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RAINWATER CAPTURE IN PUBLIC OR PRIVATE EDUCATIONAL INSTITUTIONS

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Abstract: The lack of drinking water in the country due to the more frequent droughts has worsened alarmingly worldwide, so it is necessary to address this problem by developing projects that make it possible to take advantage of the rainy seasons, in order to To help solve this situation, the following rainwater harvesting project is proposed in any Educational Institution in the country, which in the area of its buildings or constructions allow the collection of rainwater, creating cisterns that allow the storage and use of this for the basic needs of the communities that make up the educational institutions in order to make these institutions sustainable. For this reason, it is recommended that the areas of the buildings that public or private educational institutions have, have connectivity between roofs directed to collection cisterns, for which it is necessary to condition them in such a way that by gravity the water flows through pipes. towards said cisterns, which must have filters that allow the retention of impurities that may exist in the catchment areas in such a way that it reaches the tanks as clean as possible and save on the treatment of the vital liquid, so that the water be available for irrigation of green areas in the facilities of the educational center, cleaning of toilets and / or to be treated for human consumption with the support of a water purifier to offer the filling of jugs for the community. It is important to note that the cooperation of the community that conforms the institutions to participate and contribute to the care and maintenance of the facilities is proposed. In addition to an environmental education campaign/program to inform the community of the problem and the proposed project. Being created as a sustainable area, the intervention of the different governmental instances is important, as well as the community that settles in said spaces.

Keywords: catchment, rainwater, irrigation, purification.

INTRODUCTION

Faced with a problem due to water shortages throughout CDMX, as well as in its surroundings that belong to the State of Mexico, the high prices for a water pipe are considerable for low-income people, given the growth that has been suffered Over the years, it has become increasingly difficult to provide adequate services to the entire population. People have come to complain about this and one of the most affected sectors is the supply of drinking water, because this service is given certain days of the week or in the best cases at certain hours of the day.

The use of rainwater has been proposed, with which a large part of the population has contact, giving rise to an efficient way of its use, for which a collection and storage system is proposed. Giving an alternative way in which the population would benefit, this would be stored to be used for irrigation of green areas, sanitary or floor washing and even a treatment for its purification.

METHODOLOGY OR DEVELOPMENT

To face the problem of water at a global and national level, one of the alternatives is the collection of rainwater.

Collection systems to take advantage of rainwater for use in educational institutions represent a solution to supply in quantity and quality to the large population that make up public and private educational institutions, in cities as large as the city of Mexico and its metropolitan area that suffer from the lack of this vital liquid.

Considering the above, it is urgent that each living being on this planet have water in quantity and quality in order to achieve the true Sustainable Development of humanity.

Rainfall represents a valuable natural resource that must be taken advantage of, this is one of the most real options to provide water to those who do not have this resource. It is possible to establish rainwater harvesting systems for domestic use at the family and community level, for which we consider that educational institutions can be the frame of reference and example for it to be carried out.

The institutional framework, the regulations for the execution of the project.

The regulations for the adaptation of the structure and roof that schools in Mexico have have the characteristic of being interconnected as an example we will use a map of the Azcapotzalco unit of the Autonomous Metropolitan University (UAM-AZC.), which has four cisterns which will allow us to save on the expense that this would mean if it had to be done from scratch, for the use of water in the WC within the facilities, there is no problem in terms of regulations in legislation, since the collection of rainwater The use of land is allowed, under the appropriate safety regulations, no impediment to the development of the project. Only necessary measures must be taken for the permits from the mayor's office where the UAM-AZC facilities are located, to begin with the necessary modifications in the area designated for this project, which will be exposed in this document.

In Mexico there are a series of norms that regulate the quality that water must have for consumption, as well as its use, the limits of permissible contaminants are governed by these norms. Although there is increasing interest in the collection of rainwater for its reuse, there is still no regulation that endorses and encourages this practice, to carry it out in the project. For management, the reuse of rainwater must take into account the following standards [1-2].

At present, many urban populations lack drinking water, for this it is necessary then, to adopt alternative measures that allow the sustainability of the resource, knowing

techniques for the use of rainwater is a fundamental part to achieve this purpose.

The use of rainwater, in practice, is easy to implement, which allows reducing the consumption of drinking water, thus achieving a reduction in expenses for said consumption, making efficient use of the resource, so that those systems in which the drinking water is not enough can be supplied by rainwater.

The components of the system are presented, the analysis of the pluviometric information as well as the calculations made for the design of the harvesting system.

The catchment is the area destined for the collection of water. Most of the systems use the roofs, which must have an adequate slope (not less than 5%) of their surface, which are the modifications that we must make in order to facilitate runoff into the collection system. as shown in Fig. (1), which shows the layout of the buildings in the UAM-AZC, and on the other hand a sketch of what must be done.

The materials used for the roofs can be sheets of steel, wood, cement, among others. Cement and tin roofs are the most common due to their durability, relatively low price, can provide good quality water; Those with asphalt or asbestos compounds or those that are painted are recommended to be used only when the water collected is not for human consumption, since they can leach toxic materials into it.

Collection and driving. It is the set of gutters attached to the lower edges of the roof, in order to collect water as well as conduct it to the desired site. The gutters must be installed with a not very large slope that allows conduction to the downspouts. Gutter material must be lightweight, waterproof, easy to bond together to reduce leakage. For this purpose, materials such as wood, metal or PVC can be used. It is recommended that the minimum width of the gutter is 75mm and the maximum 150mm.

In Fig. (2). Some examples of what exists on the market are shown.

Interceptor is the device aimed at capturing the first rainwater corresponding to the washing of the catchment area as a first filter, in order to avoid the storage of water with a large amount of impurities. This device must take into account the volume of water required to wash the roof which is estimated at 1 liter per m2 of roof. This consists of a tank, into which the water enters through the downspouts attached to the gutters. This must be counted to a float valve that allows its filling, when it reaches the desired level, the valve will prevent the passage of water to the receiver, it will go to the storage tank. Additionally, it must have a purge valve at the bottom of the tank to do maintenance after each rain, see Figures. (3).

Storage. It is the deposit destined for the accumulation, conservation and supply of water for different uses. The storage unit must be durable, it must meet the following specifications:

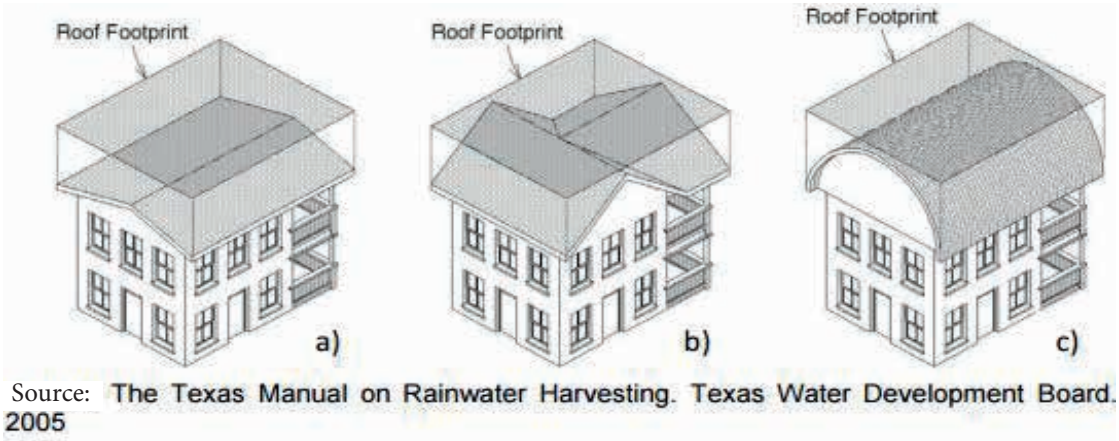
- Waterproof to prevent water loss through dripping or perspiration
- With lid to prevent the entry of dust, insects and sunlight
- Have a hatch with a cover large enough to allow one person to enter for cleaning and necessary repairs.
- The inlet and overflow must have meshes to prevent the entry of insects and animals.
- Equipped with devices for the removal of water and drainage.

The types of storage tanks can be built with the following materials:

- Masonry for smaller volumes (100 to 500 Liters)
- Ferrocement for any volume.
- Reinforced concrete for any volume.

Rainwater Distribution Network and

Source: https://mir-s3-cdn-cf.behance.net/project_modules/fs/91391833169001.56a23935bf977.jpg



Source: The Texas Manual on Rainwater Harvesting. Texas Water Development Board. 2005

Figure 1.- Arrangement of the catchment area and respective inclination to the roof.

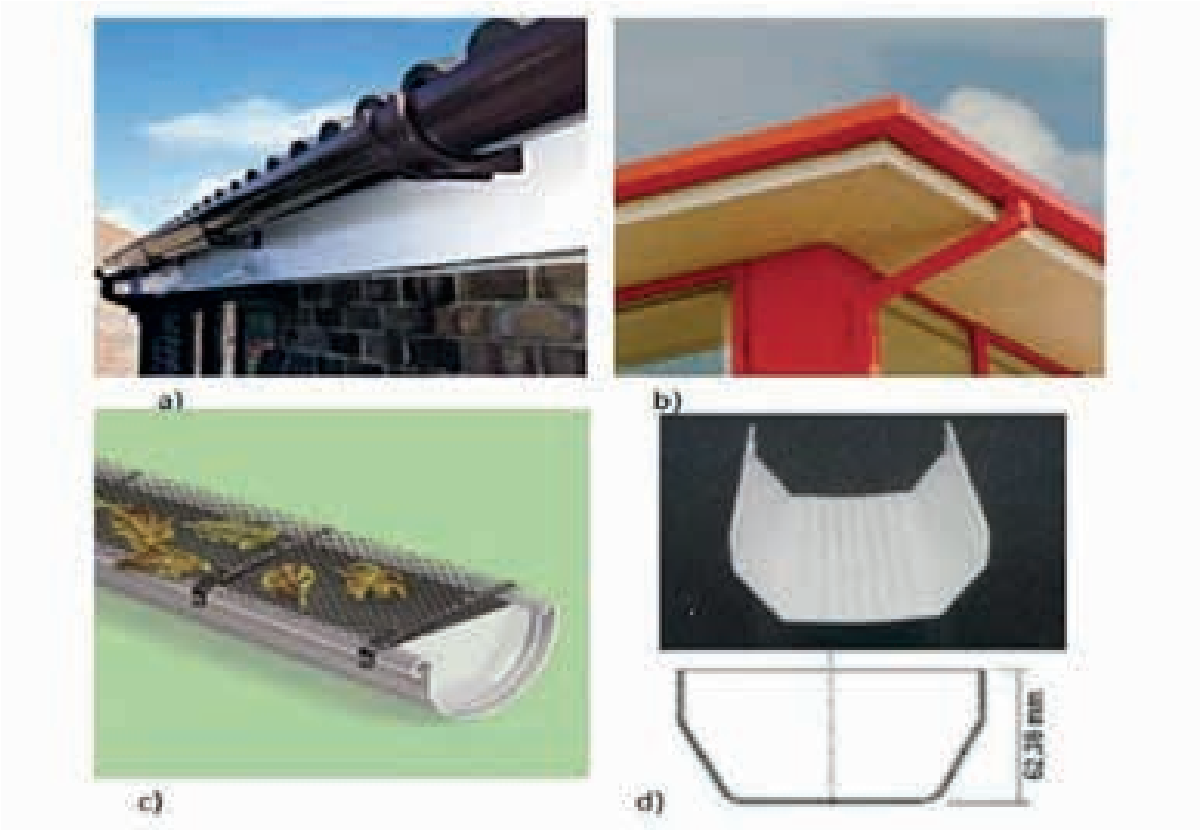


Figure 2.- Shows the design

Source: Rainwater harvesting as an alternative to face the scarcity of the resource. Training manual for community participation. Floriana Hernandez Martinez

Fuente: Captación de agua de lluvia como alternativa para afrontar la escasez del recurso. Manual de capacitación para la participación comunitaria. Floriana Hernández Martínez.

Source: https://www.sonproject.net/2021/08/cisterna-de-agua-para-casas-escuelas-hospitales-tipos-y-calculo.html

Source: https://www.milenio.com/sociedad/cuanto-cuesta-una-cisterna-en-pachuca

Figures 3.- water collector.

Pumping System. This must go parallel to the aqueduct network, reaching the hydraulic points where it will be used, so the drinking water supply network must be protected with a check valve to prevent it from mixing with drinking water. The pumping system will distribute the stored water to the required toilets. The pump suction pipe must be at least 50cm above the bottom of the tank to avoid entrainment of sludge.

Basis of design. Before undertaking the design of a rainwater harvesting system, it is necessary to take into account the following:

precipitation in the area. Rainfall data must be known for at least the last 10 years, and ideally for the last 15 years. Type of material from which the catchment area is or will be built, number of people benefited and Demand for water.

Design principles. This method known as: "Calculation of the Volume of the Storage Tank" takes as a database the precipitation during the interval from 10 to 15 of the last years. Through this calculation, the amount of water that is capable of being collected per square meter of roof surface is determined this way:

the necessary roof area and the capacity of the storage tank, the volume of water, the capacity of the tank for a certain roof area. The complementary data for the design are:

Number of users, Runoff coefficient; - sheet metal 0.9 - clay tiles 0.8 - 0.9 - wood 0.8 - 0.9 - straw 0.6 - 0.7

Water demand. The steps to follow the design of the collection system are:

Determination of the average precipitation from the data of the last 10 or 15 years evaluated in rainy season. This value can be expressed in mm/month, liters/m2/month, capable of being collected on the horizontal surface of the roof.

$$P_{p_i} = \frac{\sum_{i=1}^{n} p_i}{n} \qquad (1)$$

Where: number of years evaluated, p_i: monthly precipitation value of the month: "*i*", (mm), P_{p_i}: average monthly precipitation of month "i" of all the years evaluated. (mm/month)

Determination of demand; Based on the amount assumed per person, the amount of water necessary to meet the needs of the family or families to be benefited in each of the months is calculated.

$$D_i = \frac{N_u \, x N_d \, x D_{ot}}{1000} \quad (2)$$

Where N_u: number of users benefiting from the system, N_d: number of days of the analyzed month: D_{ot}: endowment (Liters/person x day), D_i: monthly demand in m^3

Determination of the volume of the supply tank, for this Eq. (3) is used

$$A_i = \frac{P_{p_i} x C_e x A_c}{1000} \quad (3)$$

P_{p_i} : average monthly precipitation (liters/m^2),

C_e : runoff coefficient,

A_c : catchment area in m^2

A_i: Offer of water in the month "*i*" in m^3

Taking into consideration the values obtained for the monthly water demand, the accumulated value of each of them per month is calculated, starting with the month with the highest rainfall. We proceed to calculate the difference of the accumulated values of supply and demand for each of the months.

The ceiling areas that lead to negative cumulative differences in any of the months of the year are discarded because they are not capable of capturing the amount of water demanded by the interested parties.

The minimum ceiling area corresponds to the analysis that provides a cumulative difference close to zero, the storage volume corresponds to the largest cumulative difference. Ceiling areas greater than the minimum will provide greater security for the supply of those interested.

The accumulated supply and demand in month "i" may be determined by Eq.(4), Eq.(5).

$$A_{a_i} = A_{a_{(i-1)}} + \frac{P_{p_i} x C_e x A_c}{1000} \quad (4)$$

$$D_{a_i} = D_{a_{(i-1)}} + \frac{N_u x N_{d_i} x D_{d_i}}{1000} \quad (5)$$

A_{a_i}: cumulative offer per month "*i*", D_{a_i} cumulative demand per month "*i*".

$$V_i(m^3) = A_i\,(m^3) - D_i\,(m^3) \quad (6)$$

V_i : volume of the storage tank needed for month "i", A (i) volume of water collected in month "i", D_(i) volume of water demanded by users for month "i".

Socially, the Azcapotzalco Unit is located in an area of high demand, for which it is intended to make improvements with the proposal of this project to exemplify the advantages of water collection, advice and information will be given to citizens on care and conservation of the environment. atmosphere.

Relationship with other initiatives. Due to the lack of water in CDMX, it is expected that rainwater be used as an alternative measure for domestic use, giving rise to awareness of caring for the environment, using solar heaters and photovoltaic cells that reduce consumption. of electricity provided by CFE. As well as wastewater treatment which gives a reuse of water for use in bathrooms, to clean floors or water plants.

The project consists of the modification of the roofs with a metal cover or roof reinforced with a metal structure, located in the Nueva El Rosario neighborhood, Alcaldía Azcapotzalco, C.P. 02128, Mexico City, in the facilities of the UAM-AZC, which will be directed towards the cisterns that the University has, whose structure has the advantage of having an approximate height of between 12 and 15 meters, which generates a fall of the liquid that can be used for another project such as the generation of electrical energy that will be discussed on another occasion.

The modification to the roofs will have a slope of 26% and to the center of the water collectors for the first filter.

On the edges of the roof, PVC gutters will be placed with an inclination of 15° which will redirect the flow of collected water to the cistern; It is expected that for each square meter of roof, 225 Liters/m^2/day will be collected. Before entering the cistern, it will pass through filters, which are described in the following point.

Large solids separator. Based on the evaluation of the quality of rainwater obtained, first it is proposed to remove the largest solids, among which the leaves, stones, branches, insects and other materials that may be present carried by the water stand out. An evaluated model "b" solids separator will be used, which consists of a metal grid with a 1 mm opening, arranged in a cylindrical shape inside a 4" PVC tee for areas of up to 100 m^2 and a 6" for upper catchment areas. To improve its use efficiency, it is proposed to place a commercial plug for PVC that avoids wasting water while allowing cleaning and maintenance as shown in the Figure. (4).

First rain separator. Qualitatively evaluating several models of separator filters from the first rain where the most suitable for catchment areas greater than 50 m^2 was the model proposed by Isla Urbana. In the figure. (5) an improvement to said model is observed, changing the internal arrangement for a 90 ° elbow integrating a PVC "T" to reduce the force of the jet on the ball that generates a mixture of the separated water with which it is going to be used. In the figure. (5) an improvement was made in the process.

RESULTS AND ANALYSIS

One of the greatest results of the project is the great contribution that is obtained from the collection of rainwater, since a better use and operation of a natural resource that

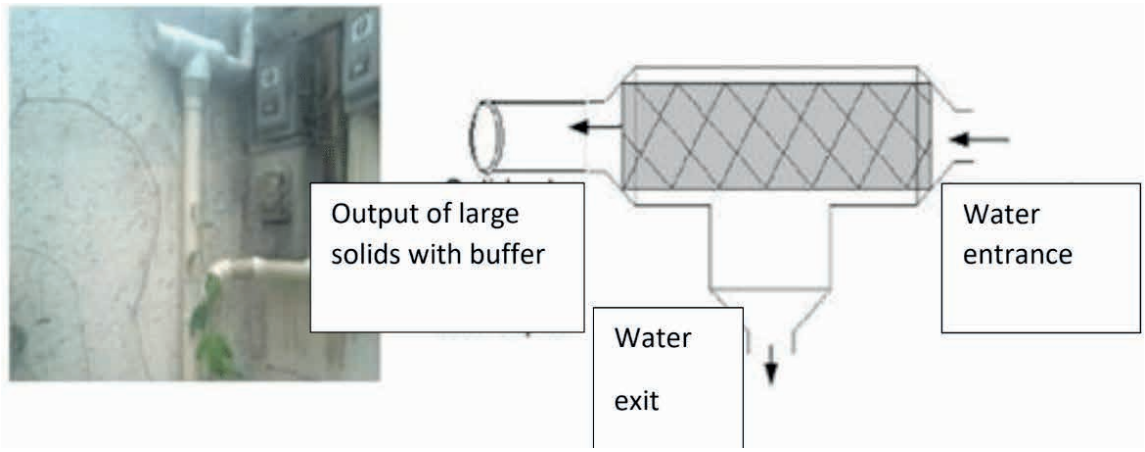


Figure 4.- Large solids separator device.

Figure 5.- it shows improvement in the model

is wasted in the rainy season is being given, together with the new modifications that are placed in the UAM-AZC, it is intended to supply the institution. Only a tiny part of the rainwater is used and according to specialists, the lag in water supply in the country could be reduced if the collection methods were used and rainwater management. If all the rain were captured on the roofs and on some floors, 10% to 15% of the water consumed in educational institutions could be saved, as well as in homes that adopt the system. If 3% of the rain that falls each year in the country were used, it would be enough to supply non-potable water for uses such as cleaning or sanitary, in addition to being able to take it to a purification process later on.

CONCLUSIONS

To promote rainwater harvesting to citizens, optimize the use of it to be used for sanitation, in sports areas, irrigation of vegetation, construction regulations must be updated to include a rainwater harvesting system mandatory whether domestic, industrial, commercial and residential.

NOMENCLATURE

To area, m2
PVC polyvinyl chloride
CDMX Mexico City
V volumen m^3

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