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PROPOSAL FOR SUSTAINABLE SANITATION FOR LOW PRECIPITATION IN URBAN AREAS IN THE BRAZILIAN SEMIARID

***[1]Fernando Antonio Portela da Cunha, [2]Virginia Tomaz Machado, [2]Pavlova Christinne Cavalcanti Lima, [3]Joanacele Gorgonho Ribeiro Nóbrega, [4]Luiz Carlos Machado de Souza Filho, [5]Marcela Viana Portela de Oliveira Cunhaa and [6]Mario Eduardo Rangel Moreira Cavalcanti Mata**

[1]Teacher course of Chemistry, Federal University of Campina Grande, Paraíba, Brazil
[2]Teacher course of Administration, Faculdade Santa Maria, Paraíba, Brazil
[3]Executive Coordinator of IMJOB – Instituto Maria José Batista Lacerda, Paraíba, Brazil
[4]Rector and Teacher of Theology of the Archdiocesan Seminary, Paraíba, Brazil
[5]Architect and Urbanist, PhD student in the postgraduate program in Architecture and Urbanism of the Federal University of Rio Grande do Norte, Rio Grande do Norte, Brazil
[6] Coordinator and teacher of the Postgraduate Program in Natural Resources of the Federal University of Campina Grande, Paraíba, Brazil

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ABSTRACT

The semiarid region of Brazil is one of the main characteristics the average index of precipitation below 800mm per year and covers a large part of the Northeast region, leading the urban populations to the rationing of water. This work proposes the application of a constructive methodology for homes, so that this can become high enough in water. It was taken as a case study, the city of Pompeii in Paraiba - Brazil. This work presents a study of the potential for storing rainwater for residences, with a view to verify the viability of a project sustainable construction. For both considered a house with $150m^2$ of covered area and the average rainfall of 730mm from the past seven years. The results show that without compromising the environment and architecture, it is possible to perform some changes in building projects of a residence, making it sustainable in the consumption of water and independent from the public provision of supply, reserving in their structure $105m^3$ of water. Considering the growth of the cities of semi-arid regions, the use of this methodology, not undermine the region's water sources and reduce public investments destined to the problem of drought in semi-arid regions of the Brazilian Northeast and with the economy of water, this could be intended to agriculture.

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INTRODUCTION

According to the Brazilian Institute of Geography and Statistics - IBGE (2017), the semiarid region of Brazil, has a total extension of 982.563,3 km², comprising 1,132 municipalities, covering most of the northeastern states, with the exception of Maranhão and north of Minas Gerais, having as main factor of division for the semiarid region the average index of precipitation below 800mm per annum. According to data from the National Institute of the Semi-arid - INSA (2017), in 2014 the population of the Brazilian semiarid overcame the house of 23.8 million inhabitants, corresponding to more than 42% of the population from the northeast and 11.8% of the national population, with a population growth rate of 5.24 percent between the years of 2010 and 2014. State governments and the European Union have promoted actions in an attempt to combat the adverse weather conditions caused by low rainfall and improve the living conditions of the population of the arid North-East. Actions such as construction of dams, reservoirs, tanks, interventions with cars pipe and as the largest project still in the final stages of construction, the transposition of the São Francisco River, has been invested a lot of money with these actions. The project of the São

****Corresponding author:*** **Fernando Antonio Portela da Cunha**
Teacher course of Chemistry, Federal University of Campina Grande, Paraíba, Brazil.

Francisco River, which aims to meet the water demand of the population was initially budgeted at 4.5 billion Brazilian real in the year 2007. Today, with the delay in delivery period, the cost of the work is already approaching the mark of 10 billion dollars, according to Cardoso *et al* (2010). According to the UN (2017), "Until 2030, the planet will face a deficit of 40% water, unless it is dramatically improved the management of this precious resource." Following the UN report on the development of water (2015), released in New Delhi (India), in celebration of World Water Day, has as its main conclusion "Water for a sustainable world" The low rainfall is characteristic not only of the Brazilian semiarid. Various parts of the world also share the difficulties encountered by this problem. As alternatives to solve this problem in the United States region of California, historically presented serious problems of supply. As a solution, the American government has works of transposition in Colorado rivers, São Joaquim and Sacrament. Today the California figure among the most food-producing regions of the world. The northern region of China also had problems of water supply mainly in the capital of the country, Beijing. According to Cardoso *et al* (2010), the Chinese government has concluded, at the cost of 81 billion dollars and after 12 years of work, 1,200km of channels for the transpositions of the Yang Tse River in order to minimize the problem in the capital. According to the portal "CLIMATE-DATA. ORG" (2017) the region of Beijing has an average annual rainfall of 610mm. Faced with these realities, it is necessary to the development of researches and technologies that will improve the quality of life of people living in these regions. In this sense this work proposes the application of a constructive methodology for homes, so that this can become high enough in water, even in the face of adverse weather conditions caused by low rainfall, in several regions of the world.

MATERIALS AND METHODS

For a more precise analysis of the problem of low rainfall in the semiarid, it was as a research field the city of Pompeii in high backwoods from Paraíba The 460km of coast capital João Pessoa, which according to the IBGE (2017), the city has an estimated population of 61,816 inhabitants in the year 2016. According to the INSA (2017), the population of the semiarid has presented a tendency of population growth, with a rate of 5.24 percent between the years of 2010 and 2014. Currently in the city of Cajazeiras there are some blends of land in urban areas that are being exploited in an exponential way for the construction of homes. Data from the Executive Agency for the management of Waters of Paraíba - EFSA (2017) show that in the city of Pompeii in the last seven years (2011 to 2017), the average index of rainfall is 730mm. This volume was not enough to replenish the reservoirs in trusted levels and as a consequence the supply of the city suffers rationing in its distribution. Efsa's data show that in June 2017 of 126 monitored reservoirs, 88 (70%) is stored volume below 20% of its capacity. Half of these (44) is in a critical situation with volumes stored below 5%. The city of Pompeii is currently supplied by two reservoirs: the weir Avid Engineer with the potential of 255,000,000 m^3 and the Lagoon of the Rice with the potential of 80,220,750 m^3. Both in June of 2017, were respectively 5.1% and 12.9% of its capacities (EFSA, 2017). Information obtained from the water company and sewage from the Paraíba (CAGEPA) show that the average monthly consumption of water in Cajazeiras in 2017 is about 280 thousand m^3 and that there are currently 21,752 points of connection with these 20,077 houses, 1,412 shops, 208 public institutions and 55 industrial plants. With this information, it can be concluded that the average monthly consumption per connection point is 13.3 m^3. Considering the estimated population of the city in 61,816 inhabitants, we can conclude that the consumption per capita is approximately 150 liters/day. According to a survey from IBGE (2017) in the year 2000, the average water consumption per capita in the northeast was 170 liters/day. With this it appears that in the year 2017 lyman presented a consumption below the regional average. Another important information obtained from the CAGEPA is that among the 21,752 total points of connection, 14,575 equivalent to 67%, consumes up to 10m^3 per month. According to the UN (2017), each person needs to 110 liters of water per day to meet consumption needs. As stated above, the city of Cajazeiras shows per capita consumption of 150 liters/person/day. Although this consumption is below the regional average (170 liters/day), lies above the average necessary according to the UN. Several studies corroborate the prerogative of that with simple actions is possible, a reduction in water consumption by at least 20%. The Secretary of Education of Porto Alegre, reported that 84 schools in the state education network installed flow reducers in their water structures. Flow restrictors are simple devices composed basically of a disk with a hole that to be placed at the entrance of the supply of taps, restricts the flow of water. According to the Secretary of Education of Porto Alegre (2017)

"*since they were deployed in 2008, the equipment provided monthly savings of 28% in water consumption, the equivalent to R$ 40 thousand monthly. Per year, the reduction in expenditure reaches more than R$ 400 thousand*".

Even from this perspective, Pereira, S.F., Cunha, F.A.P and Silva, E.L (2016), with a study published in the ***XIV*** International Congress of Technologies in Education reported having achieved through educational lectures and installing flow reducers reduction of 26.4% in the monthly water consumption in primary school and middle Colonel Jacob Wilhelm Franz of the city of São João do Rio do Peixe, the 40km of Cajazeiras. The project "1 million cisterns" of the Ministry of Social Development and Agrarian, funded since 2003 by the federal government, went on to win the second place in the International Prize of policy for the Future (*Future Policy* Award), with the construction of tanks with a capacity of approximately 16m3. This project aims to promote access to water in family farming through the capitation of rain water. This project has brought relief to the populations living in rural areas of the semiarid. This water is intended primarily to meet basic needs, drinking and cooking, however, is not sufficient to supply a full year of consumption. For the care of the annual water demand it is necessary to recharge with the action of the cars Pipa (water transport vehicle).

RESULTS AND DISCUSSION

Based on the foregoing, this project aims to pointing out suggestions to minimize, if not remedy the problem of lack of water in urban areas of cities located in the semiarid region of Brazil, and/or for the whole world, through actions, namely: first reduce consumption through environmental education and installing flow reducers; and second with the presentation of the possibility of capturing and storing rainwater. Based on the research presented, it can be concluded that the reduction in consumption is a fact as possible as concrete. With respect to the capitation and storage of rainwater, outlining a more detailed approach may emerge very interesting results. Taking as a pilot the city of Pompeii, we intend to show mathematics and structurally, that the problem of low rainfall, having as a consequence the water shortages in urban areas of the arid North-East can be circumvented without large investments and without the need for changes in the socio-regional geography in damages to the environment, or in the landscape of the cities, promoting local sustainability. We will concentrate our focus on 14,575 (67%) connecting points of Cajazeiras that consume up to 10m³, according to CAGEPA (2017). We will call the basic residence that consists of three bedrooms, living room, kitchen and terrace, which features on average 150m² of covered area. Considering that such homes monthly consumption of 10m³, as the majority of the residences of Cajazeiras, this residence consumes annually 120m³ of water year.

We believe that through the first action, i.e., through awareness and deployment of flow restrictors this consumption is reduced by 20%, a percentage lower than those obtained in the work referenced above. The annual consumption will drop to 96m^3 per point. Let us now focus to the second proposed action in this project. Consider a year where the precipitation of rain in the region was exactly the average for the last seven years, i.e., 730mm and on the other hand in the presentation of the basic residence, i.e. that has covered area of 150m^2. For the correct calculation of the volume of rain precipitate that effectively can be leveraged, if use of the runoff coefficient (C) '*run off*', which is defined as the ratio between the volume of water drained (VTE) superficially and the volume of water to precipitate (VTP), in order to remedy losses in the process of acquisition. For roofs of ceramics, characteristic of the region, the coefficient of *runoff* can assume the value of 0.9 (Tomaz, 2009). Whereas the parameters presented the volume of water that can be captured will be:

$$C = \frac{VTE}{VTP} \quad \text{And q.} \qquad (1)$$

150mm^2 x 0,73m x 0.9 = 98,5m^3

With this we arrive at an interesting result. The water needed for the annual consumption of 67% of the residences of Cajazeiras of 96m^3 (ANCAR) can be collected from the precipitation over the roofs of houses, the value of 96m^3. The big question is: how to store in a basic residence, 98,5m^3 of water from rain? Normally the residences of the region are endowed with water box with capacity that varies from 1 to 3m^3, located on the roof and responsible for distribution to the rooms in the house. The principle would seem to be impossible to build a reservoir for 96m^3, but a small change in the design of houses in preliminary constructions can bring the solution to the problem. A basic residence which has a covered area of 150m^2, logically has a floor area of 150m^2. Below the floor area (APRB), in all its dimensions, build a reservoir of only 70cm deep (PR), this will have a capacity for the storage of rain water in quantity (QCAC) satisfactory for the annual supply of residence, as shown in equation 02:

$$APRB \ x \ PR = QCAC \qquad (2)$$

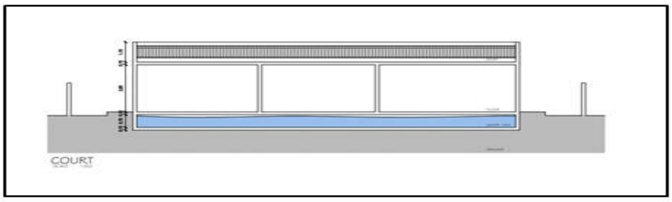
150m^2 x 0,7m = 105m^3

In this way, the reservoir, with more than enough capacity to meet the needs, would be on the floor of the house without causing damage to the environment, nor change the architecture of the same, according to figure 1. There is also need to consider some aspects of the project, with respect to the sewage system in the house. For such projects, orients itself to allocate the bathrooms in the regions of the perimeter of the area covered to avoid conflicts of space between the sewer pipes in the bathroom and the reservoir. This fact could somewhat reduce the volume of the reservoir, but as has been shown in equation 01 reservoir volume presents excess water (EA) as shown in equation 03:

$$QCAC - ANCAR = EA \qquad (3)$$

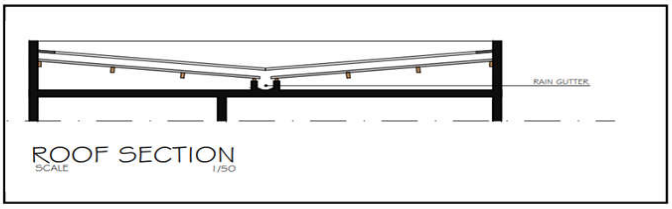
105m³ - 96m³ = 9m^3

Enhancing the project would be with respect to the rooftops. In these cases give preference to roofs with fall from water positioned inside, using fascia structures giving more modern aspect at the premises, according to Figure 2.



Source: Prepared by the authors (2018)

Figure 1. Plant cut



Source: Prepared by the authors (2018)

Figure 2. Fascia structures giving more modern aspect

The ABNT NBR 10844: in its 1989, with respect to the process of capturing rainwater in buildings brings all necessary rules to deployment and sizing of systems for collecting rainwater identifying the possibility of estimating the dimensions of devices based on the characteristics of each project and rainfall in the region, according to the rules allowing the achievement of this research. With respect to projects for construction of reservoirs to collect rain water, the ABNT NBR 15527: through 2007 brings various regulations and suggestions of methods of pre-sizing the volume of reservoirs, whereas some factors, such as number of months without rainfall, losses in process, "*first flush* runoff " (initial) among others. The reservoir suggested in this study took into account only the coefficient from *run off,* having in view that was used an example with actual values as the average precipitation in the region of 730mm, the covered area of a basic residence of 150m^2, and considering also that in the proposal, enough space available even for larger volumes of precipitation. The NBR 15527:2007 defines how *first flush* water from CAPITATION needed to clean of dust or debris from the surfaces of CAPITATION. In this sense, the NBR suggests despise the first 2mm from the capture of rainwater. Second Tomaz (2017) this procedure must be repeated if the period between the rainfalls exceeds three days. The same NBR still considers that the waters obtained from the direct acquisition of rains are not drinkable which restricts its use. According to NBR 15227 these waters must be intended for sanitary discharges, wash, wash floors, among others, but should not be used in baths and personal hygiene, unless you pass through a process of purification.

Final Considerations

This work shows that despite the low rainfall in the semiarid region of northeastern Brazil, is possible through punctual actions and simple, get the water sustainability in the region. The calculations showed that a basic residence may also reduce your consumption by approximately 20%, through awareness and deployment of a flow reducer, capture and store rain water enough for your annual consumption, except for bathing and personal hygiene, promoting a better quality of life of the inhabitants. This leads us to conclude that the great problem of various regions of the world who suffer with low rainfall, which has as a consequence the drought itself, is the lack of proper management of resources that the studies and the development of researches provide. This work is presented the possibility that is sustainable for the existence of a reservoir with a capacity of 105 m^3 in full urban area, in which advocates the *triple bottom line,* that is, does not cause damage or modifications to the environment and socially does not generate disorders in the physical structure of the cities and homes, as well as the reduction of public investment intended to problem management, bringing a great relief to water sources that supply the city. This water saved of water could be destined to agriculture by bringing greater development in the region. Within this aspect, with the houses in the semiarid being built using this technology, the fact of population growth, not bring with you problem with the water supply nor the increase in consumption of the waters of the fountains.

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