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A constructed wetland system for residential greywater reuse: economic feasibility of, and willingness to pay for

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ABSTRACT

This paper evaluates the net present value (NPV) of the investment in a single-family constructed wetland system that provides water for reuse for non-potable purposes. Different scenarios were considered, using purchasing-power parity and different rates of water saving in 13 representative countries around the world. Moreover, the contingent valuation method was applied to assess the willingness of people to pay for such a system. The payback period for the constructed wetlands varies between 1 and over 20 years, depending on the scenario chosen, with about 47% of the scenarios presenting a positive NPV in 20 years. Generally, greywater treatment systems have economic viability mainly in low and medium investment scenarios, like using a handmade tank, when considering tax incentives, or when pumping costs are ignored. Considering foreseeable stress on water supply systems, governments should encourage the implementation of greywater reuse systems, seeking to improve access of the population to water and sanitation. In relation to contingent valuation, 65% of the respondents indicated a willingness to pay about US$ 630 for the greywater treatment system, but the most desirable value would be between about US$ 160 and US$ 470, indicating that people are more interested in low cost systems. No correlation was found between socioeconomic indicators and the willingness to pay for the system.

Keywords: Greywater; Net present value; Contingent valuation method; Constructed wetland; Willingness to pay; Life cycle assessment; Wastewater treatment

1. Introduction

Continued populational growth, increased urbanisation, changing food consumption patterns, and climate change are some of the key drivers that are likely to increase pressure on water resources in the future. Although populational growth and growing demand, especially in developing countries, are the most important factors, the impacts of climate change pose obvious threats to people's access to a sustainable water supply and sanitation services. About 30% of the global population currently lives with water stress, that is, in basins where >40% of the available water is withdrawn [1]. This fraction may increase up to about 50% by the end of the century [1], and thus, actions need to be taken. Additionally, data show that worldwide more than 1 in 3 people have no access to appropriate sanitation [2]. Fig. 1 shows the effort required in terms of strategies to contribute a 2% decrease in the proportion of the population living in water-stressed regions by 2050 [1]. Many regions can be expected to increase reliance on non-renewable groundwater, water reuse, and desalinated water, but they also highlight an important role for development and deployment of water conservation technologies and practices [3].

Treatment of domestic wastewater for reuse, essential in water scarcity areas, is thus gradually becoming common practice in many parts of the world [4]. But due to

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socioeconomic–environmental reasons, the reuse of water in different countries is strongly dependent on local conditions [5]. Even today, huge differences already exist in water consumption between countries. Whilst in Angola, for example, the per capita average water consumption is only 36 L cap^{-1} d^{-1}, in the USA this figure is 562 L cap^{-1} d^{-1} [6], as shown in Fig. 2.

Household water use and per capita water consumption, however, are not directly related to water availability. For instance, in Australia, the driest populated continent, the average water consumption of 497 L cap^{-1} d^{-1} is amongst the highest in the world [6]. Thus, even though water consumption differs depending on region (climate and country), it mainly depends on a number of sociodemographic factors, like residents' age, income level, family size, education level, consumption habits, and ecological awareness, as well as it depends on characteristics of the household-like size of the building and appliances fitted. Still, decreasing per capita freshwater availability does pose threats to sustainable access to water and sanitation services, and thus actions need to be taken to encourage people to use less water, as well as create an alternative water supply through water conservation, and other sustainable technologies, like greywater reuse.

Greywater is generally considered to have lower concentrations of organic compounds, and fewer pathogens

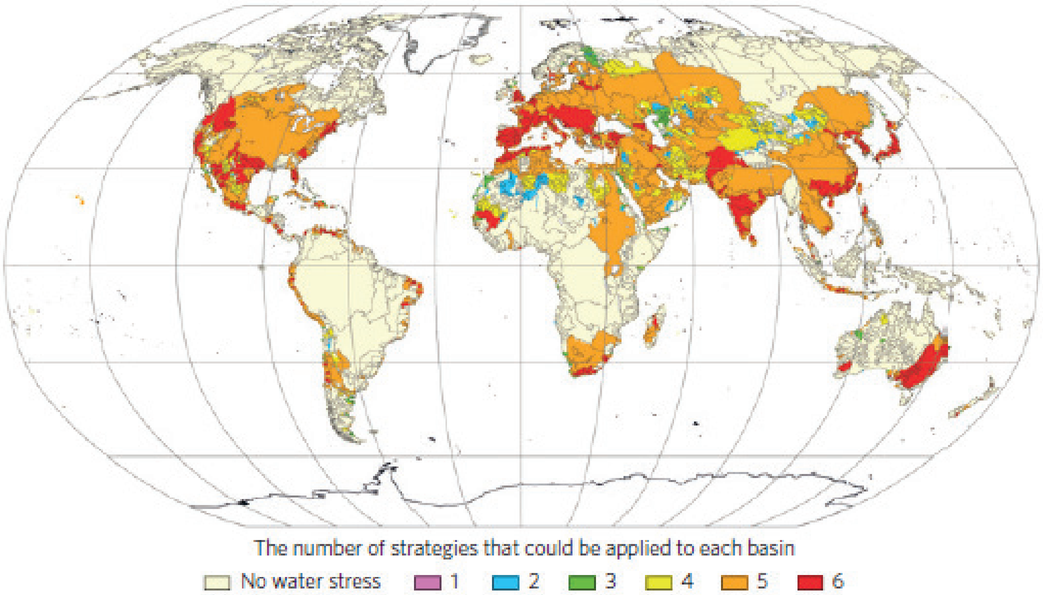

Fig. 1. Intensity of efforts in water-stressed regions by 2050. Source: [1].

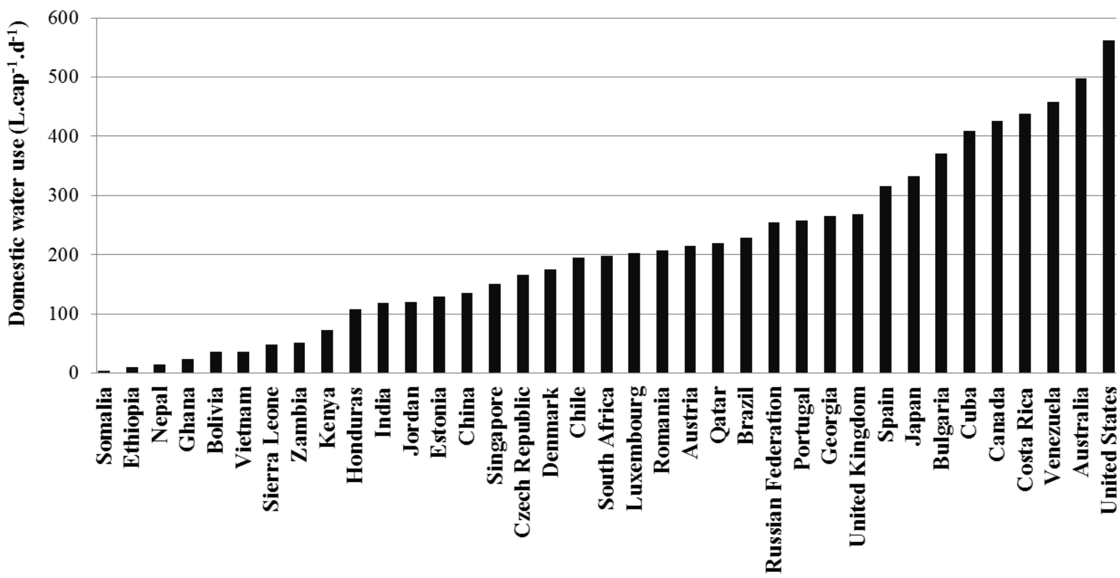

Fig. 2. Domestic water use per country. Source: [6] based on annual freshwater withdrawals.

than combined domestic wastewater [7]. According to different habits of the local population, the amount of greywater may vary between 63% and 75% of the total amount of wastewater generated in a residence [8,9]. Depending on the established water quality standards, treated greywater can be used for non-potable applications like toilet flushing, gardening, fire protection, washing, and cleaning, thus reducing the freshwater consumption in the residence [10]. It was reported that reuse of treated greywater originating only from the bathroom is already sufficient to meet the onsite reuse requirements and thereby reduce the potable water consumption by a significant amount of around 30% [9]. Additionally, the combined use of alternative water supplies, including treated greywater, together with water efficient appliances could achieve water savings up to around of 80% of total household water usage. Community receptivity for reusing greywater, however, is highest for uses such as landscaping and flushing toilets; and it progressively decreases with increasing personal contact with the greywater [11]. Adequate treatment of greywater prior to reuse is important to reduce the risks of pathogen transmission [12,13]. So, balancing the positive and negative consequences of wastewater reuse will challenge decision makers to identify practical, affordable, and safe strategies for this practice.

Long-term investments in sanitation are economically favourable because of improved public health leading to an increased productivity of society [14]. Especially in developing countries, cities must implant sanitation for all, considering sewage as a resource and not as a problem [15]. Thus, a focus is needed on ecological sanitation systems. Such systems are based on the systematic implementation of the reuse and recycling of nutrients, organic matter, and water in a hygienically safe, closed-loop: a holistic alternative to conventional solutions [16]. The constructed wetland has been considered as the most environmentally friendly and cost-effective technology for greywater treatment [10]. The efficiency of a constructed wetland for greywater treatment can reach >90% for removal of suspended solids and biological oxygen demand, and >80% for removal of chemical oxygen demand [17,18]. Additionally, depending on conditions, constructed wetlands can reach >50% of phosphorus removal efficiency [19,20]. For a long time now, constructed wetlands have proven efficient applicability around the world. For any project, specific criteria must be considered, which depending on the situation can be technical, political, social, economic, and so forth [21–26].

The discharge of wastewater, without treatment or with inadequate treatment, involves significant costs, including environmental and social ones [27]. Inadequate wastewater management pollutes water bodies that are also important sources for drinking water, fisheries, and other services. Adequate wastewater management may thus generate significant benefits that can be grouped into two general categories: market and non-market benefits. Market benefits are easily identifiable and quantifiable, but non-market benefits are difficult to measure and require specific economic valuation methods, involving knowledge of many different disciplines [27,28]. Benefits to the environment, like the environmental and health benefits as associated with improving wastewater management, often fall into the second category. Evaluations of the economic feasibility of water reuse projects will jointly evaluate the environmental questions and the availability of resources [29].

The financing of water treatment and sanitation, including the proportion contributed by households, varies widely from country to country, as does the willingness to pay (WTP) for these services. Data on household contributions are few and generally available only at national level, preventing assessment of affordability for the poorest [30]. In addition, water scarcity can significantly affect the WTP for water by the population, and WTP may thus vary from year to year, even within one country, depending on the climate. One method to determine WTP is by application of the contingent valuation (CV) method, which is not based on what people do, but on what people say they will do under certain scenarios in a hypothetical market. The CV method, applied in a survey, may thus directly indicate the maximum WTP for better water quality [27]. As a result, direct valuation methods, like the CV method, have become common practice for assessing the economic value of such projects, using surveys with respondents from a representative sample of the population affected by that project [31]. The adoption of alternative systems of water supply by households appears to be limited and depending on available income [32]. The costs of water reuse vary greatly, depending on location, water quality requirements, treatment methods, energy costs, interest rates, subsidies, and many other factors. In order to better assess the role of some of the key variables regarding the economic viability of the constructed wetlands, we compared the predicted probabilities of adoption of different scenarios as a function of the percentage of water saving, the geographical location, and variations in price and discount rates. Given this context, the purpose of this paper is to assess the economic viability of greywater segregation for treatment and reuse of water by means of a constructed wetland system, and identify the willingness of the population to pay for such a system.

2. Methods

2.1. Net present value

The economic feasibility of saving water by greywater reuse, using a single-family constructed wetland system, was analysed by calculating the net present value, considering a 20-year period (NPV20). The NPV20 was calculated for different scenarios and in 13 different countries by means of a simplified NPV calculation of the overall financial balance, according to Eq. (1), where y represents the year, i the discount rates, and C_0 the total initial investment costs. Apart from assuming 20 years of continuous operation, the net cash flow (NCF) took into account local energy and water rates:

$$\text{NPV} = \sum_{y=0}^{n} \frac{\text{NCF}_y}{(1+i)^y} - C_0 \quad (1)$$

An analysis was carried out for 13 different countries, following the methodology as suggested by Estrada et al. [33]. We considered an effective volume of a constructed wetland of 2.4 m^3 to attend the demand of three residents. Installation costs were estimated according to Gkika et al. [34], based on

USA conditions. However, variations of prices of goods in various countries can make a huge difference in a global analysis of NPV. The same product probably does not have the same price in the USA, as it has in Brazil or in Qatar. Thus, in order to estimate the cost in different countries, using the cost in the USA as a starting point, we considered the theory of purchasing-power parity (PPP). This theory is based on the notion that with a global market, in the long run currency exchange rates should move towards the rate that would equalise the prices of an identical basket of goods and services in any two countries. Eq. (2) shows the PPP in US dollars related to the local exchange rate. In this case, the PPP of the gross domestic product (GDP) of the USA is set to 100, and the parity index is calculated from World Bank data [6] using Eq. (2), where "I\$" is the conversion factor of local per capita national product relative to the US per capita national product.

$$\text{PPP} = \frac{100(\text{I\$})}{\text{Exchange rate US\$}} \tag{2}$$

In the same way, it is difficult to quantify the value of the water savings, because the economic analysis always depends on a series of case-specific parameters. The system for instance can be made in masonry, fiberglass, or other different ways, influencing the cost. When evaluating an investment, it is important to know how sensitive it is to data variations. So, due to the inherent uncertainty of the costs associated to the different conditions, a substantial flexibility of price scenarios, with 80% of variation was taken into account in order to check the robustness of our results, determining scenarios of low, medium, and high prices in each country. Table 1 shows water prices, daily water use, the estimated total cost of construction, installation and operation of the system, the actual exchange rate, and the PPP conversion factors. That cost is supposed to include all materials, sealing, filling, labour, costs of reservoirs, pump, piping, and plumbing. The detailed quantitative results are available in supplementary material. The sensitivity analysis shows that the economic feasibility of the greywater treatment system for water reuse at household level is very dependent on the initial investment made.

The investment is balanced by the reduction of consumption of drinking water from the local public utility, which tariffs are usually calculated on a volumetric basis, depending on the residential category. Depending on the quality of the greywater treated by the constructed wetland, the reuse rate can vary, so we consider reuse ranging from 10% to 50% of the total water consumption in the residence, as the possibility to reduce drinking water consumption by up to 50% by greywater reuse has been reported, depending on the type of use, including garden irrigation, toilet flushing, cleaning, and others [9]. We also assumed a cost of energy for water pumping of 0.3 kWh m^{-3}. With these assumptions, it was possible to calculate the cash flow due to the water reuse, considering 2% and 12% discount rates.

2.2. Contingent valuation method

The CV method was applied only in Brazil, as a case study to assess the willingness of people to pay (WTP) for the water reuse system, considering local conditions. This method is not based on what people do, but rather on what people say they will do in a hypothetical market. In accordance with the CV method, several data were collected in our survey, including socioeconomic characteristics of the households like income and educational level, to relate sociocultural factors of the population sampled with the WTP for a constructed wetland to treat the greywater. When designing and conducting the survey, attempts were made to minimise biases which may arise when applying a CV methodology questionnaire. In order to reduce any kind of bias, the questionnaire was designed carefully, and the purpose of the study was explained explicitly before starting the questionnaire.

The Brazilian population is currently estimated to be about 207 million. Thus, considering a 10% margin of error, 50% of the sample population proportion (no prior information about P is available), and a 95% confidence level, the required sample size was calculated according to Eq. (3), where n is the sample size, Z is the confidence level, P is the sample proportion (%), and e is the margin of error (%):

$$n = \frac{Z^2 \text{x } P \text{ x}(1-P)}{e^2} \tag{3}$$

The applied survey is shown attached and it was distributed through an Internet link. A total of 97 surveys were demanded and obtained. In order to obtain consistent results, two types of value elicitation formats were considered to assess the WTP for the greywater treatment system, starting with the open-ended format and then applying the discrete choice format.

3. Results and discussion

3.1. Net present value

Tables 2 and 3 show the year of positive NPV for 10%–50% of water saving by using constructed wetlands for discounting rates of 2% and 12%, respectively, considering different price scenarios regarding the initial investment for each of the 13 different countries. Actual payback times should be a bit shorter, as avoided costs related to the reduction of the volume of domestic wastewater sent to the municipal wastewater treatment plant were not included in the calculation.

Generally speaking, greywater treatment systems are economically viable mainly in low and medium investment scenarios. Such scenarios can be realised using a constructed (rather than a prefabricated) system or when not considering pumping costs. Pumping water costs as discounted from the water saving economy provided by the constructed wetland represent the following proportions for the selected countries: Australia 3%; Spain 4%; Canada 1%; United States 2%; Brazil 1%; South Africa 2%; Qatar 0.4%; India 2%; China 10%; Japan 1%; Singapore 10%; Bulgaria 2%; and Denmark 1%.

As a result, countries like India, China, and Singapore, with a low water cost, need many years to reach a positive NPV. On the other hand, countries like Denmark and Japan, with a high water cost, present shorter payback periods. Water pricing responsibility is mostly managed by the public sector. Low water rates, apart from encouraging the inefficient use of water, result in low revenue collections and contribute to the growing burden of government subsidies, incapacitating public administration to obtain funding for future expansion.

Table 1
Water prices, daily water use, estimated cost variation, and undervalued rate of the constructed wetland in different countries

Reference country	Domestic water use[a] (L cap^{-1} d^{-1})	Water cost[b] (US \$ m^{-3})	Energy cost[b] (US \$ kWh)	Cost of implantation (US \$)			PPP conversion factor, GDP (LCU per 1\$)[a]	Actual exchange rate (November 2016)[f]	Currency
				Low[d]	Average[c]	High[e]			
USA	562.37	0.949	0.061	500	2,500	4,500	1.00	1.000	US Dollar
Australia	497.06	1.444	0.142	562	2,809	5,057	1.49	1.326	Australian Dollar
Canada	425.58	1.785	0.062	462	2,310	4,157	1.25	1.353	Canadian Dollar
Bulgaria	370.84	1.289	0.081	192	959	1,726	0.69	1.799	Bulgarian Lev
Japan	332.10	4.428	0.193	494	2,469	4,445	105.33	106.640	Japanese Yen
Spain	315.36	1.289	0.152	364	1,821	3,277	0.67	0.920	Euro
Brazil	228.81	3.224	0.107	291	1,454	2,617	1.85	3.181	Brazilian Real
Qatar	219.48	1.271	0.017	260	1,298	2,336	1.89	3.641	Qatari Rial
South Africa	198.05	1.207	0.064	192	960	1,729	5.52	14.370	South African Rand
Denmark	174.91	7.220	0.130	548	2,739	4,931	7.50	6.845	Danish Krone
Singapore	151.10	0.386	0.126	301	1,504	2,707	0.85	1.413	Singapore Dollar
China	135.64	0.228	0.077	256	1,279	2,303	3.47	6.780	Chinese Renminbi
India	118.45	0.098	0.008	127	636	1,146	17.00	66.780	Indian Rupee

[a]Reference [6].
[b]Exchange rate of January 2012 [33].
[c]USA average cost estimated based on [34].
[d]80% less than average cost.
[e]80% more than average cost.

Table 2
Year of positive NPV of the residential constructed wetland in different countries, depending on water saving target and initial investment (i = 2%)

Water saving target	Initial investment	Australia	Spain	Canada	USA	Brazil	South Africa	Qatar	India	China	Japan	Singapore	Bulgaria	Denmark
10%	Low	8	10	7	10	4	9	10	>20	>20	4	>20	4	5
	Medium	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
	High	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
20%	Low	4	5	3	5	2	4	5	>20	>20	2	>20	2	3
	Medium	20	>20	>20	>20	11	>20	>20	>20	>20	9	>20	11	12
	High	>20	>20	>20	>20	>20	>20	>20	>20	>20	17	>20	>20	>20
30%	Low	3	3	2	4	2	3	3	>20	>20	2	>20	2	2
	Medium	13	17	11	18	7	15	17	>20	>20	6	>20	7	8
	High	>20	>20	>20	>20	13	>20	>20	>20	>20	11	>20	13	14
40%	Low	2	3	2	3	1	2	3	>20	>20	1	16	1	2
	Medium	9	13	8	13	5	11	13	>20	>20	5	>20	5	6
	High	18	>20	15	>20	10	>20	>20	>20	>20	8	>20	10	10
50%	Low	2	2	2	2	1	2	2	>20	>20	1	12	1	1
	Medium	8	10	7	10	5	9	10	>20	>20	4	>20	4	5
	High	14	19	12	20	8	16	19	>20	>20	6	>20	8	8

Lower viability ↔ Higher viability

Table 3
Year of positive NPV of the residential constructed wetland in different countries, depending on water saving target and initial investment (i = 12%)

Water saving target	Initial investment	Australia	Spain	Canada	USA	Brazil	South Africa	Qatar	India	China	Japan	Singapore	Bulgaria	Denmark
10%	Low	14	>20	10	>20	6	20	>20	>20	>20	5	>20	6	6
	Medium	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
	High	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
20%	Low	5	7	4	7	3	11	12	>20	>20	2	>20	3	3
	Medium	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
	High	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
30%	Low	3	4	3	4	2	4	4	>20	>20	2	>20	2	2
	Medium	>20	>20	>20	>20	12	>20	>20	>20	>20	9	>20	13	15
	High	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
40%	Low	2	3	2	3	2	3	3	>20	>20	1	>20	2	2
	Medium	>20	>20	17	>20	7	>20	>20	>20	>20	6	>20	8	9
	High	>20	>20	>20	>20	>20	>20	>20	>20	>20	17	>20	>20	>20
50%	Low	2	3	2	3	1	2	3	>20	>20	1	>20	1	1
	Medium	14	>20	10	>20	6	20	>20	>20	>20	5	>20	6	6
	High	>20	>20	>20	>20	14	>20	>20	>20	>20	10	>20	15	18

Lower viability ⟷ Higher viability

In addition to the inadequate pricing, the water sector is characterised by huge inefficiencies due mainly to unaccounted water losses and poor quality [35,36]. Thus, strong increases in water prices have been seen lately, especially in developing countries [35,37,38], coupled with the search to achieve tariffs covering actual costs, that automatically improve the economic feasibility of water reuse projects. These reforms should address the water scarcity and water quality degradation problems, creating incentives for water saving systems, including systems for greywater reuse, and also improve legislation and regulations to ensure public and environmental health [35]. Thus, when water reuse systems do not achieve the necessary economic feasibility, some form of subsidy from water utilities, local, state, or national governments may be required, which can be completely justified, since they generate positive externalities that improve social welfare [39]. Practical ways of subsidizing constructed wetlands can be done by the implementation of tax benefits (for instance, exemptions on the property tax) for properties where a water conservation initiative has been implemented, or by the implementation of a funding grant that covers part of the expected installation costs [40,41]. Table 4 shows the year of positive NPV of the constructed wetland with funding grants covering 30% and 50% of average installation costs, as described in reference [41].

The cost avoided by the wastewater that is not destined to the public treatment system was not considered and can substantially improve the economic viability scenarios of the constructed wetlands, depending on the tariff applied in each country.

3.2. Contingent valuation method

From the CV questionnaires a correlation was made between the socioeconomic characteristics of the respondents and the WTP for the water reuse system. Socioeconomic characteristics of the respondents are shown in Fig. 3.

As can be seen, the majority of respondents were female, with an age between 21 and 30 years, undergraduate and with an income of between 4 and 8 minimum wages. Acceptance of the population to use the proposed system may be strongly linked to socioeconomic factors and therefore knowing these is important [32].

The WTP for the greywater reuse system is shown in Fig. 4. First, respondents were asked if they would be willing to pay a fixed amount of R$ 2,000 (US$ 630, exchange rate of November 2016) for the system and later the real WTP was asked, with multiple choices based on different ranges of values.

Of all respondents, 63% responded to be willing to pay for the greywater reuse system. Regarding the real WTP, a value of between R$ 500 and R$ 1,500 (between US$ 157 and US$ 472, exchange rate of November 2016) was predominant, showing that the more desirable value is less than suggested initially and indicating that generally, people are more interested in low cost systems.

Table 4
Year of positive NPV of the constructed wetland systems, considering funding grants covering 30% and 50% of average installation costs (i = 2%)

Funding grant	30% of implantation costs			50% of implantation costs		
Water saving target	10%	30%	50%	10%	30%	50%
Australia	>20	9	5	20	6	4
Brazil	15	5	3	11	4	2
Bulgaria	16	5	3	11	4	2
Canada	>20	8	5	17	5	3
China	>20	>20	>20	>20	>20	>20
Denmark	17	5	3	12	4	3
India	>20	>20	>20	>20	>20	>20
Japan	13	4	3	9	3	2
Qatar	>20	12	7	>20	8	5
Singapore	>20	>20	>20	>20	>20	>20
South Africa	>20	10	6	>20	7	4
Spain	>20	12	7	>20	8	5
USA	>20	12	7	>20	8	5

Lower viability ↔ Higher viability

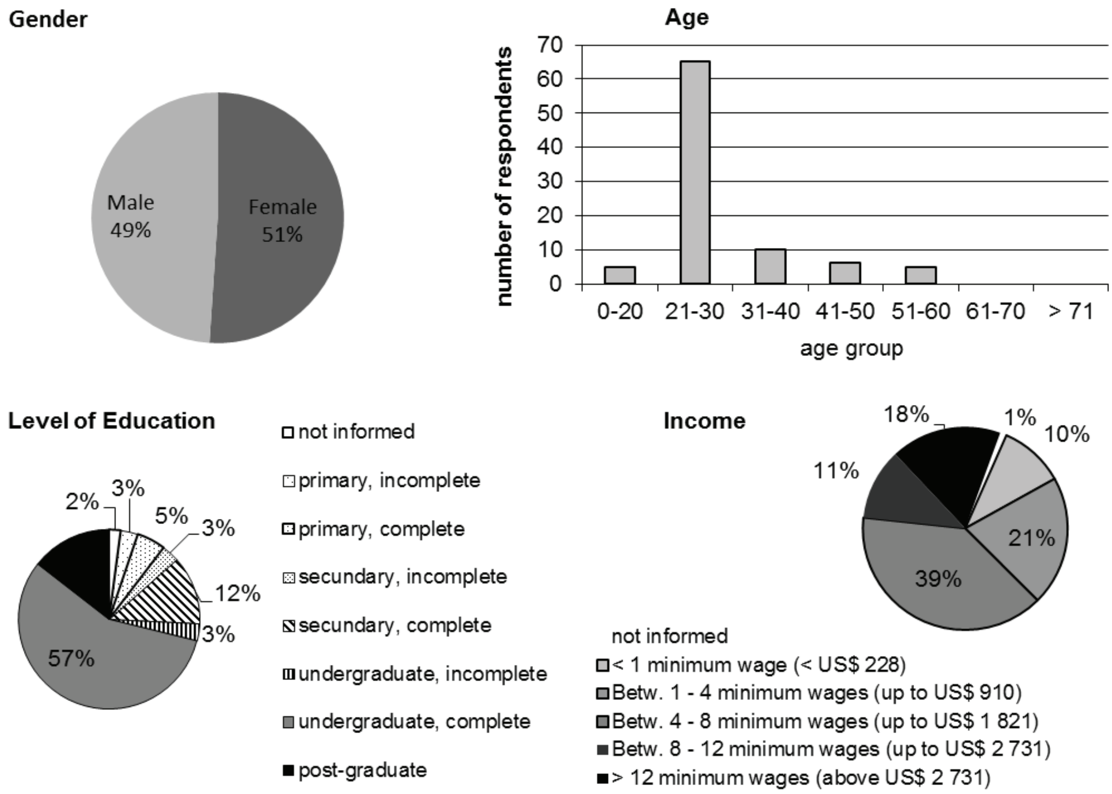

Fig. 3. Socioeconomic characteristics of respondents.

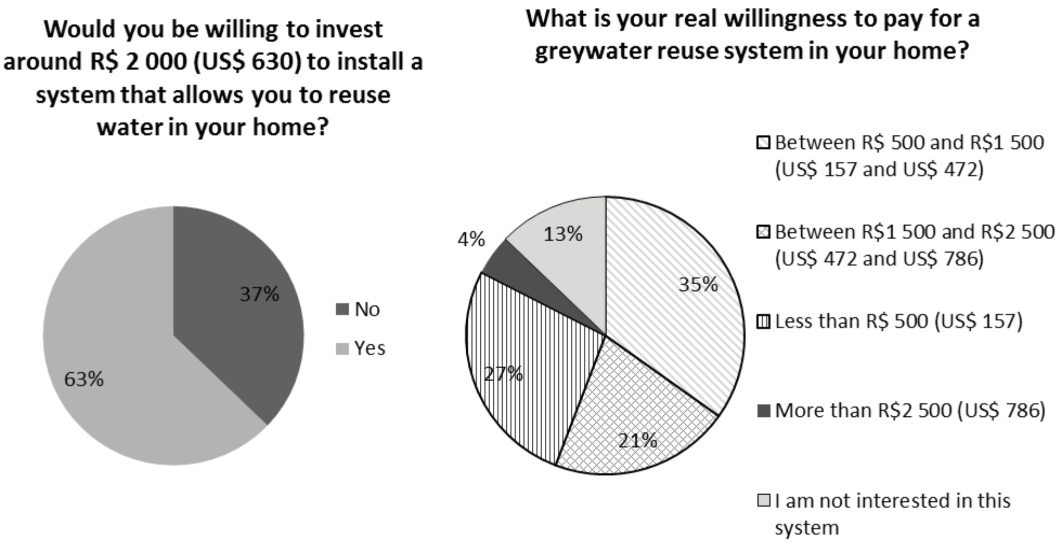

Fig. 4. Respondents' willingness to pay (WTP) for a greywater reuse system.

No strong correlation was found between socioeconomic characteristics of respondents and the WTP for the system. The most important factor correlated to the WTP for a greywater treatment system was the fact that the person interviewed had previously considered using a water reuse system. This can be interpreted as the environmental awareness regarding the importance of these systems being the predominant factor, rather than income, gender, educational level, or age. For practical reasons the surveys was conducted only in Brazil. No papers were found in literature discussing the willingness of people in other countries to pay for constructed wetlands for greywater treatment and reuse, but the WTP for reclaimed water has been assessed in Europe, USA, and Australia, showing that generally people are willing to pay for recycled water especially during drought spells [42–44].

Considering foreseeable stress on water supply systems, governments should encourage the implementation of water reuse systems, seeking to improve access of the population to water and sanitation. The costs of inertia, like for instance economic losses arising from climate change, will be greater than the cost of interventions needed for mitigation and adaptation. Additionally, increasing pollution of natural water reservoirs, demographic expansion, global warming, and failures in water governance may result in future global water price level increases. In such a scenario, future demand for greywater reuse systems will increase, favouring their economic viability and probably raising the willingness of people to pay for systems that promote the reduction of water consumption [45].

4. Conclusions

In this paper, the economic feasibility of different scenarios regarding greywater reuse was evaluated. Of these scenarios, 47% presented a positive NPV in 20 years. The payback period for a constructed wetland system varies from 1 to >20 years, for a 10%–50% reduction of potable water use, depending on country and price scenario considered.

Generally, greywater treatment systems are economically viable mainly in low and medium investment scenarios. Such scenarios include using a handmade tank or not considering pumping costs. When considering subsidies to incentive implementation of these systems, the payback time can improve substantially.

A contingency value survey shows that 63% of respondents are willing to pay up to about US$ 630 (R$ 2,000, exchange rate of November 2016) for the greywater reuse system, but the predominant price range that the respondents were willing to pay was between US$ 160 and US$ 475 (between R$ 500 and RS$ 1,500, exchange rate of November 2016), showing that the majority prefers to pay less than suggested initially and indicating that generally, people are more interested in low cost systems.

No strong correlation was found between socioeconomic characteristics of the respondents and their WTP for the system. In any way, the decision to choose one system or another for any specific situation must be based on an assessment of the environmental conditions of the site, taking into account sociocultural and economic aspects as well.

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ANNEX 1

Survey for contingent valuation

I. Respondents characteristics:

1. City: .... 2. Age: ....

3. Gender: ( ) Male, ( ) Female

4. What is your highest level of education?

( ) Without education
( ) Primary education
( ) Secondary education
( ) University (undergraduate)
( ) University (postgraduate)
( ) Other: ....

5. Profession:

( ) Independent professional
( ) Salaried worker
( ) Retired
( ) Student
( ) Other: ....

6. What is your family income?

( ) Up to 1 minimum salary (R$ 724.00)
( ) From 1 to 4 minimum salaries (up to R$ 2,896.00)
( ) From 4 to 8 minimum salaries (up to R$ 5,792.00)
( ) From 8 to 12 minimum salaries (up to R$ 8,688.00)
( ) More than 12 minimum salaries (more than R$ 8,688.00)

7. How many people live in your home?

( ) Just me
( ) Two
( ) Three
( ) Four or more

8. What is the volume of water consumed monthly in your home?

( ) Up to 10 m^3
( ) Up to 20 m^3
( ) Up to 30 m^2
( ) More than 40 m^2

9. What are benefits of constructing this system?

( ) Water economy
( ) Produce jobs
( ) Improving health
( ) Political interest
( ) Other: ....

10. Have you ever thought about reusing water in your home?

( ) Yes, ( ) No

11. Would you be willing to invest around R$ 2,000.00 to install a system that allows you to reuse water in your home?

( ) Yes, ( ) No

12. If you answered no, what is the reason?

( ) It is expensive
( ) My income does not allow me
( ) Water economy is not important
( ) I do not believe that the money will be used for a good reason
( ) These costs must be covered by taxes
( ) Other: ....

13. What is your real willingness to pay for a greywater reuse system in your home?

( ) I am not interested in this system
( ) Less than R$ 500.00
( ) Between R$ 500.00 and R$ 1,500.00
( ) Between R$ 1,500.00 and R$ 2,500.00
( ) More than R$ 2,500.00

Supplementary material

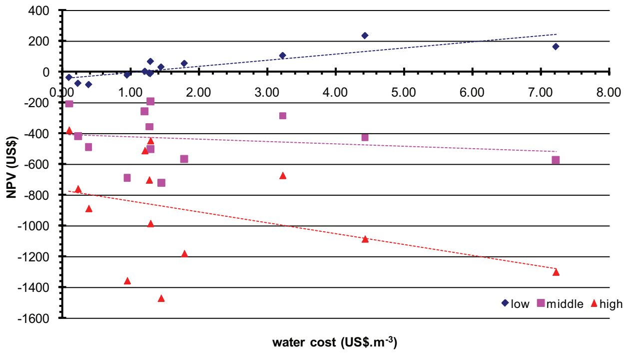

Fig. S1. Rrelation between water cost and NPV for greywater treatment.

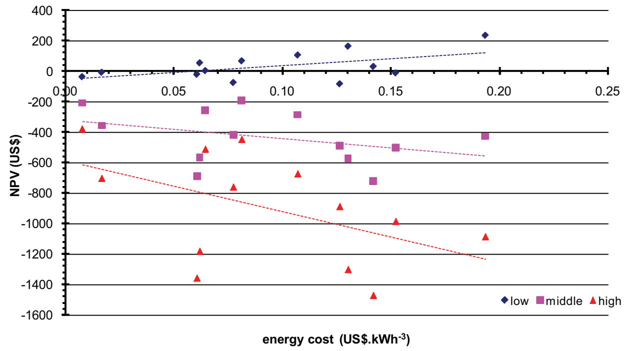

Fig. S2. Relation between energy cost and NPV for greywater treatment.