped water (CoNViRI, 2011).

Annual CO_2 emissions due to WKW transport from the WK to the final user ($E_{CO2\,WKW}$, in kg CO_2 y^{-1}) has been estimated considering the following formula:

$$E_{CO2\ WKW} = (2L_{WKh}\, f_{s\ WKW}\ 365)\ F_{d\ WKW}\ n_f\ P_{CO2} \qquad (2)$$

where L_{WKh} is the average distance between the market and the final user house (in km), $f_{s\,WKW}$ is the WKW supply frequency (in d^{-1}) and $F_{d\,WKW}$ is a coefficient, ranging from 0 to 1, which takes into account how the route is specific for the purchase. $f_{s\,WKW}$ takes into account health issues due to unknown information about disinfection status of WK users' bottles.

Estimated values, conversion factors and other data used for environmental assessment are reported in Table 2.

The economic assessment focuses on costs for the consumer and compares the:

- average cost of BW, still and carbonated, with reference to the results of a survey carried out by the author in large retailers and shopping malls in the area where the WK is located (Table 6);
- cost of WKW delivered to the consumers by the case study WK, considering the balance between the water costs and the maintenance ones.

Savings have been evaluated on consumers (single inhabitant and average family) using parameters listed in Table 2 and data listed in Table 6.

3. Results and discussion

3.1. Water quality aspects

Table 3 compares the water quality parameter limits contained in Italian law with the results of water analyses taken from three different water supply systems in Northern (Cermenate, in the Province of Como), Central (Rome) and Southern (Apulia) Italy.

Table 4 compares the parameters listed on the labels of some well-known water brands on the market with those defined Italian legislation.

Considering the physical and chemical composition, the BW quality generally can be defined as good and normally better than tap water supplied by the public aqueduct. For various and obvious reasons, the water distributed by public aqueducts achieves a good level of quality, but cannot guarantee the same quality level of spring BW (Cidu et al., 2011).

Two considerations must be made. The first is that the variability of the chemical–physical characteristics and of the overall quality of BW is very high, going from good to absolutely excellent (Temporelli and Cassinelli, 2010). The second is that the water distributed by the public aqueducts is controlled and, although the levels of quality guaranteed are lower than those of BW, the service provided is generally good and safe (Table 1) (Niccolucci et al., 2011).

3.2. Environmental aspects

Considering CO_2 emissions, Table 5 shows that an equivalent 1.5 L BW has an environmental impact about five times higher than WKW. The difference mainly stands in the emissions due to PET bottle production, which are the 56% of the total amount. Another relevant contribution is the spring-to-market BW transportation (17%), while the final step of transport (from the delivery point to house) is of the same order of magnitude for both BW and WKW; such aspect is strongly influenced by WKW frequency of supply ($f_{s\,WK}$), which is limited to 0.50 d^{-1} for sanitary reasons.

Considering the assumptions regarding the potential consumption of oil for PET bottle production, Table 5 shows a saving of 1,237,067 1.5 L plastic bottles (the most diffused bottle capacity volume), with a subsequent saving of PET, oil and waste (about 10.95 kg PET $inhab^{-1}$ y^{-1}). Another important aspect relates to the lack of any need to transport the water (with positive consequences on suburban traffic), except the aqueduct water supply, since the use of the public dispensers ensures the availability of "quasi-zero km".

From the environmental point of view, one negative aspect that certainly constitutes a great problem is the management of used filters. In terms of maintenance costs, this expense is incorporated in the single item "maintenance costs", however, it is not always clear whether there is a process of regeneration or disposal involved. It should, however, be emphasized that, irrespective of the economic costs for regenerating or disposing of the used filters, the cost to the environment may be significant.

3.3. Economic aspects

The environmental benefits are not always sufficient to convince consumers to change their habits and customs. At this point, one powerful incentive may be the potential cost savings.

Table 6 shows the annual amount of water supplied by the kiosk: 50.1% of it is carbonated.

Clearly there is a very significant economic saving for consumers: an average family who drinks still WKW can save up to 339 € y^{-1}.

Table 2
CO_2 emissions conversion factors, means of transport average fuel consumptions and estimated parameters used in the environmental assessment.

Issue	Description/symbol	Unit	Value	References
CO_2 emissions conversion factors	PET bottles production	$kgCO_2\ kg^{-1}$ PET	2.6	US-EPA (2012)
	EURO IV lorry (max payload: 17.3 t)	$kgCO_2\ kg^{-1}\ km^{-1}$	5.852E−05	EC–JRC (2012)
	Medium car (P_{CO2})	$kgCO_2\ km^{-1}$	0.200023	DECC–DEFRA (2011)
	Electric energy	$kgCO_2\ kW\ h^{-1}$	0.52114	DECC–DEFRA (2011)
Means of transport fuel consumption	Diesel EURO IV lorry (max payload: 17.3 t)	$L\ kg^{-1}\ km^{-1}$	2.474E−05	EC–JRC (2012)
	Equivalent diesel medium car	$L\ km^{-1}$	7.835E−02	DECC–DEFRA (2011)
Estimated parameters	L_{Mh}	km	3.000	Estimated by the author for a small Italian town
	L_{WKh}	km	0.500	
	$f_{s\,BW}$	d^{-1}	0.14	
	$f_{s\,WKW}$	d^{-1}	0.50	
	$F_{d\,BW}$	–	0.50	
	$F_{d\,WKW}$	–	0.50	
	n_f	Inhab $family^{-1}$	2.29	ISTAT (2011)

Table 3
Comparison between Italian legislation limits and characteristics of three tap water supplied by public aqueducts.

Parameter	Unit	Legislation limits	Cermenate aqueduct (Lura Ambiente Spa, 2012)	Rome aqueduct (Acea Spa, 2012)	Apulia aqueduct (Acquedotto Pugliese, 2012)
Escherichia coli	cfu/100 mL	0	0	0	0
Enterococcus	cfu/100 mL	0	0	0	0
Coliforms at 37 °C	cfu/100 mL	0	0	0	0
Conductivity	μS cm^{-1}	2500	445	546	–
pH	–	6.5–9.5	7.6	7.5	7.9
Temperature	°C	Not expected	12.9		14.0
Total dissolved solids at 180 °C	mg L^{-1}	1500	289	390	287
Total hardness	°F	15–50	21.5	32.0	20.0
Calcium	mgCa L^{-1}	Not expected	27.5	98.0	–
Magnesium	mgMg L^{-1}	Not expected	7.3	19.0	–
Chloride	mgCl L^{-1}	250	24.0	6.5	29.6
Sulfate	mgSO$_4$ L^{-1}	250	24.7	15.0	–
Iron	μgFe L^{-1}	200	17	5	–
Ammonia	mgNH$_4$ L^{-1}	0.50	<0.25	–	–
Nitrite	mgNO$_2$ L^{-1}	0.50	<0.06	–	–
Nitrate	mgNO$_3$ L^{-1}	50.0	25.8	3.5	4.4
Potassium	mgK L^{-1}	Not expected	1.1	3.0	–
Bicarbonates	mgHCO$_3$ L^{-1}	Not expected	169	–	–
Silice	mgSiO$_2$ L^{-1}	Not expected	8.5	–	–
Sodium	mgNa L^{-1}	200	12.8	5.5	–
Arsenic	μgAs L^{-1}	10	–	–	–

– : Not available.

Table 4
Comparison between Italian legislation limits and characteristics of still waters reported on bottle labels of four brands.

Parameter	Unit	Legislation limits	Sant'Anna	Lurisia	San Benedetto	Lilia
Escherichia coli	cfu/100 mL	0	0	0	0	0
Enterococcus	cfu/100 mL	0	0	0	0	0
Coliforms at 37 °C	cfu/100 mL	0	0	0	0	0
Conductivity	μS cm^{-1}	No limits	21.7	31.0	41.5	46.8
pH	–	No limits	6.50	6.20	7.42	6.33
Temperature	°C	No limits	7.3	–	15.4	17.8
Total dissolved solids at 180 °C	mg L^{-1}	No limits	22.3	34.8	272.0	383.0
Total hardness	°F	No limits	0.6	<1.0	–	–
Calcium	mgCa L^{-1}	No limits	1.6	–	48.6	33.9
Magnesium	mgMg L^{-1}	No limits	–	0.3	28.2	10.5
Chloride	mgCl L^{-1}	No limits	–	–	2.4	–
Sulfate	mgSO$_4$ L^{-1}	No limits	3.4	–	4.1	–
Iron	μgFe L^{-1}	No limits	–	–	–	–
Ammonia	mgNH$_4$ L^{-1}	No limits	Not detected	–	–	–
Nitrite	mgNO$_2$ L^{-1}	0.02	Not detected	–	–	–
Nitrate	mgNO$_3$ L^{-1}	45.0[a]	1.0	–	8.5	6.0
Potassium	mgK L^{-1}	No limits	–	0.84	1.00	29.10
Bicarbonates	mgHCO$_3$ L^{-1}	No limits	6.0	18.5	–	268
Silice	mgSiO$_2$ L^{-1}	No limits	10.1	12.8	15.2	–
Sodium	mgNa L^{-1}	Not expected	1.9	2.5	5.8	–
Arsenic	μgAs L^{-1}	10	–	–	–	–

– : Not available.

[a] The limit for water to childhood is 10 mg L^{-1}.

Table 5
Environmental balance: annual CO$_2$ emissions.

BW		WKW	
Item	CO$_2$ emissions (kg CO$_2$ y^{-1})	Item	CO$_2$ emissions [kg CO$_2$ y^{-1}]
PET bottle production	96,512	Water withdrawal	685
Spring-to-market transport	29,326	WK energy consumption	5811
Market-to-house transport	46,318	WK-to-house transport	27,019
Total	172,156	Total	33,516
Total (kg CO$_2$/1.5 L bottle)	0.139	Total (kg CO$_2$/1.5 L bottle)	0.027

Often, local governments that use WKs for promotional purposes, do not demand any payment from customers (or minimum fee for carbonated water, as in the case study). Moreover, it is correct to make an assessment, considering the real cost to the public administration, in order to establish the fee that may be requested from the community, for providing an economically sustainable and public service.

Table 6
Volume of water distributed at the WK, WKW vs. BW costs and economic savings based on change of habits in drinking water use.

Supplied Water type	Volume ($m^3\ y^{-1}$)	WKW cost (€ L^{-1})	Average BW cost (€ L^{-1})	Per-capita saving (€ y^{-1})	Family saving (€ y^{-1})
Still	925.200	0.00 (free)	0.27	148	339
Carbonated	930.400	0.05	0.25	110	251
Total	1855.600				

Table 7
Annual operating costs in the case study.

Operative management	Item	Quantity	Unit	Unitary cost (€ per unit)	Cost (€ y^{-1})	Incidence (%)
CO_2 cylinders	CO_2 supply	6513	kg	0.80	5210	12.2
	Cylinder change	217	–	3.20[a]	694	1.6
	CO_2 injection system rental	5	–	18.00	90	0.2
Filters	Filter replacement	372	–	67.50[b]	25,110	59.0
UV lamps	Lamps replacement	6	–	9.00	54	0.1
Electricity consumption		11,151	kW h	0.169[c]	1885	4.4
Maintenance		1	y	1200	1200	2.8
Automatic sanitizing		365	d	0.60	219	0.5
Chemical analysis		1	y	0.00	0	0.0
Depreciation installment		1	y	8100	8100	19.0
Total					42,562	100.0

[a] Including charges and ADR contribution.
[b] Including disposal and regeneration.
[c] Including fixed costs.

An annual operating cost analysis of the case study WK has been carried out.

The CO_2 cylinders, filters and UV lamps replacing costs are deduced by annual WK functioning report and from replacement frequencies (see Section 2.1). The automatic sanitizing cycle cost considers the dosed volume of reagents. WK electricity consumption costs, including fixed fees, has been made reading Electric company invoices.

The maintenance cost assessment is the most critical. In fact, all the other instruments (switchboxes, pressure pipes, electrical boards, counters, etc.) only require minimal maintenance. So, it is plausible to assume (given the lack of a precedent), that the annual maintenance cost is of the order of 15% of the cost of the devices that most require maintenance, that is the carbonation device (about €8000).

The water chemical analysis cost is not taken into account, assuming that it will be absorbed into the corresponding cost of the public aqueduct service.

The last item necessary for the economic assessment is the amortization cost relating to the construction (civil works, electric and hydraulic plants, architectural solutions, urban design, aqueduct, electrical and sewage networks connection, etc.). The cost of building was about €68,000, which was shared among the following items:

- civil works (structure and lacing to supply networks): €42,000;
- hydraulic works (including regulators, carbonation devices, general equipment, filters, etc.): €14,000;
- electrical systems (including switchgears and electric board): €4000;
- other technical items (e.g. design): €4000;
- finishing operations (including wall painting and green area): €4000.

An analysis of the return on investment must also include a loan to fund the work (the repayment of the economic resources spent) at an annual rate of 3.5%, assuming a depreciation period of 10 y both for the civil works and for the electromechanical equipment.

Table 7 shows the summary of the annual operating costs.

The items that require most attention are the costs related to the filters replacement (59% of the annual operating costs) and the carbonation system (14%). UV lamps replacement, automatic sanitizing, system maintenance and electricity consumption are less than 9% of the annual costs. The remaining 19% is due to the depreciation installment.

Therefore, considering the total amount of water supplied by the kiosk and the total annual management cost, it was obtained a specific cost of less than 0.023 € L^{-1} both for still and carbonated water.

In the case study, the costs were covered by introducing a price for the carbonated water(Table 6). This achieved annual revenues of about €46,520 (reduced to €38,700, after VAT).

Thus, considering the annual maintenance costs, other solutions for WK break even can be:

- establishing the same price for both carbonated and still water (0.03 € L^{-1});
- introduce a cost for still water which does not consider carbonation costs (0.02 € L^{-1} for the still water and 0.03 € L^{-1} for the carbonated one).

4. Conclusions

The paper describes an environmental and economic impact evaluation carried out on a WK situated in a Northern Italy town with 9000 inhabitants. WK supplies controlled still and sparkling water in general with a better organoleptic quality, thanks to further treatment (Casa dell'Acqua, 2012). Such water has lower quality than BW but improved quality characteristics respect to tap water.

After a running time of 1 year the estimation of environmental benefits are clear, particularly with respect to reducing (a) to about one fifth the estimated CO_2 emissions (mainly related to the elimination of PET bottles production and transportation), (b) the consumption of raw materials necessary for PET bottles production and transportation. Moreover, the environmental benefits include the waste reduction, even if the WKs filter disposal is a problem that should be deepened.

Another important aspect was economic, with a significant yearly reduction in the cost of the drinking water supply for consumers.

Thus, considering the annual maintenance costs, the WK can break even, with different solutions. But the determination of the break-even is not the main object of the paper.

Considering both the economic aspects (WK realization and management cost vs. PET BW cost at the selling points) and the environmental impact (WKs energy consumption vs. PET bottles production, use and disposal), the work would encourage the sustainable behavior of non-bottled water consumption. For such a reason, one of the aspects to be considered is the need to change people's habits, with a view to achieving sustainable development. To this end, the spread of WKs is a solution that should be encouraged, because, by maintaining a good level of service, they will guarantee better environmental and economic performance than the established habit of stocking up plastic water bottles.

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