Greywater Storage, Treatment and Reuse in Residences

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Abstract. The growing scarcity of water leads to the need for adoption of practices, techniques and technologies that provide more efficiency in its use. This problem affects systemically on the demand and supply of this element and on its conservation. Of these practices, it can be highlighted the system of treatment and reuse of greywater, i.e. from wastewater of water consumption in buildings (sinks, showers, bathtubs, kitchen sinks, washing machine), which can be treated and reused for non-potable uses. This article therefore aims to estimate the consumption reduction achieved using storage equipment, treatment and reuse of greywater. The results show that the average monthly consumption of non-potable uses will reduce from 13,200 L to 8,880 L, a 32,73% decrease. Analyzing the total consumption of a regular residence, there would be a reduction from 15,600 L to 11,280 L, i.e. 27.69% less. It is concluded that the deployment of this system, therefore it can present high initial cost, is viable, since it greatly reduces the water consumption of the residence, which is a way to encourage the use of this technology, and to get financial incentives by Governments and public campaigns about this practice.

Keywords: Greywater reuse · Consumption · Treatment

1 Introduction

Water has been gradually recognized as a scarce resource on a global scale, either due to its quality-related limitations, or to its limits related to the quantity [9]. Given this fact, there is an increasing need to adopt actions aiming at the conservation of water, which can be defined as a set of practices, techniques and technologies that promote the improvement of the efficiency of its use, focusing in a systemic way on the demand and supply of this element [8].

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The Initiatives to rationalize the use and reuse of water are fundamental elements for the expansion of the efficiency of its use, resulting in an increased availability for other users, facilitating existing supplies for other purposes, attendance to population growth, support for the implementation of new industries and environment preservation and conservation [10].

Reuse is the process of using water for more than once, treated or not, for the same or other purpose. This reuse can be direct or indirect, to planned actions or not [14]. The great advantage of using reuse water is the preservation of water to meet needs that require its potability, as for the direct ingestion or preparation of food. The reuse of greywater can result in the saving of potable waters, electricity savings and lower sanitary sewage production on the scale of buildings [8]. On a larger scale, it results in preservation of water sources, by decreasing the amount of water captured and by reducing the launch of sanitary sewage in urban areas, in addition to reducing the consumption of electricity.

Among these measures, the treatment and reuse of greywater can be cited. The greywaters are defined as wastewater from the various water consumption points in a building, such as washbasins, showers, bathtubs, kitchen sinks, washing machine and tank, except the wastewaters from sanitary vessels [18]. However, some authors [5, 16] do not consider the wastewaters of kitchens as greywater, but rather as black water, due to the high concentrations of organic matter and fats present in them. The sewage wastewater from washbasins, showers, hand washing tanks and washing machines can be reused in some activities, provided that the system is designed for this purpose and prevents the reused water from being mixed with drinking water and also does not allow the use of reused water in direct consumption, food preparation and personal hygiene [11]. These waters generally present low nutrient concentrations, but they can be treated relatively easily and reused for various purposes, in addition, it is responsible for a large portion of the residential effluent, which can represent approximately 56% up to 70% of the domestic sewage volume generated in the day [6–9, 17].

As established in Brazilian Technical Regulation - NBR 5626 [1] a system of reuse of greywaters requires a building network of distribution of distinct non-potable water, avoiding cross-connections, and atmospheric separation devices, for sanitary protection of the potable water network during the concessionaire's water supply process in the non-potable water building system. The greywaters can be directed to a small station or treatment equipment in order to be reused in activities that do not require the use of drinking water or more restricted quality, such as irrigation of gardens, sanitary discharges and floor washing [3].

In order to combine the reuse and proper disposal of the treated greywater in the environment, there is a need to promote the treatment of this effluent. Several types of treatment for greywaters have been proposed by many authors, and the choice of the system to be used depends on the characteristics of the effluent, the purpose of treatment and the availability financial and available area [14, 17]. Applied technologies include physical, chemical and biological systems, with the combination of biological processes with physical filtration followed by disinfection, as one of the most economical and viable solutions [12].

In view of the above, this article aims to estimate the reduction of water consumption in a popular residence, achieved with the reuse of greywaters from the shower, washbasin and tank, in sanitary basins and taps for general use (washing).

The main contribution of this work refers to the adopted procedure that seeks simplification and better possibilities for the domestic use of the technique employed, making the practice accessible to society and, consequently, easily disseminated, contributing to the reduction of water pollution resulting from domestic sewage.

2 Material and Methods

2.1 Area of Study

To accomplish this work we adopted a single-family residence performed in social programs, which is characterized as a Habitation of Social Interest (HIS), with: living room, two bedrooms, bathroom and kitchen, totaling an area of 41, 87 m^2. Habitation of Social Interest (HIS), has the concept of housing focused on the low-income population [13]. Public policies in the area of social interest housing focus their guidelines on combating the quantitative housing deficit, a situation that affects 90% of Brazilian families with monthly income between 0 and 3 minimum wages [2]. We will adopt the occupancy rate of 2 people per room [4], which results in an estimated population of 4 people.

2.2 Characterization of the Greywaters

The quality of the greywater will depend on the various domestic activities performed, and the components present vary from residence to residence, where the lifestyle, customs, facilities and the quantity of chemical products used will influence. For such as turbidity, for example, the concentration range reported in the literature is wide, ranging from 37 to 328 Nephelometric Turbidity Unit (NTU) [19]. In terms of carbonaceous organic matter, indirectly expressed as COD and BOD5, there is a range of concentration values ranging from 352 to 673 mg/L and 96 to 324 mg/L [7, 19]. Other factors that may contribute to the characteristics of greywater are the quality of water supply and the type of distribution network of both the supply water and the reuse water.

2.3 Distribution of Potables and Non-potable Uses

To perform the simulation proposed in this work, we adopted the distribution of potable and non-potable uses in a popular standard residence as in Table 1.

Table 1. Distribution of potable and non-potable uses in popular pattern residency

Point of use	Daily consumption (L/inhabitant, day)	Consumption drinking (%)	Consumption no drinking (%)
Toilet	36.0	0.00	27.69
Shower	60.0	0.00	46.15
Washbasin	9.0	0.00	6.92
Sink	20.0	15.38	0.00
Tank	3.0	0.00	2.31
Watering of the garden	2.0	0.00	1.54

Source: [6, p. 545]

2.4 System of Greywater Storage and Treatment

The configuration of a system of use of greywater must consist of a system of water collection, a conduction subsystem (extensions, drop pipes and collectors), a water treatment unit and an accumulation reservoir [16]. Currently there are in the market, compact systems of treatment and storage of the greywaters, that provide its use and reduce the water consumption of the buildings.

To accomplish this work, the Kit Water Reuse, by Tecnotri® (see Fig. 1). The Kit Of 1000 L has four treatment filters: anti-leaves filter, decanter, slim filter and chlorinator filter, assisting in the non-contamination of the reused water by bacteria and insects. The kits have capacities that vary from 150 L to 1000 L and can be purchased at prices ranging from R$658,00 (150€) to R$2.858,00 (650€) on average [21]. Other costs the system will have refer to a centrifugal pump with ½ CV which costs on average R$150.00 (34€); An upper reservoir of 500 L, which costs on average R $166.78 (38€), but this volume may be different for each situation and the costs with the pipelines, which will be relative, depending on the distances between sanitary appliances, filtration/chlorination system and the upper reservoir. We will also have the labor costs for installation of the system and all its components, which, too, depend on each case. The 200 g chlorine inserts cost on average R$6.00 (1.30€) and lasts 10 to 15 days. Considering that every three days, we will pump the water to the upper reservoir we will have a monthly average cost of R$25.00 (5.60€) with energy consumption.

The system was designed for rainwater harvesting, treatment and storage. In this work we are simulating an adaptation in its location (semi-buried or buried) which allows the collection of greywaters from the shower, washbasin and tank, to the cistern, where it will pass through the chlorinator filter.

The greywater treatment systems are designed to have the least amount of intervention, generally only disinfection is that it requires verification, especially when it comes to the chemical process; except for filters requiring periodic cleaning. It is recommended a weekly or monthly cleaning. The cisterns and reservoirs must be inspected every six months and washed at least once a year [20].

In this work will be simulated the collection of the water from the shower, washbasin and tank to the cistern. After treatment, the water is pumped into a superior reservoir, exclusive to reuse water, which feeds the non-potable consumption points

Fig. 1. Cistern modular 1000 L Tecnotri® with filter. Water reuse kit with chlorinator. (Source: https://cisternas.tecnotri.com.br/)

served by this treated water. In this work the sanitary basin and a general-purpose faucet, according to the flowchart presented in the Fig. 2.

Fig. 2. Flowchart of the greywater treatment and reuse system. (Source: the authors, 2017)

2.5 Operation of the Filtration System

The system characterizes by presenting a triple filtration plus the dosage of chlorine. The water initially passes through the leaf filter (J4) and goes to the Decanter (J1), which serves to eliminate the first few minutes of rainwater, which is being slowly discarded by the flea. As the decanter is full, the water reaches the level of the inlet of the reservoir and passes through the slim filter (J2), which has the function of retaining the material that was not eliminated by the decanter. After the slim filter, the water then passes through the chlorinator, which has a chlorine tablet (J3) of the same type used in pools, as the objective of keeping the reuse water conserved, avoiding the formation of microorganisms [21]. Figure 3 illustrates the steps in this process.

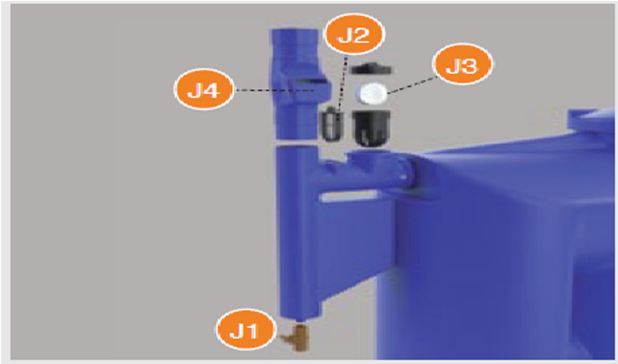

Fig. 3. Smart filter Tecnotri® (Source: https://cisternas.tecnotri.com.br/produto/smart-filtro-8-litros-tecnotri/)

According to the manufacturer, the stored reuse water can be used for various household functions. Cleaning of the house, sidewalks, garage and cars and even sanitary discharge are possible uses for this water [21]. It is worth noting that if the system is to be installed for larger residences or multifamily buildings, it can be idealized by placing several systems in series, reaching the desired storage volume, due to the non-potable consumption estimated for each case.

3 Rand Discussion

Considering the consumption indicated by the Table 1, Sect. 2.2, for a residence with four people, simulations were performed to estimate the average monthly consumption without and with the use of the treatment equipment, of which the results are exhibited in the Fig. 4.

As shown in Fig. 4, a monthly average consumption was obtained without the reuse system of 15,600 L; 13,200 L considered to be non-drinkable and 2,400 L of drinking use. The estimated monthly average volume of greywater generated by the shower, washbasin and tank is 8640 L. The estimated monthly average volume consumed by the sanitary basin is 4320 L, i.e. 50% of the volume of greywater collected. The total monthly average consumption drops to 11280 L, since the non-potable uses have reduced to 8880 L. Thus, we will have an attendance of 100% of the consumption of the sanitary basin, and still, we will have a monthly surplus of 4320 L for other uses, such as those indicated by the manufacturer, such as floor cleaning, sidewalks, garage and cars.

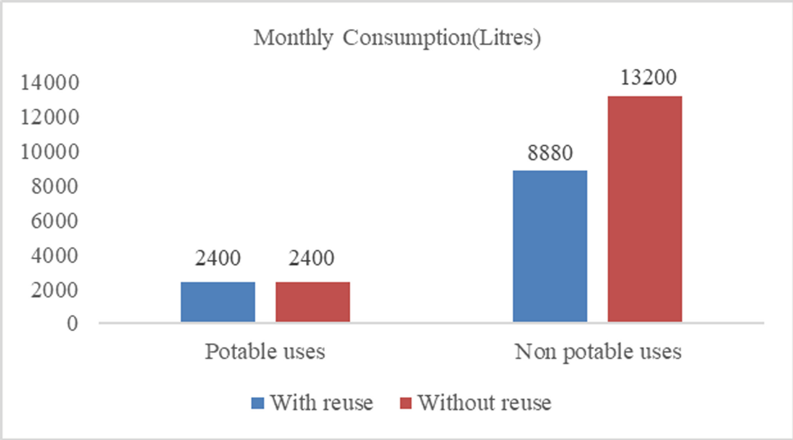

Fig. 4. Simulation of monthly consumption with and without reuse system (Source: Study results)

Considering only the uses indicated in Table 1, as well as the use of greywater only for sanitary discharges, we will have an average estimate of reduction of the monthly consumption of the residence in the order of 27.69%. It is worth pointing out that in practice this reduction will be greater, considering that there is a surplus of 4320 L for other uses.

4 Conclusion

It was possible to perceive through the results of the study that the use of this system can bring several advantages for the population, especially the low income and the residents in urban conglomerates, where water scarcity is a constant threat. However, the little diffusion of this practice, the low knowledge of the system by the population and the initial cost of its implantation, are still limiting agents of its use.

One way to circumvent the problem of high initial cost would be a governmental incentive to implement reuse systems in homes, or the construction of popular housing (by the federal, state or municipal governments) already with a system of treatment and reuse of grey water.

About the issue of the initial cost, a possibility would be through governmental subsidies, financing the implantation of the system in the residences as a way of encouraging the population and giving viability to its use.

To ensure the widespread knowledge and awareness of the population for the use of the system, a viable solution would be the presentation of pilot projects with confirmed results and the realization of public campaigns to encourage the practice.

With the results obtained, it can be noted that the implantation of storage systems and treatment of greywater is viable, since it considerably reduces the water consumption of the residence.

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References

1. ABNT: Associação Brasileira de Normas Técnicas. NBR 5626/1998: instalação predial de água fria. Rio de Janeiro (1998)
2. Alice, C.F.: Method of evaluation of rainwater utilization systems in housing of Social interest (Método de Avaliação de Sistemas de Aproveitamento de Água Pluvial em Habitações de Interesse Social). 151 f. Dissertation (Master's Degree)-Production Engineering Course, Technological Center, Federal University of Santa Catarina, Florianópolis, BR (2014)
3. Bazarella, B.B.: Characterization and utilization of grey water for non-potable use in buildings (Caracterização e aproveitamento de água cinza para uso não potável em edificações.). Dissertation (Master's Degree) - Postgraduate Degree in Environmental Engineering - Federal University of Espirito Santo, Vitória, BR (2005)
4. Carvalho Júnior, R.: Hydraulic Installations and Architectural Design (Instalações hidráulicas e o projeto de arquitetura), 5th edn. Blucher, São Paulo (2012)
5. Christova-Boal, D., Eden, R.E., Macfarlane, S.: An investigation into greywater reuse for urban residential properties. Desalination **106**(1–3), 391–397 (1996)
6. Dias, I.C.S., Athayde Junior, G.B., Gadelha, C.L.M.: Use of rainwater for non-potable purposes in the city of João Pessoa-PB (Análises da viabilidade econômica de sistemas de aproveitamento de águas pluviais para fins não-potáveis em residências na cidade de João Pessoa – PB). Revista Engenharia Civil **34**, 39–50 (2009). Guimarães
7. Fiori, S., Fernandes, V.M.C., Pizzo, H.: Qualitative and quantitative evaluation of the reuse of ash water in buildings (Avaliação qualitativa e quantitativa do reúso de águas cinzas em edificações). Ambiente Construído **6**(1), 19–30 (2006)
8. Gonçalves, R.F., Alves, W.C., Zanella, L.: Water conservation in the urban environment. In: Gonçalves, R.F. (ed.) Rational use of water in buildings. Cap, vol. 2, pp. 29–73, ABES, Victory, Brazil (2006)
9. Hernández Leal, L., Zeeman, G., Temmink, H., Buisman, C.: Characterization and biological treatment of greywater. Water Sci. Technol.: J. Int. Assoc. Water Pollut. Res. **56**(5), 193–200 (2007)
10. Hespanhol, I., Gonçalves, O.M.: Conservation and reuse of water (Conservação e reúso de água). In: Handbook of Guidelines for the Industrial Sector, vol. 1. Federation and center of Industries of the state of São Paulo, Fiesp/Ciesp, São Paulo, BR (2005)
11. Kemper, K.E.: The cost of free water: water resources allocation and use in the Curu Valley, Northeast Brazil. Linköping Studies in Arts and Science, Linköping (1996)
12. Li, F., Wichmann, K., Otterpohl, R.: Review of the technological approaches for grey water treatment and reuses. Sci. Total Environ. **407**(11), 3439–3449 (2009)
13. Librelotto, L.I., Ferroli, P.C.M., Mutti, C.N., Arrigone, G.M.: The Theory of Equilibrium: Alternatives to Sustainability in Civil Construction (A Teoria do Equilíbrio: alternativas para a sustentabilidade na construção civil). DIOESC, Florianópolis (2012)
14. Lobato, M.B., Santos, D.C., Volpi, N.M.P., Borges, L.Z.: Establishing a hierarchy of water conservation actions in residential buildings using multicriteria analysis (Hierarquização de medidas de conservação de água em edificações residenciais com o auxílio da análise multicritério). Ambiente Construído **6**(1), 31–47 (2006)

15. Monteiro, V.R.C., Sezerino, P.H., Philippi, L.S.: Characterization and treatment of residential greywater applying the ecothecnology of constructed wetlands (Caracterização e tratamento de água cinza residencial empregando a ecotecnologia dos wetlands construídos). Engenharia Ambiental **12**(2), 93–109 (2015)
16. Nolde, E.: Greywater reuse systems for toilet flushing in multistory buildings-over ten years' experience in Berlin. Urban Water **1**, 275–284 (1999)
17. Oliveira, L.H., Campos, C.C., See, E.Q., Parkinson, J.: Technologies for optimizing the use of water at home. In: 4th Research Notebook in Public Health Engineering, 4nd edn. Funasa, Brasilia (2010)
18. Ottoson, J., Strenström, T.A.: Feacal contamination of greywater and associated microbial risk. Water Res. **37**(3), 645–655 (2003)
19. Rebêlo, M.M.P.S.: Characterization of grey and black waters of residential origin and analysis of the efficiency of aerobic reactor with Chicanas (Caracterização de águas cinzas e negras de origem residencial e análise da eficiência de reator aeróbio com chicanas). 115 f. Dissertation (Master's degree) – Master's Course in Water Resources, Coordination of the Postgraduate Program in Water Resources and Sanitation, Federal University of Alagoas, Maceió, BR (2011)
20. Sant'ana, D.R. (org.): Technical and operational feasibility of rainwater harvesting and the reuse of ash water in non-residential buildings in the Federal district (Viabilidade técnica e operacional do aproveitamento de águas pluviais e do reúso de águas cinzas em edificações não-residenciais do Distrito Federal). University of Brasilia, Brasilia (2017)
21. Tecnotri (Brazil). Kit Reuse water with chlorinator (2017). http://www.tecnotri.com.br. Accessed 07 Sept 2019