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# *Use of rain water in floor washing and garden irrigation: a case study*

The socioeconomic context brought by the COVID-19 pandemic and the war in Ukraine, caused a crisis in the world economy. Faced with this situation of inflation and the rise of the dollar, access to basic items such as water and cooking gas has become an obstacle for the needy population. There are alternatives to overcome water scarcity, and one of them is the use of water harvesting systems with low-cost technologies, which facilitate replication in environments that do not have a water distribution network, allowing the economical-ly disadvantaged population access the water. This work analyzes the use of rainwater in garden irrigation and floor washing in a public building. The case study was carried out at the Civil Court and Consumer Relations Court in Camaragibe, PE. The rainfall index and the history of water consumption were analyzed, as well as the analysis of rainwater in the study region. Reservoir simulations and economic analysis were performed using the NETUNO software. The economic simulation resulted in the value of R$3,000.00 (three thousand reais), and a payback time of 5 years. After analyzing the simulations and the results of the rainwater samples, as well as complying with the requirements of the ABNT 15527/2019 standard, it can be inferred that the im-plementation of rainwater harvesting for non-potable use is feasible.

**Keywords:** Harvesting rainwater; Sustainability; Low cost technology.

# *Aproveitamento da água da chuva na lavagem de pisos e irrigação de jardins: um estudo de caso*

O contexto socioeconômico trazido pela pandemia do COVID-19 e a guerra na Ucrânia, provocaram uma crise na economia mundial. Diante dessa situação de inflação e alta do dólar, o acesso a itens básicos como água e gás de cozinha tornou-se um entrave para a população carente. Existem alternativas para superar a escassez hídrica, e uma delas é a utilização de sistemas de captação de água com tecnologias de baixo custo, que facilitam a replicação em ambientes que não possuem rede de distribuição de água, permitindo o acesso da população economicamente desfavorecida. Este trabalho analisa o aproveitamento da água da chuva na irrigação de jardins e na lavagem de pisos de um prédio público. O estudo de caso foi realizado na Vara Cível e de Relações de Consumo de Camaragibe, PE. Foram analisados o índice pluviométrico e o histórico de consumo de água, bem como a análise das águas pluviais da região de estudo. Simulações de reservatórios e análises econômicas foram realizadas usando o software NETUNO. A simulação econômica resultou no valor de R$ 3.000,00 (três mil reais), e um tempo de retorno de 5 anos. Após analisar as simulações e os resultados das amostras de água de chuva, bem como atender aos requisitos da norma ABNT 15527/2019, pode-se inferir que é viável a implantação da captação de água de chuva para uso não potável.

**Palavras-chave:** Captação de água de chuva; Sustentabilidade; Tecnologia de baixo custo.

Topic: **Uso de Recursos Naturais**

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## INTRODUCTION

Water is a connecting element to achieve the different Sustainable Development goals, being related to all priority areas. There has been a sixfold increase in water consumption in the world in the last hundred years and it has continued to grow at a rate of 1% per year, factors such as population growth, changing consumption patterns, as well as irregular water supply and changing climate worsen water scarcity (UNESCO, 2020). Investment in water and sanitation is one of the ways to leverage several sectors of the world economy after COVID 19 and induce the reduction of losses due to floods, water shortages and epidemics (MELO et al., 2020).

Waste and misuse of water are worrying problems, since it is a scarce resource and regions of the country face periods of drought (OLIVEIRA et al., 2020). In the Northeast Region of Brazil, there are places where water scarcity has been experienced for many years, according to information from the National Water Agency - ANA "[...] in Pernambuco, there was an expansion of the drought area on the South Coast [...] and in the Sertão, the intensification of drought in part of the Agreste [...] The impacts of drought are short- and long-term" (ANA, 2013). The socio-economic context of crisis in the world economy caused by the COVID 19 pandemic and the war in Ukraine, which generated inflation and a rise in the dollar, makes it difficult for the economically disadvantaged population to access basic items. On the other hand, there are alternatives to overcome water scarcity, one of which is the use of low-cost social technologies, which allow access to water through the replication of rainwater harvesting systems through the use of materials accessible to the needy population.

The objective of this study was to analyze the possibility of implementing rainwater harvesting for use in floor washing and irrigation for landscaping purposes, in a public building. of water, as well as the demand, pluviometric index and quality of rainwater. The motivation of this work was to contribute to water efficiency in urban public infrastructure facilities, seeking sustainability.

## METHODOLOGY

### Characterization of the study area

The building where the Special Civil Court and Consumer Relations Court of Camaragibe - PE operates was the selected one for this study. It is located in the Metropolitan region of Recife-PE, with a built area of around 500 m². It works from Monday to Friday from 07:00 to 13:00. Nine servers, a magistrate and an employee from an outsourced company are fully employed; around 150 people circulate through the building during a day, the frequency of people is variable, both for different services as well as to participate in hearings. The study area was chosen because it is a small construction, characteristic of many public buildings located in the municipality of Camaragibe such as schools, health and security services. In the Pernambuco Judiciary alone, there are around 100 buildings with a built area similar to the one in the study, where municipalities in the metropolitan region and inland operate.

Data collection was carried out through a visit to the study site, where information was collected through a partially structured direct interview with the manager for the water characterization of the building. Surveys were carried out such as the supply of drinking water, rainfall, estimated population (number of employees and jurisdictions), types of water uses, as well as the covered area, types of tile used on the roof of the building, gutters, measurement of the area destined to capture rainwater, pump and accessories, number of reservoirs, measurement of the external and internal area. Verification of potable and non-potable water sources and water demand was also carried out. Based on these surveys, a correlation was made between demand and supply of water to establish the water balance.

The rainfall was prepared through the APAC website from 2009 to 2019, as well as simulations were carried out through the NETUNO program, as a tool for analyzing the sizing of reservoirs and economic analysis. Finally, rainwater samples were collected and taken to the ITEP laboratory where analyzes of the bacteriological and physicochemical samples were carried out.

**Number of samples and collections**

The delimitation of the number of samples considered the data from Annex XV of Ordinance 888/2021 of the Ministry of Health, which indicates the minimum number of 1 weekly sample for water quality control of collective alternative solution for the purpose of physical, chemical and bacteriological analyzes in depending on the type of source and sampling point (BRAZIL, 2021). This study also considered the number of people who work or attend the building object of the research.

During the month of March 2022, ten rainwater samples were collected in subsequent weeks, in the locality of Timbi Camaragibe - PE, 15 analyzes were carried out, five of which were bacterial, for quantification of E. Coli and ten physicochemical samples for Turbidity and pH analysis. The analyzes were performed by the laboratory of the Pernambuco Technology Research Institute – ITEP, using the APHA method – Standard Methods for the Examination of water and wasterwater, 23st edition, to evaluate the parameters. 2017, part.9000/9223,4500- H+B and 2130 A, for Escherichia coli, pH and Turbi-dez, respectively.

For the microbiological analyses, the collections were carried out in sterile flasks, provided by the analysis laboratory of Pernambuco Technology Research Institute - ITEP, while the physical-chemical analyzes were collected in appropriate containers, also provided by the ITEP (Figure 2). The samples were taken to the laboratory, all identified with the date and time of collection, accompanied by a form containing information regarding the place of collection, date, time and person responsible for the collection.

**Number of samples and collections**

The collections were carried out directly from the rain (Direct from the rain), after the rain passed through the gutter (After gutter) according to Figure 1; as well as samples of rainwater reserved for three days (Re-reserved) were collected. Samples were also collected after treatment with sodium hypochlorite (Treated water 1 and treated water 2).

**Figure 1:** Collected samples.

## Sodium hypochlorite treatment

Seeking to carry out treatment that is available to the economic population medically disadvantaged, two samples were treated with sodium hypochlorite, popularly known as sanitary water, since this product is easily found in the market, warning that the bleach used for the treatment or disinfection of water tanks and cisterns of rainwater storage, it must not contain dye or essence (BRAZIL, 2018).

The samples that received treatment were collected directly from the rain; such samples (treated water 1) intended for physical-chemical analysis, as well as the sample intended for microbiological analysis, received 0.2 ml per liter of sodium hypochlorite, with active chlorine content between 2.0% to 2, 5 p/p.

In the following week, new rainwater samples (Treated Water 2) destined for physical-chemical analysis, as well as microbiological analysis, were treated with 2.5 ml per liter of sodium hypochlorite, with an active chlorine content between 2, 0% to 2.5 w/w.

## RESULTS AND DISCUSSION

The use of rainwater also involves issues related to regulatory norms, specific laws and Public Policies, in this sense, Cauduro et al. (2021) ensure that NBR 15527 (ABNT, 2019) no longer emphatically presents the methods of sizing reservoirs; said author, notes that the catchment area, rainfall issues and water demand must be met.

In turn, Santos et al. (2021) present general aspects about Brazil's advances in relation to water reuse and point out the importance of the Water Sector Development Program - Interáguas Program and Law 14,026 of 2020, which deals with updating the regulatory framework for basic sanitation and, it gives the ANA the power to issue regulations on sanitation at the federal level.

With regard to social technology, works were carried out that proposed water reuse solutions for this purpose. Dias et al. (2021), talk about social technology of rainwater harvesting and the high potential to minimize the absence of public power and Arriada et al. (2021) discuss Nature-Based Solutions (SBN); and highlight Permaculture as an ecosystem with a reduced environmental impact whose scope is an ethic of care and careful verification of natural patterns.

## Field research

In the present work, a field research was carried out in the building of the Special Civil Court and consumer relations in Camaragibe-PE, located in the metropolitan region of Recife; data on the building was collected to identify the covered area that could be used to capture rainwater, the channels, reservoirs and water tanks; in accordance with the aforementioned standard. The consumption was identified through the analysis of the activities that consume water and the quantity of water used in the respective activities, the data collected and analyzed resulted in the estimate of the consumption of potable water and in the amount that can be replaced by non-potable water, such as activities such as garden watering and floor washing, which is not required to use potable water. The survey of the Pluviometric Profile of the City of Camaragibe, from 2009 – 2019, based on data provided by APAC, indicates that the annual average is 1,970 mm and the months with the highest rainfall are May, June and July.

To create a rainwater harvesting system, it is necessary to capture, pre-treatment, storage, monitoring of water quality, so that the water can then be used. The rainwater harvesting system idealized in this study was illustrated (Figure 2).

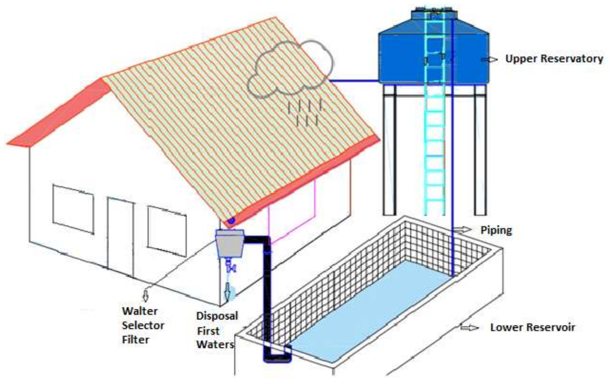


**Figure 2**: Simplified illustration of the rainwater harvesting system.

## Water demand

Invoices for consumption of treated water issued by Companhia Pernambuca-na de Saneamento – COMPESA were analyzed. In this sense, Martins et al. (2021) used the concessionaire's invoices to measure monthly consumption. They concluded that the savings generated with the rainwater harvesting system are directly linked to the replacement of potable water for use in the sanitary basins. Consumption at the study site in 2019 was 160 m³, and it can also be inferred that the average monthly consumption was 13.3 m³.

## Demands that can be replaced by rainwatergarden

Some non-potable demands can be replaced by the use of rainwater such as toilet flushing, floor washing, and garden watering. For this study, the use in sanitary discharges was calculated from Monday to Friday, which is equivalent to twenty-three days per month; while in garden irrigation, the months with the highest rainfall, namely May, June and July, were not accounted for (Table 1).

**Table 1**: Demand for use of toilets, irrigation and floor cleaning (m³).

| Location of consumption | Consumption | Units | Frequency | Monthly demand |
|---|---|---|---|---|
| **Toilets** | 6L/flush | 10 employees | 4 times a day | 5,5m³ |
| **Irrigation** | 2L/m² | 100 m² | 3 times/week | 2,4³ |
| **Floor cleaning** | 1L/m² | 200 m² | 3 times/week | 2,4³ |

Regarding the use in sanitary appliances, Santos et al. (2021) state that the flow of sanitary appliances (sanitary flush) is between 3 liters per flush in single-drive toilets and 6 liters per flush in equipment that has double drive. While Silva (2019) estimated the indicator of 2 L/m²/day, for garden watering and floor washing, garden watering would be carried out on interspersed working days and informed that the washing of waterproofed areas would be carried out once per week.

## Theoretical availability of rainwater

In order to obtain the theoretical availability of rainwater, according to NBR 15227 (ABNT, 2019), an area of 365.75 m² for rainwater harvesting was considered; surface runoff coefficient value of 0.85 and adopting the capture factor = 1.0 (Table 2).

**Table 2**: Average annual precipitation, precipitation volume and available volume.

| Period | Average annual precipitation (mm) = P | Precipitated volume over the chosen area (L) | Available volume (L) = Vdisp |
|---|---|---|---|
| **2009/2019** | 1.969,9 | 720.490,9 | 612.417,28 |

## Potential value

The potential value is the result of the calculation of the volume used from the available volume (Table 3), it was carried out in accordance with the aforementioned standard and considering that the discharge of the first waters is 2 mm.

**Table 3**: Available volume and leveraged.

| Period | Available Volume (L) = Vdisp | Volume discarded(L) | Volume used(L) | potential value in m³ |
|---|---|---|---|---|
| **2009/2019** | 612.417,28 | 731,5 | 611.685,78 | 611,68 |

## Result of sample analysis

The result of the physical-chemical analyzes of the rainwater samples collected in the region of Camaragibe - PE demonstrate compatibility with the parameters (Table 4) established in NBR 15527 (ABNT, 2019) except for the water sample treated 2, which after collection received 2.5 ml/liter sodium hypochlorite, with active chlorine content between 2.0% and 2.25 p/p.

**Table 4**: Minimum quality parameters for non-potable uses of Rainwater.

| Parameter | Value |
|---|---|
| ***Escherichia coli*** | < 200 NMP/ 100 mL |
| **Turbidity** | < 5,0 uT |
| **pH** | 6,0 a 9,0 |

**Source:** based on NBR 15525 - Brazilian Association of Standards Techniques (2019).

The result of the physical-chemical analyzes of the rainwater samples collected in the region of Camaragibe - PE demonstrate compatibility with the standards established in NBR 15527 (ABNT, 2019) except for the treated water sample 2, which after collection received 2.5 ml/liter sodium hypochlorite, with active chlorine content between 2.0% and 2.25 p/p; after analysis by the ITEP laboratory, it showed pH 10.6 and the value indicated in the standard is between 6 and 9.0.

Considering that all the other samples, even without treatment, were compatible with the specific standard and also because this study did not specifically address the quality of rainwater (Table 5), no other sample collections were carried out to verify the pH, this study may be the object of future works.

**Table 5**: Result of the physical-chemical analysis of rainwater collected in the region of Camaragibe – PE.

| Sample type | Parameters | Value found | Value NBR 15527:2019 |
|---|---|---|---|
| Reserved | Turbidity | 0,79 NTU/ 100 ml | < 5,0 uT |
| After gutter | Turbidity | 1,35 NTU /100 ml | < 5,0 uT |
| Direct from the rain | Turbidity | 1,89 NTU /100 ml | < 5,0 uT |
| Treated Water 1 | Turbidity | 4,0 NTU /100 ml | < 5,0 uT |
| Treated Water 2 | Turbidity | 1,18 NTU/100 ml | < 5,0 uT |
| Reserved | pH | 7,54 | 6,0 a 9,0 |
| After gutter | pH | 6,93 | 6,0 a 9,0 |
| Direct from the rain | pH | 6,50 | 6,0 a 9,0 |
| Treated Water 1 | pH | 7,16 | 6,0 a 9,0 |
| Treated Water 2 | pH | 10,6 | 6,0 a 9,0 |

Note - NTU: Nephelometric Turbidity Unit.

The microbiological analyzes of rainwater samples collected in the region of Camaragibe - PE demonstrate compatibility with the standards established in the NBR 15527 standard (ABNT, 2019). It is noteworthy that the treated water 1, after collection, received 0.2 ml/liter of sodium hypochlorite, with active chlorine content between 2.0% and 2.25 p/p, while the treated water sample 2, after collection received 2.5 ml/liter of sodium hypochlorite, with active chlorine content between 2.0% and 2.25 p/p (Table 6).

**Table 6**: Result of the microbiological analysis of rainwater collected in the region of Camaragibe – PE.

| Sample type | Parameters | Value found | Value NBR 5527:2019 |
|---|---|---|---|
| Reserved | *E. Coli* | NMP 3,0/100 ml | < 200 NMP/ 100 ml |
| After gutter | *E. Coli* | NMP 1,0 /100 ml | < 200 NMP/ 100 ml |
| Direct from the rain | *E. Coli* | NMP 47/ 100 ml | < 200 NMP/ 100 ml |
| Treated Water 1 | *E. Coli* | NMP 4,0/100 ml | < 200 NMP/ 100 ml |
| Treated Water 2 | *E. Coli* | NMP <1,0/100ml | < 200 NMP/ 100 ml |

Note - Most likely number (MPN) <1.0/100 ml, indicates absence of Escherichia Coli.

Vieira et al. (2021) concluded in their study that the use of the first water disposal device is recommended since it positively influences the quality of rainwater and is simple to perform. Santos et al. (2021) state that rainwater is of good quality and is even used for human consumption, requiring the water to undergo filtration and chlorination processes. In this sense, Dolabella et al. (2021) discuss the use of chlorine for water treatment. These authors report that chlorine is used worldwide as a disinfectant, since it has low toxicity and solubility, being easy to handle. They warn that used inadvertently may pose health risks.

In turn, Lins et al. (2021) analyzed rain samples collected at points located in the neighborhood of Boa Vista, Recife PE, on the outskirts of the Catholic University of Pernambuco, after analysis in a laboratory, they concluded that there is a possibility of mild acid rain in the studied region.

Souza et al. (2021), analyzing the quality of rainwater in cisterns in the interior of PE, concluded that some samples do not present sanitary conditions for use, and that factors such as the frequency of cleaning of the reservoirs, atmospheric pollution in industrial areas and the lack of disposal of the first waters as well as the type of material used in the construction of the reservoir can contribute to this; while Machado et al.

(2021) concluded that the type of material used in the manufacture of reservoirs can influence the quality of rainwater.

**Lower and Upper Reservoirs**

It is worth mentioning that during the data collection in the present study, a swimming pool with a capacity of 60m³ was identified, currently unused, which can be used as a lower reservoir for rainwater, supplying the demand in the summer months, counting that the lower reservoir is one of the items that makes the project more expensive, the use of the pool as a lower reservoir will lead to significant savings.

For the present study, simulation was used for two reservoirs; the pool that is unused at the study site and has a capacity of 60m³ for the lower reservoir was used. While for the upper reservoir, a 1,000 liter reservoir was chosen.

**Reservoir with several volumes**

In the case study, it was observed that the simulation for different volumes indicates that the lower reservoir with a capacity of 10,000 liters meets the demand. It should be noted that, for the dimensioning of the reservoirs, it is necessary to consider items such as rainfall data, catchment area and demand. Batista (2021) infers that the use of rainwater presents itself as an alternative both for human consumption and for various uses in homes.

It also ensures that, for a minimum daily demand of 20 liters per person in dwellings with five people, in order to reach 100% of that demand, the reservoir with a capacity of 4,500 liters and a catchment area of 200m² meets the annual demand. It also warns that if there are other sources of drinking water, smaller areas and reservoirs can be dimensioned. In the event of purchasing water from other sources, making up 10% of the minimum annual water demand, 500 liter reservoirs and a 70m² catchment area or a 35 m² catchment area and a 3,000-litre reservoir can be used.

**Economic analysis**

Faced with this situation of inflation and the rise of the dollar, access to basic items such as water and liquefied petroleum gas - LPG known as cooking gas, has become an obstacle, especially for the needy population. A possible way to circumvent water scarcity is the use of rainwater harvesting systems with low-cost technology. These systems are characterized by using accessible materials that facilitate the replication of the system in environments that do not have a regular water distribution network, as they are simple to execute, they allow their accessibility to the economically disadvantaged population, and, therefore, which would benefit most in this context. Melo et al. (2020) conclude that a way to leverage several sectors of the world economy after COVID 19 and induce the reduction of losses due to floods, water scarcity and epidemics is the investment in water and sanitation.

As an auxiliary tool in the analysis, a simulation was carried out through NETUNO, based on the data selected and inserted in the aforementioned tool, the net present value was calculated around R$3,000.00

(three thousand reais); the investment payback time is approximately 5 years (62 months) and the internal rate of return is 2.12% per month, after analyzing the data, it can be inferred that the investment is economically viable.

## Costs and savings

The pricing of the material needed for the rainwater harvesting system was carried out on the internet by consulting the stores that sell civil construction materials in the municipality of Camaragibe, PE, valuing local companies and avoiding the cost of delivery of products (Table 7).

**Table 7:** Initial costs.

| Item | Cost (BRL) |
|---|---|
| lower reservoir | 270,00 |
| Labor | 250,00 |
| pipes | 150,00 |
| Accessories | 120,00 |
| pump motorbike | 270,00 |
| Upper Reservoir | 360,00 |

One of the factors that contributed to the reduction of operating costs was the use of the swimming pool, which is not in use, as a lower reservoir; It should be emphasized that the case study took place in a public building whose entity has an engineering department, with sectors responsible for demands in the area of hydraulics, electricity and maintenance in general, with professionals who can be relocated without additional labor costs for the execution of services, as well as the design and execution of a rainwater harvesting system, which greatly reduces the cost of the project and the execution of the work.dos fatores que contribuiu para a redução dos custos operacionais foi a utilização da piscina, que encontra-se sem uso, como reservatório inferior; deve-se enfatizar que o estudo de caso se deu em um prédio público cujo ente dispõe de departamento de engenharia, com setores responsáveis por demandas na área de hidráulica, eletricidade e manutenção em geral, contando com profissionais que poderão ser deslocados sem custos adicionais de mão de obra para execução de serviços assim como a elaboração de projeto e execução de Sistema de aproveitamento de água de chuva, o que reduz em muito o custo com o projeto e com a execução da obra.

## Environmental sustainability in the PE Court of Justice

The TJPE has been developing actions and activities based on economic, social and environmental aspects, aiming at the current and future generations' needs, for this purpose it follows the indications selected below. The buildings that are currently being designed by the TJPE are committed to sustainability.

Regarding the implementation of rainwater capture and use, within the scope of the Pernambuco Court of Justice, it is noted that the building of the Forum of the Comarca de Bezerros, located in the municipality of Bezerros-PE, located in the rural region of Pernambuco, it was designed with sustainability in mind, it has internal and external LED lighting, as well as a highly efficient air conditioning system; fire detection and fighting system, highlighting the rainwater harvesting system.

Martins Primo (2020) lists environmental sustainability initiatives that can help the TJPE to seek innovations and efficiency, pointed out by its interviewees, among which are the implementation of green roofs, use of rainwater, selective collection, replacement of lamps, construction technologies, carpooling, composting solar energy. (2020) enumera iniciativas de sustentabilidade ambiental que podem contribuir para que o TJPE possa buscar inovações e eficiência, apontadas por seus entrevistados, entre as quais se encontram implantação de telhados verdes, uso de água de chuva, coleta seletiva, substituição de lâmpadas, tecnologias construtivas, carona solidária, compostagem energia solar.

**Installation of rainwater harvesting in small buildings**

Pernambuco has around 100 counties located in the metropolitan region and in the interior of the state that work in small buildings, if rainwater harvesting systems were implemented according to the demand and water characteristics of each location, it could bring significant water savings, as well as the institution of water managers, aiming at a process of communication, sensitization of users, replacement of equipment or implementation of a pumping system using photovoltaic energy, meeting the dictates of integrated sustainability in the various areas, as well as the periodic verification of the system.

Another aspect would be the implementation of a landscape project according to the peculiarities of the locality, taking advantage of the climate and topography, using native species adapted to the region and according to the need for irrigation, if necessary using irrigation controllers automatic and programmed, where irrigation is suspended on rainy days.

## CONCLUSIONS

This study aimed to identify the possibility of implementing rainwater harvesting for use in floor washing and garden irrigation, in a public building; and can serve as a parameter for the manager to provide the necessary interventions, paying attention to each specific case, meeting the specific rules and the foundations and objectives of the National Water Resources Policy, as provided for in articles 1, inc. and 2nd inc. IV of Law No. 9,433/1997, known as the Water Law.

From the analysis of the simulations carried out through the NETUNO program, compliance with the requirements established in NBR 15527 (ABNT, 2019), as well as the test reports of the samples collected from rainwater, it can be inferred that there is the possibility of using rainwater for floor washing and garden irrigation activities in the building of the Special Civil Court and Consumer Relations Court in Camaragibe, PE.

An issue to be raised is the sensibilization and adhesion of the public entity, aiming to oppose the bureaucratic and cultural obstacles of planning and the causes of the limitations of execution, for the viability and compliance with environmental legislation.

After carrying out this study, it became evident that in addition to the feasibility of implementing rainwater harvesting for use in floor washing and garden irrigation, it can also be used to replace the water used in the toilets; such issues may be the subject of a forthcoming study.

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