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Rainwater Catchment System in Public Sector Housing

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Title:

RAINWATER CATCHMENT SYSTEM IN PUBLIC SECTOR HOUSING

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Abstract:

Water is a universal right for all living beings on the planet, but today it has become a commercial good. It costs significantly to extract water from increasingly distant storage sources. For these reasons and many more the fight for water has become increasingly intense. Precisely, an alternative to avoid more dam construction is the implementation of public politic with actions focused on the integral solution of water, that is to say, that it be distributed fairly and equitably to all users, avoiding more concessions to great industries like as soft drinks and breweries, which are the main consumers and demanders of water. On the other hands, the water supply problem will not end with the construction of more dams, but create of a resilient water culture among citizens, local actions such as control of household leaks, rational use of supply sources, in addition to alternative methods such as rainwater harvesting, as well as better operation of wastewater treatment plants, but above all, an integral management of groundwater and its aquifers should be a priority. The goal of this project is the implementation of the Water Catchment System of Rain (WCRS) as a prototype in popular houses using green energy (solar panels) based on System Photovoltaic. The results of this study were the determination of rainfall potential, as well as the annual volume of precipitation, proposing an automated prototype system for saving rainwater at scale.

Key words: Rainwater Catchment, concessions, resilient water culture.

1. INTRODUCTION

The COVID-19 pandemic that broke out worldwide at the beginning of 2020, as well as the earthquakes that occurred in the Mexico region on September 19-23, 2022, put to the test the resilience of societies and governments that are failing not only in terms of public health in the face of health emergencies and natural disasters, but also in terms of Integrated Water Management. The deficit in water supply, deficiencies in water quality and over-exploitation, contamination of streams and rivers, are some of the problems that directly affect all the countries in the world (Gleason, 2017). Furthermore, urbanization is one of the main causes of flooding. The changes in land use associated with urbanization affects flooding in various ways. Removing vegetation, grading the land surface, and constructing drainage networks increases runoff to streams from rainfall significantly increases the chances of floods (Konrad, 2003).

Highest risk areas in the city

The points of greatest vulnerability in Mexico to flooding are all the overpasses, as well as the avenues: Lopez Mateos, Mexico, Calzada Independencia low area such as Expo Guadalajara, Plaza del Sol, The Osorio basin (Solidarity Park), Plaza Patria, which hydraulically is like a stopper, since it crosses the rainwater channel of the same name. In Tlajomulco de Zuñiga, the channels coming from Santa Anita and San José del Tajo, las Pintas Channel, Union del Cuatro, Adolf Horn Avenue, to name just a few, in short, the municipality urban behavior is linked to the perverse interest of real estate developers (Hernández and López, 2020).

The anarchy and disorderly growth has caused an atomized distribution of urban settlements and as a consequence a limited connectivity of functional spaces and scarce urban integration of the city, which reinforces the existence of segregated geographic spaces that mark the exclusion in the municipality (Caro et al, 2022), especially in the southeastern portion in the urban settlements on Chapala highway and the Miguel Hidalgo International Airport of Guadalajara (ibid).

The global use of natural resources has significant favorable and unfavorable impacts of increasing intensity on society due to its high demand threatening to exceed supply parts of the world so it is urgent to reduce its demand capacity (Rascon, 2012). This has led to change the paradigm on the issue of water demand, use and management in all countries, since perverse figures of first and second class citizens have been created where the citizens of higher economic income or who live in areas of greeted capital gain are granted environmental benefits in terms of drinking water and sewer system coverage (Aguilar, 2015).

Under the context of global warming the problem of water scarcity tends to worsen in those areas where there is a deficit of water resources, either due to the reduction of rainfall due to the La Niña phenomenon or perhaps due to the increase in temperatures or simply because of not knowing how to use rainwater.

It is important to establish rainwater harvesting systems immediately and store rainwater in cisterns. Otherwise the water simply flows to other neighboring basins or passes to other phases of the hydrological cycle making it unusable (Wambeke and Vieira, 2013).

From the hydrological point of view, the use and management of water should be oriented to the search for a better use in all phases and forms the hydrological cycle, since it is of utmost importance to know these parameters: evaporation, condensation, percolation and precipitation, in order to achieve one of the objectives which are the saving and use of rainwater.

2. MATERIALS and METHODS

To obtain a better rainwater catchment surface, it is recommended to use smooth materials: glass, laminate, and polycarbonate. In the case of a slab without downspouts, a row of bricks is placed on the edge on the roof. In the case of a sloping roof, a gutter should be installed to conduct the rainwater to the downspout and then to the cistern according to its designed capacity.

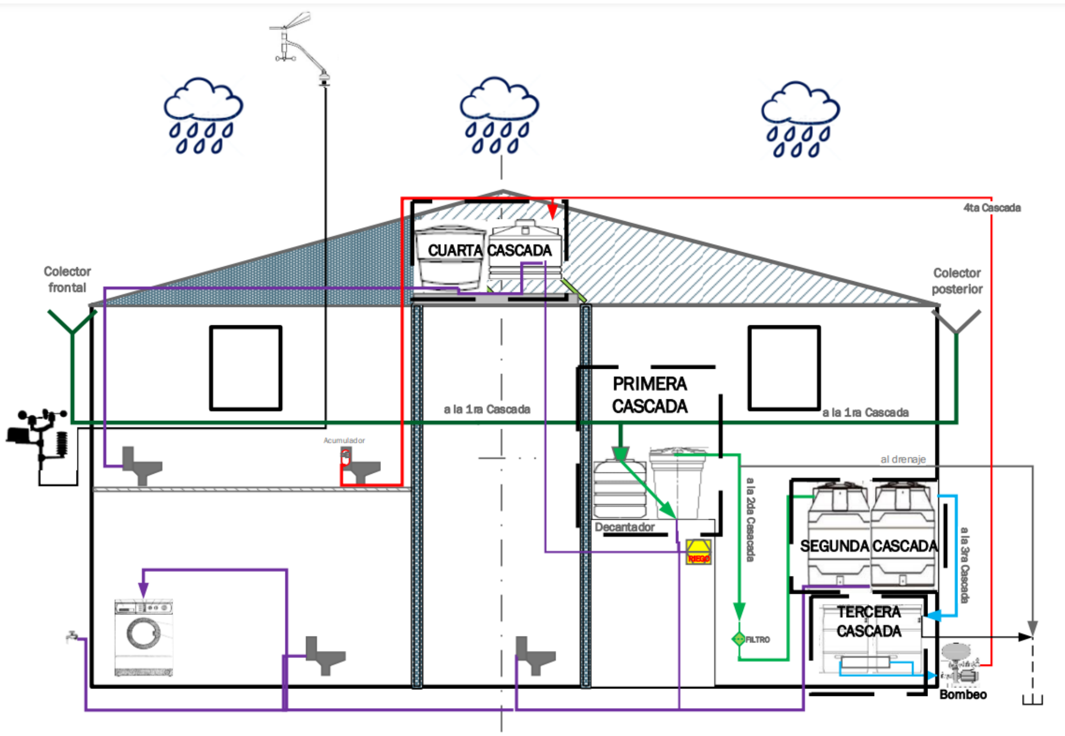

Figure 1. Prototype of a rainwater harvesting system
Source: Ramírez and Buriticá , 2020

The next step consists of treating the rainwater through a process called sedimentation and/or filtration, which includes separating the first rainwater for washing the cistern. Once the rainwater is captured a ½ HP, submersible pump will be installed to provide both primary and secondary treatment to eliminate suspended solids (from 1 to 100 microns). These filters can be activated carbon where their basic function is to retain substances that produce: smell, color and taste in the water.

Another product used for the filtration process is KDF (Kinetic Degradation Fluxion). It efficiently removes diverse chemical sediments of heavy elements (Lead, Nickel, iron, etc.), and chlorine to use in traditional or advanced filter stations, such as reverse osmosis plants or ion exchange water filters (Majdi, Jaafar, and Abed, 2019).

3. RESULTS

In order to estimate the Rainwater Harvesting Potential (POTCALL), it is necessary to determine the available rainwater that can be harvested. To calculate the amount of rainwater, the following variables were calculated.

A = Catchment area, such as the rooftop of a house living for example 85 m²
P = Average Daily Precipitation (Ixtapaluca State) = 75 mm = 0.075 m
C = Runoff coefficient which depends on the material if it is smooth or rough, when the surface is smooth high values are used, on the other hand when the surface is rough low values are used.

FS = Safety Factor, to determine the factor of safety it is necessary to examine leaks, plug-type obstructions and other factors that reduce the efficiency of a collection system (Gleason, 2017).

$$POTCALL = FS * C * A * P = 0.80 * 0.85 * 85 * 0.075 = 4.335\, m^3 = 4335\, lt$$

Runoff Coefficient			
Surface	Material	Maximum Value	Minimum Value
Roof	Metal, gravel, asphalt shingle	0.95	0.75
Pavement	Concrete, asphalt	0.95	0.70
Soil	With vegetation	0.60	0.10
Sandy-soil	2% to 7%	0.15	0.10

Table 1. High and low runoff coefficients for catchment areas
Source: Haan, Barfield and Hayes, 1994

To determine the sizing of the cistern, it was designed in a rectangular shape. The reason for this is the limited space in public sector housing. The depth of the cistern was taken as 2 m, for optimal design considering the groundwater level low..

Calculations

$$vol = Abase * h \qquad \text{eqn. 1}$$

vol = Volume of storage needed
Abase= Base area of the cistern
h = Height of the water corresponding to ¾ of the depth of the cistern H, which corresponds to:

$$h = ¾ * H = ¾ * 2 = 1.50\, m \qquad \text{eqn. 2}$$

Then the base area will be:

$$Abase = \frac{Vol}{h} = \frac{4.335}{1.50} = 2.89\, m^2 \qquad \text{eqn. 3}$$

4. CONCLUSIONS

Knowledge of the destructive effects of the transit of maximum floods along a channel allows us to take preventive measures in the event of overflows in channels and streams caused by high intensity storms.

Rainwater harvesting has the potential to improve the hydrological behavior of the Ixtapaluca basin, and capture most of the runoff upstream of Mexico City which otherwise is wasted. Due to increasing urbanization, the infiltration of rainwater into the ground has decreased. This overtime may lower the groundwater levels. Furthermore, new settlements in the suburban periphery of Mexico City have experienced severe urban flooding, which in some places has accentuated the risks and disasters. However, a rainwater harvesting system is a possible solution to mitigate these issues.

In summary, irreversible urban growth has modified the system of the basin of Mexico City. In addition, many of the new public sector housing complexes, such as in the municipality Ixtapaluca, are being developed, since they are located in topographically flat areas, which increases the risk of flooding, hence the need to establish a paradigm shift in the management of watersheds and natural disasters.

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