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Rational Water Use: A Case Study of Gray Water in Brazil

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Abstract

The purpose of this study is to show that, given the global water crisis, it is possible to find alternatives to reuse gray water. A gray water source may be an alternative for use in irrigation in grain crops, among other applications. This feasibility analysis was carried out for two years. The solution promotes the efficient use of water in an existing vertical building, based on the physical and social aspects of the building, adopting the rational use of water, and considering the reuse of laundry gray water for garden irrigation and cleaning of the common area. This model was used for a full-scale building, medium to high standard, vertical, condominium regime. The study found that the implementation of the measures studied may generate volume savings equivalent to the consumption of 30 families annually. To increase sustainability on a global scale it is essential to implement new water reuse projects, and to promote wise water management in buildings.

Keywords: Sustainability of water resources; Water demand management; Rational water use; Water reuse in Brazil

Introduction

Rational use of water is required both in the management of large river basins and in the management of small water supply systems.

Urban growth in their expansion areas requires minimal infrastructure services in four areas of sanitation (water supply, sanitation, drainage, and solid waste); however, the slowness in the implementation of sanitation systems is deteriorating waterways closer to the cities. This fact could lead to scarcity of water resources and increased treatment costs.

Based on the premise that it becomes necessary for society and the government to promote actions aimed at rational use of water, this work illustrates and motivates the adoption of rational water use and encourages policies that generate benefits to society.

The implementation of a proposed PCA Water Conservation Program aims to reuse gray water and motivate the implementation of both reuse and efficiency projects from an economic point of view.

The rational use of water generates less cost to the user, thus reducing the generation of waste and environmental damage. Therefore, regions that efficiently use water are able to provide a better quality of life to the local society.

Vertical buildings have unique characteristics that are scarcely explored, yet enable the efficient use of on a global scale water. The great supply and demand of water along with large areas to capture rainwater favor the implementation of a reuse system.

"The residential water use includes both internal uses as external use to homes. Cleaning and hygiene activities are primarily responsible for internal use, while the external is due to the irrigation of gardens, washing outdoor areas, swimming pools and car washing, among others. Studies in Brazil and abroad show that inside a residence the highest consumption of water is concentrated in the discharge of toilets, washing clothes and bathing. On average, 40% of all water consumed in a residence is intended for non-potable uses" [1].

To conserve water is to exercise the rational use of the resource, and to analyze the systemic effect of supply and demand. Increasing the use efficiency directly impacts the economy and the extent of use in the supply network. This in turn eases existing water supplies for other purposes, whether in urbanization, industrialization, or even the preservation and conservation of water resources.

The water reuse technique carries in its essence this new paradigm of being cost-effective and environmentally conscious. In its various forms, reuse is revealed to be a safe and reliable technique, requiring small investments that encourage an increasingly affordable practice.

This research evaluated, as an alternative, the reuse of laundry gray water for use in patio cleaning and irrigation of green areas in a vertical building in Cuiabá - Mato Grosso, Brazil.

Specific goals were worked to characterize the structure of the building and the resident population; collect water consumption data; trace the water consumption profile; determine the demand and availability of water reuse based on preliminary information; check deployment and maintenance costs of the system; and choose the best intervention that:

Reduces the amount of water extracted from the source,

Reduces costs of drinking water supply,

Reduces water waste,

Reduces consumption and water losses,

Increases the efficiency of water use,

Recycles and reuses water.

Residential buildings have a constant scarcity of water, and thus provide a unique opportunity for study.

The purpose of this study is to show that it is possible to find alternatives to reuse gray water and address the global water crisis.

Literature Review

Countries like Africa and Asia are particularly vulnerable to the scarcity and quality of water (http://www.unep.org/dewa/vitalwater/article192.html).

In 2008, an update of the 'Vital Water Graphics' aimed at giving an overview of the state of water resources in the world, and providing answers to important questions. It was observed that in Africa, less than 65% of the population had access to an improved water source. Asian residents ranked second to last with only 83% of the population having access.

Over the past decades, the Arabian Gulf region has witnessed a great economic development and social transformation. This region is facing one of the largest water insufficiency problems in the world. The level of available, renewable water in the region is one fifth of what the rest of the world enjoys on a per capita basis.

In a sustainable world–one that is achievable in the near future – water and related resources are managed in support of human well-being and ecosystem integrity in addition to a robust economy. Sufficient and safe water is made available to meet everyone's basic needs, with healthy lifestyles and behaviors easily upheld through reliable and affordable water supply and sanitation services. These benefits are in turn supported by equitably extended and efficiently managed infrastructure. Water resource management, infrastructure, and service delivery are sustainably financed. Water is duly valued in all its forms, with wastewater treated as a resource that avails energy, nutrients, and viable water for reuse. Human settlements develop in harmony with the natural water cycle and the ecosystems that support it, with measures in place that reduce vulnerability and improve resilience to water-related disasters. Integrated approaches to water resource development and management support human rights as the norm. Water is governed in a participatory way that draws on the full potential of women and men as professionals and citizens, guided by a number of able and knowledgeable organizations, within a just and transparent institutional framework.

Brazil: In May 2007, the global urban population finally exceeded its rural counterpart [2]. In Brazil, the urban population had already exceeded the rural population in 1960. Indeed, 84% and 16% of the population lives in urban and rural areas, respectively [3].

This process of concentration of the urban population has led to decreased levels of specific water availability (m^3 per year per inhabitant) of metropolitan areas, which is of concern to governments and societies alike.

Residential buildings account for 20% of humans' consumption of water [4], second only to the demand of the irrigation sector. In the metropolitan regions of Brazil, water consumption corresponds to: 84.4% residential sector, 2% industrial, 11% commercial, and 3% public sector.

The Brazilian territory is considered the fifth largest area in the world. It covers an area of 8,547,403 square kilometers, occupying 20.8% of the territory of the Americas and 47.7% of the land in South America [5]. Brazil is covered by fresh water (55.457 km^2) in the interior, and accounts for 1.66% of the planet's surface water. The humid climate of the country provides a large hydrographic network of rivers, a large volume of water that flows into the sea.

Despite the abundance of water resources, there is a big problem of resource distribution, coupled with the large concentration of people in urban centers, which generates water stress zones, and contamination issues.

It is interesting to note that the vision of Brazil as a country with abundant water resources has generated harmful effects such as: inappropriate use of water resources, waste, lack of understanding throughout society that water is an economic good and should be preserved, and the failure to establish water supply policies. Over the past decade, this vision was reviewed, and rational use of stocks and management offerings began to be discussed by society.

"The possibilities and potential forms of reuse depend, of course, features, conditions and local factors such as political will, institutional arrangements, technical availability and economic, social and cultural rights" [6]. According to Hespanhol, factors related to the process of reuse that may be adopted – deployment costs, maintenance, operation, treatment, water quality, and safety parameters – will depend on, and are closely linked to, the fate of the reused water.

Characterization: Reuse of water is a process whereby the treated or untreated water is reused for the same purpose or other purposes (Farmer Son 1987). This reuse can be direct or indirect, arising from planned and unplanned actions.

Reuse of gray water: In a home, gray water may be reused as follows: wastewater from sinks, showers, dishwashers, laundry, and the kitchen is directed to undergo appropriate treatment and a redistribution to discharge. This discharge is then used to for watering gardens, washing floors, and many other activities that do not require potable water.

Due to the poor knowledge about water requirement to agricultural uses, irrigation efficiency is low or crops are exposed to water stress in many villages. Thus, Hydro-Module determination gives many advantages to experts and farmers [7].

Agricultural issues around the world: Vanaei Village is located at Eslam Abad Gharb in Iran (query from local farmers and using NETWAT software). By using CROPWAT software, a Hydro-Module was determined for the village. Finally, results were compared with AGWAT software. The amount of calculated Hydro-Module using CROPWAT software and AGWAT software were 0.78 and 0.73 liter per second in each hectare, respectively. Among the cultivated crops in the villages, sugar beets have the greatest net irrigation requirement. Therefore, given the limited water resources, it should be further considered. Because there is sugar factory in the Eslam Abad Gharb city, there is no likely chance of reducing sugar beet production, or changing the cropping pattern. Therefore, it is essential to use the correct administrative procedures in the village for avoid water loss and increase crop yield.

Assessment of Important Factors for Water Resources Management in European Agriculture: According to [8], water is a key natural resource targeted within resource efficiency policy of both the European Union and the world. The aforementioned study, focused on research, technologies, and options for sustainable water use and water efficiency; agricultural land management with soil and water benefits;

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and measures within the Common Agricultural Policy (CAP) to address sustainable management of water and soil resources.

Poláková [8] reviewed the results of more than one hundred articles, published in scientific journals, with respect to simulation of surface irrigation. The results showed that 53.4% of the simulations belong to furrow systems. Border systems and basin irrigation account for 35.9% and 10.7% of simulations, respectively. However, satisfactory simulations were 70.3%, 63.6%, and 54.5% for border, basin, and furrow systems; respectively. The priority of irrigation methods to simulate using hydrodynamic (HD) and other models is: border, basin, and furrow irrigation. The priority is border, furrow, and basin for kinematic wave (KW) and volume balance (VB) models. Finally, the priority is basin, border, and furrow for zero inertia (ZI) models. Meanwhile, the models estimated advance and infiltration phases better than recession and runoff phases during an irrigation event [9].

In 2009, [10] showed that Latin American countries present great potential for expanding their irrigated areas. Irrigation is important for strengthening local and regional economies, and for enhancing food security. The paper provided a brief review on key aspects of irrigation management in Latin America. Poor irrigation management can have great impact on crop production and on the environment, while good management reduces the waste of soil and water and helps farmers maximizing their profits.

Oliveira [10] also noted that additional research is needed to allow better understanding of crop water requirements under Latin American conditions, as well as to provide farmers with locally-derived information for irrigation scheduling. The advantages of deficit irrigation practices and the present and future opportunities with the application of remote sensing tools for water management were also considered.

Due to the importance of irrigated agriculture, collaborative work among Latin American researchers and institutions is paramount to face the challenges imposed by a growing population, environmental degradation, and competition in the global market.

Table 1 summarizes studies by Valipour that address agricultural water management in the world.

Author / year	**Studied area**	**Indexes selected**	**Analyses**	**Results and conclusions**
Valipour M 2014 [11]	In the world. This study goals to investigate the variations of irrigated agriculture indicators in Asia Oceania, Europe, and Americas from 1962 to 2011	In 2011, the most value of area equipped for irrigation belongs to Asia-Oceania (about 30%).	Studying variations of irrigated agriculture indicators gives an opportunity to stakeholders for better investment and reduction of risk and uncertainty However, the most variation of pressurized irrigation belongs to Americas (from 7.8% to 54.1%) during 1977-2011.	In addition, the maximum variation of agricultural conservation belongs also to Americas (from 0.6% to 29.9%) during the same period.
Valipour, M 2014 (a) [12]	Agricultural water management in Americas between 1962 and 2011	These indexes are permanent crops to cultivated area (%), rural population to total population (%), total economically active population in agriculture to total economically active population (%), human development index (HDI), national rainfall index (NRI) (mm/yr), value added to gross domestic product (GDP) by agriculture (%), irrigation water requirement (mm/yr), percent of total cultivated area drained (%), difference between NIR and irrigation water requirement (mm/yr), and area equipped for irrigation to cultivated area (%).	All 36 countries in the study area and amount of area equipped for irrigation to cultivated area (10th index) was estimated by two different formulas and using the other 9 indexes	The results showed relative error is less than 20%. In addition, an average index was calculated using two various methods for assessment of countries conditions for agricultural water management. Ability of irrigation and drainage systems was studied using other 8 indexes with more limited information. These indexes are surface irrigation (%), sprinkler irrigation (%), localized irrigation (%), spate irrigation (%), agricultural water withdrawal (10 km3 /yr), conservation agriculture area as percent of cultivated area (%), percent of area equipped for irrigation salinized (%), and area waterlogged by irrigation (%). Finally, tendency of farmers to use of irrigation systems for cultivated crops has been presented.
Valipour, M 2014 (b) [13]	The study aimed at estimation of area equipped for irrigation in Americas in 2035 and 2060 using study of agricultural water management during 1962 to 2011	These indexes are; permanent crops per cultivated area (%), rural population per total population (%), total economically active population in agriculture per total economically	Among all presented data in FAO database, 10 indexes were selected for importance and more availability basis for all the regions in Americas and analyzed for all 5 regions in the study area.	The results the study showed that trend of permanent crops per cultivated area (with the exception of Northern America), HDI, irrigation water requirement and percentage of total cultivated area drained is increasing and trend of rural population per total population, total economically active population in agriculture per total economically active population, value added to GDP by agriculture, and difference between NRI and irrigation

		active population (%), human development index (HDI), national rainfall index (NRI) (mm/year), value added to gross domestic product (GDP) by agriculture (%), irrigation water requirement (mm/year), percent of total cultivated area drained, difference between NRI and irrigation water requirement (mm/year), and area equipped for irrigation per cultivated area (%).	The amount of area equipped for irrigation per cultivated area (10th index) was estimated for three different scenarios by the other 9 indexes.	water requirement is decreasing. The results also showed changes of area equipped for irrigation as 9.1 to 26.3% and 17.6 to 51.3% in 2035 and 2060, respectively.
Valipour M 2014 (c) [14]	Describe hundred essential problems related to water engineering with a small volume. In this condition, role of water science researchers is more important than ever.	The author recommends studying the references to better understanding of the problems and presented solutions	20 problems about irrigation, 20 problems about drainage, 20 problems about water quality, 20 problems about hydrologhy, and 20 problems about hydraulics.	In the future, energy will be converted as a luxury item and water will be considered as the most vital item in the world due to reduction of water resources in most areas. If a water engineering student is not educated well, they will not solve problems of water sciences in the future.
Valipour M 2014(d) [15]	Handbook of irrigation engineering problems	-	According with the author this study is for help students and teachers	The handbook is indicated for agricultural, civil, and environmental students, teachers, experts, researchers, engineers, designers, and all enthusiastic readers in surface and pressurized irrigation, drainage engineering, agricultural water management, water resources, hydrology, hydrogeology, hydro climatology, hydrometeorology, and hydraulic fields.
Valipour, M 2014 (e) [16]	The study developed by Among all presented data in the FAO database, 10 indices were selected (due to more importance and more availability for all the regions in Asia Pacific).	These indices are permanent crops per cultivated area (%), rural population per total population (%), total economically active population in agriculture per total economically active population (%), (HDI), (NRI) (mm/yr), value added to (GDP) by agriculture (%), irrigation water requirement (mm/yr), percent of total cultivated area drained (%), difference between NIR and irrigation water requirement (mm/yr), and irrigated agriculture per cultivated area (%).	These indices were investigated for all 9 regions in the study areas and amount of irrigated agriculture per cultivated area (10th index) was estimated by three different scenarios and using the other 9 indices.	The results show that variations of irrigated agriculture are 4.4% to 41.1% and 16.1% to88.8% in 2035 and 2060
Valipour M 2014(f) [17]	The most pressure on renewable water resources is related to the agricultural sector and irrigation has the maximum water withdrawal in agriculture	The aim was an estimation of pressure on renewable water resources by irrigation in 2035 and 2060 using the study of agricultural water management during 1962 to 2011. 10 indexes were selected (due to more importance and more availability for all the regions in the world).	The selected indexes were analyzed and amount of area equipped for irrigation to cultivated area (10th index) was estimated by three different scenarios and using the other 9 indexes.	The value of pressure on renewable water resources was estimated. The minimum change related to the third scenario by 2035 (11.4%) and the maximum change related to the first scenario by 2060 (66.6%). Thus, pressure on renewable water resources will increase in the future and it can be considered in much different section.
Valipour, M 2014 (g) [18]	The aim of this study was the estimation of area equipped for irrigation in Europe in 2035 and 2060 using study of agricultural	10 indices were selected and analyzed for all 5 regions in the study area and value of area equipped for irrigation to cultivated area (10th	Eastern Europe has a better potential to increasing area equipped for irrigation in the future. The author could estimate area equipped for irrigation for after 2060.	An estimate is advised that we update our information every year and decade, or at least every half of century. The results show that changes of area equipped for irrigation is 6.4% to 40.9% and 27.2% to 83.5% in 2035 and 2060, respectively

	water management from 1962 to 2011	index) was estimated by 3 different scenarios and using the other 9 indices		
Valipour, M 2015 [9]	The aim was estimate the areas equipped for irrigation and the desirability of agricultural water management in Europe	Ten indices were selected (based on relevance and the availability of information on all the countries in Europe	The selected indices were analyzed for all 46 countries and the extent of areas equipped for irrigation of cultivated areas was estimated by two different formulas, using the other nine indices	The results demonstrated that value of relative error is less than 20%. In addition, an average index was calculated using two methods to assess each country's conditions for agricultural water management.
Valipour, M 2015 (a) [10]	aims to estimate ratio of area equipped for irrigation to cultivated area (AI) in Africa in 2035 and 2060 using studies of agricultural water management from 1962 to 2011	Among all presented data in the FAO database, 10 indices were selected (due to more importance and more availability for all the regions in Africa).	The selected indices were analyzed for all seven regions in the study area and the amount of AI was estimated by three different scenarios and using other nine indices	The results show that changes of AI are 0.3% to 49.5% and 16.5% to 83.2% from 2011 to 2035 and 2060, respectively. Indian Ocean Islands has a better potential to increase AI in the future. A considerable note is the change of irrigation status in the future than the current status. In 2011, AI of Sudano-Sahelian is more than AI of Indian Ocean Islands, however, AI of Sudano-Sahelian would be less than AI of Indian Ocean Islands based on all scenarios. respectively
Valipour, M 2015 (b) [20]	The most pressure on renewable water resources is related to the agricultural sector and irrigation has the maximum water withdrawal in agriculture	The aim in the study was an estimation of pressure on renewable water resources by irrigation in 2035 and 2060 using the study of agricultural water management during 1962 to 2011	10 indexes were selected (due to more importance and more availability for all the regions in the world). The selected indexes were analyzed and amount of area equipped for irrigation to cultivated area (10th index) was estimated by three different scenarios and using the other 9 indexes. Then, using these data, the value of pressure on renewable water resources was estimated	The minimum change related to the third scenario by 2035 (11.4%) and the maximum change related to the first scenario by 2060 (66.6%). Thus, pressure on renewable water resources will increase in the future and it can be considered in many different sections.

Table 1: The studies developed by Valipour were based on information gathered from the Food and Agriculture Organization of the United Nations (FAO) and checked using The World Bank Group (WBG).

Materials and Methods

This research was conducted in Cuiabá, Mato Grosso, Brazil (Figure 1); the methodology used for this study was based on the proposal of [21], which was one of the first works to establish guidelines for the implementation of water conservation program in buildings. Thus, the design of this study was structured in the following steps:

Step 1: Preliminary Technical Assessment,

Step 2: Water Demand Evaluation,

Step 3: Water Supply Assessment,

Step 4: Technical and Economic Feasibility Study.

Step 1: Preliminary technical assessment

This step surveyed all of the information and data involving the use of water in the condominium to determine the current conditions of use. It is comprised of the mapping of water use in the building and water consumption history, method of assessing the cost/benefit of the type payback projects (financial return). In the case of ready constructions: document analysis, and field surveys and opinion polls. With the help of the liquidator it was possible to host a meeting with the team that manages the condominium in order to publicize this project.

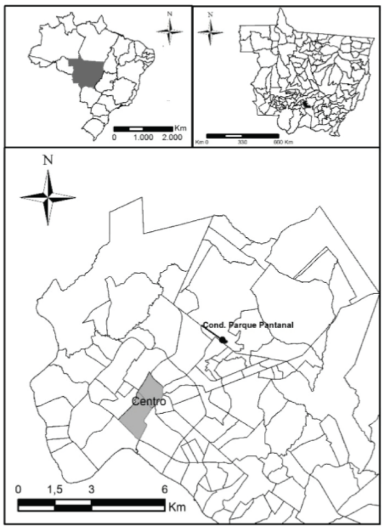

Figure 1: Geographical location of the study area in Brazil.

Step 2: Water demand assessment

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The water demand assessment was based on data collected in the previous step. This step identified the potential claims and selected the most viable option.

Analysis tools included: processes that use water, reuse water demand, residents' opinions, physical losses, hydraulic equipment, and pressure of the hydraulic system, proposed intervention types.

Step 3: Water supply assessment

In general, buildings have a public supply (local responsibility of the Basic Sanitation Company) or one of the following sources: direct funding sources, subterranean water, rainwater, or reused wastewater [21].

Step 4: Technical and economic feasibility study

This methodology followed that of [22]. After the supply and demand analysis was completed, an alternative to optimize water consumption in the building was prepared. Volumes and the reservoir were sized, and payback time was calculated.

Results

Step 1: Preliminary technical assessment

The estimated population in the project considers four persons per housing unit, and 300 apartments for a total of 1,200 people.

Project-type flat: Analysis of the consumption of water between rooms has become simpler because the three towers are equal in terms of their low plant. There are four apartments per floor and 25 floors of the tower. Each apartment has two bedrooms, a suite, living/dining room, kitchen, laundry area and balcony with barbecue. The apartment type has four bathrooms and an en suite, one in the hallway, a toilet in the living room and one in the service area.

Opinion poll: About 74% of residents say that they know what the reuse of water is, and 26% admit that they know about the theme of water reuse.

The degree of interest of the resident by theme was assessed. It was observed that 84% of residents consider these very important studies, while 10% considered them important and only 6% felt indifferent.

In the case of a possible adaptation of the building to increase its water consumption efficiency, 44% were interested since it could reduce property rates (Figure 2), while 41% were more concerned with environmental issues than economic issues (and already proved favorable to such efforts), and 12% were concerned about the non-interference with their routine. Only 3% did not show any interest.

The data clearly demonstrate a preference for how the recycled water should be used: 44% of residents indicated the water should be used to wash sidewalks, 35% suggested gardening, 13% preferred toilets, and only 8% of residents suggested the water be used for washing cars.

In addition, 44% of residents favor the exchange of taps in order to reduce water consumption. While 33% say that they already have taps and valves that reduce water consumption. A further 3% say they have no interest in the topic, or find it very uncomfortable to consider exchanging equipment. 20% said that had discharge valve economic.

The majority of the population accepts the substitution of parts and fittings to reduce water consumption, or already have such a tap installed, and also shows a high level of concern about environmental issues.

Most residents say that they use the washing machine at least twice a week (37%), 23% say they only use it once a week, another 23% say they do wash three times a week, while 14% say they use the washing machine four times a week, and 3% say use it more than four times a week. Here, it is interesting to note the frequency of laundry water for reuse: it is potentially quite frequent.

The residents had relatively high contact with domestic water use (59%). Roughly 22% of residents had a fixed employee, and 19% used a diarist service for cleaning the home. The latter was used either once (6%) or twice (13%) per week.

It is worth noting that the resident often personally promotes a rational use of water, while outsiders – such as hired services – are often not as motivated to conserve water.

In general, residents who answered the questionnaire have proven to be generous with regard to funding for a possible project. Many residents (35%) say they are willing to invest up to $25, 23% would invest an amount of $50 to $100, another 27% would invest $100 to $150, and 15% would invest over $150.

Completion of questionnaire: Through the questionnaire, it was possible to draw a profile of the residents in the studied community, a tool that was vital to subsequent steps. Considering the manner of approach and the number of replies, it is believed that people who answered these questions naturally tended to be more favorable to water reuse, while residents who did not respond were probably not interested in water reuse or the project in general.

Step 2: Water demand assessment

Before deploying a system of reuse or recovery of rainwater, it is necessary to know whether water is available for these purposes. Based on the information collected in the previous step, it is evident that local habits and customs track the following trends (Figure 2).

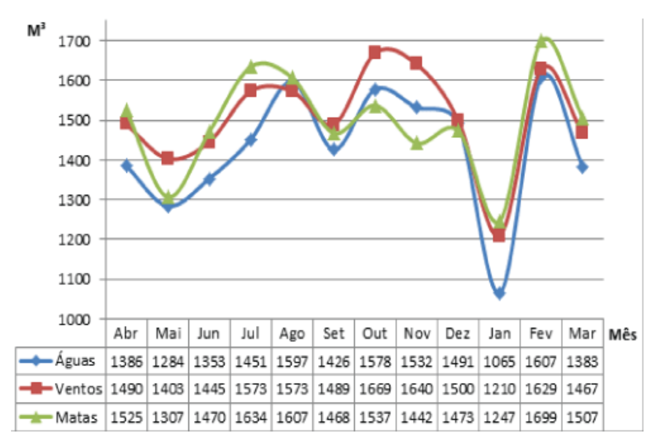

Figure 2: Monthly consumption water in three residential towers, (Denominated, Aguas, Ventos and Matas).

According to the consumption it is evident that the average monthly consumption of 4,430 cubic meters generates an average water bill of $

4,000. This is largely because the utility charges for water distribution and by treatment of the wastewater generated.

Step 3: Water supply assessment

The building has no alternative water sources, such as a deep tube well, and uses only water supplied by the water utility (CAB). The average water consumption was 4,430 cubic meters per month. Reused water could go towards washing floors or an irrigation garden.

As previously mentioned, the condominium has an approximately 6,033 square meters garden area, dominated by emerald grass (Zoysia Japonica) and some small bushes.

The use of irrigation for maintenance of lawns places a high demand on urban water. Even in humid climates, lawns require periodic maintenance and irrigation for survival during drought periods [23]. The 6,033 square meters of green area would thus require a daily irrigation of four liters per square meter, or about 24,132 liters of water per day.

Step 4: Technical and economic feasibility study

The building facilities are not designed to perform reuse, although the water distribution system has been designed for individual use allowing the rational use of water by apartment. However, it is worth noting that the building in question could be a good subject to study to draw up a viable proposal, because of its physical characteristics (e.g. area of availability, high water consumption and difference between the geometric dimensions).

A detailed analysis has come up in the proposed reuse of gray water for laundry. Although consumption in a home is a very small percentage compared to the total consumption in an apartment, to collect the wastewater generated by laundry could result in a significant volume for use in other non-potable settings such as watering the garden or cleaning the patio.

It is important that the proposed intervention is at least technically and economically feasible, and promotes the conservation of water resources.

The project payback time (i.e. economically viability) is found when the monthly reduction of the invoice amount, multiplied by the number of months needed for the total saved, is equal to the amount invested in the system deployment.

Treatment process: The most appropriate treatment processes for recovered sewage systems and water reuse in buildings, according to [24], is the treatment used to recover gray water: the effluent passes through a solid liquid separation system and can then go through biological treatment (if there is available space) or physical-chemical treatment (using iron salts or aluminum or polieletrólise and ozone to promote the desalination of colloidal particles in recovered sewage and phosphorus precipitation). The latter requires less area and may offer a faster payback time. Filtration may be completed by reverse osmosis or by membrane. A membrane system typically separates ions based on the solution of the reverse osmotic pressure differential. At the end, final disinfection can be performed with use of oxidizing chemicals, ultraviolet rays, heat, or physical separation processes (membrane) consisting of inactivation of pathogenic organisms.

Analysis of proposed system: In order to reconcile demands and offers, water from laundry should be reused within the condominium complex.

Return volume: According the literature even if 30% of the volume of gray water to be reused is lost, there is still 15.78 m^3/day available for use. Thus, annual volume will reach 5,765,55 m^3/year (15,78m^3/day x 3.4375 days x 12 months = 5763,55 m^3/year). The annual consumption is thus equivalent to the consumption of 30 families, the same per capita consumption of the apartment.

Return time: 1 year and 4 months.

Considerations

The content of existing literature does not seem to closely tie-in with the structure of the study (an assessment of gray water reuse in a particular residential structure). However, it is still possible to have an overview of the amount and availability of water, which can be reused for irrigation, minimizing the cost of treatment (irrigation does not require the same portability standard as water for human consumption, and can thus go through simplified treatment). As detailed above, the studies developed by Valipour showed that is necessary for people to think about water and its uses.

Water use and applicable conservation program(s) vary by type of building. The technical and economic viability of a water resource can often be limited by the time in which the use or program is deployed. For example, the costs for retrofitting an existing building may be significantly more than those involved in new construction. It is thus important to deploy a program at the time of construction, whenever practicable.

The proposed solution to reuse gray water can generate large water savings of up to 5,680m^3 per year, if it is streamlined with the collection and treatment of laundry water and subsequent applications to irrigation of the garden and patio cleaning.

It is worth noting was noticed that each building may have its own most appropriate solution based on technical and economic analysis. The example of this proposed solution to this building may not be suitable for another, due to difference in physical and social characteristics.

The implementation of a PCA Water Conservation Program in a building will often require maintenance of the system. This maintenance should be periodic and can be daily, weekly, or monthly. The quality of service is critical to continuity of services. A service that does not fulfill its purpose becomes unnecessary. One possibility to guarantee the viability of periodic maintenance is to hire a company that is able to carry out cleaning the pool along with the maintenance of gray water treatment plant (ETAC).

Some studies have shown that a reuse system would have a high investment cost. However, other studies have shown that it is possible to get a lower rate condominium when the building uses a PCA Water Conservation Program. This suggests the opposite point of view. It is a misunderstanding that implementation of a reuse system implies an increase in the overall cost of the work, which would cause a loss of sales. This research shows that the majority of customers consider other factors, such as environmental sustainability, when deciding to purchase an apartment. A water reuse system can thus provide a competitive advantage and increase sales to customers who think long term.

If analyzed individually, there is a reduction and savings in individual water bills that implement a reuse system. This benefit ends up being of little relevance, however, if it is analyzed in general, considering the community as a whole. The implementation of a PCA provides annual savings of $5,000 approximately (five thousand US dollars annually). This is a noteworthy amount of money that can be used to meet other demands of residents and improve their quality of life, as well as provide environmental protections and relieve stress on municipal supply systems.

This research can encourage the adoption of public policies, and lines of financing for apartments to adopt this PCA Water Conservation Program solution.

Using the same concepts and standards for the establishment of an independent sewage treatment system in a subdivision, it is reasonable to develop a reclaimed water system for condominiums. Is the typical practice. The entrepreneur should build the water reclamation system as part of the new construction or complete a retrofit, and bear all expenses. In the case of popular buildings, this approach may have government incentives.

The water supply and Sewage Company can operate the reuse system, or delegate the operation to a third party.

The general public shows a longing for the use of reuse technology. The urban way of living does not prevent sustainable use. It is, however, missing important mechanisms to encourage water improvement and use.

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